CROSS SECTIONING OF PHOTOGRAPHIC ARTIFACTS

by Kathy Mayhall and Siegfried Rempel

Cross sectioning is a destructive, analytical technique that can provide useful information on the internal structure of a given specimen. This project was our first attempt at mastering the technique. Our motivation to apply the technique was not as an active, analytical tool, but rather, to be able to use it at a later date to confirm or support other nondestructive analytical techniques. Such nondestructive techniques could provide similar information on the internal structural components of photographs, but such methods require confirmation through the use of an independent technique.

The supports sampled included artifacts on paper and plastic supports, specifically gum bichromate, carbon transfer, and silver gelatin print materials, and cellulose nitrate. Those sampled, but not included here, are the albumen, salted silver, cyanotype, and palladium print processes and the cellulose acetate film support. The latter group is representative of the two categories we have delineated for this study: photographer-fabricated and manufactured processes.

Sample Preparation

The preparation of the samples included the use of the JB-4 Embedding Kit by Polysciences, Inc., as the embedding medium. This product is described by the manufacturer as a "water soluble plastic

media" that can "replace most embedding procedures in which paraffin or epoxy resins are used, and offers the advantage of less distortion and tissue shrinkage." As the medium is water soluble, dehydration of the sample before embedding is not necessary, a factor which can drastically reduce processing time. The medium preparation involves three components: 1) a formulated water-soluble monomer based on glycol methacrylate; 2) an amine activator and plasticizer; and 3) a peroxide catalyst. Preparation of the embedding solution from these components is straightforward, the only constraint being that care be taken in mixing. Note the toxicity of the embedding-medium components. Use of a fume hood, gloves, and disposable containers and utensils is essential. Polymerization of the embedding solution takes place shortly after catalysis and speed may become an important factor in sample preparation.

The sample blocks were prepared by cutting a 6mm x 2mm strip from the didactic artifact. In most cases we tried to take the strip from an exposed/unexposed interface to provide a contrast between high- and low-density areas. The embedding solution was dropped into small rectangular mold cups until half full. The sample strip was then oriented within the cup to provide a maximum surface for the microtome knife. The cups were then completely filled with embedding solution and covered to exclude oxygen. Polymerization and then curing of the blocks took anywhere from four hours to two days, depending on the accuracy to which the embedding components had been measured. After curing, cross sections were cut from the block using a Hacker Instruments manual rotary microtome, with

glass knives made on a Hacker Instruments knife-maker. Glass knives were utilized because they can be cut into various blade shapes and sizes and because of the degree to which they can be sharpened. After the sections were cut they were put onto microscope slides and stained with Graff's C stain. This paper stain was used primarily because of the large number of paper-supported processes we were examining. The slides were then covered with cover slips and viewed with a Leitz Ultralux microscope at magnifications of 10X, 25X, and 40X. The following photomicrographs were taken at 10X magnification.

Discussion

The historic photographic processes included in the photographer-fabricated category are: gum bichromate (Figures 1 and 2), carbon transfer (Figures 3 and 4), cyanotype, albumen, palladium and salted silver. These processes are related because individuals treated and coated the papers by hand. Such processes tend to produce distinctive configurations. The image carrying "layer" may penetrate into the upper layer of the paper's fibers, resulting in a photograph with a matte surface. The texture of the paper is clearly visible. This is the case in processes such as gum bichromate printing, where the paper needs to have "tooth" as well as high wet strength, to withstand multiple printings and developings.

Manufactured products, on the other hand, are defined as those processes which include mechanical application of several specialized layers to a continuous support. The paper supports have been

prepared prior to coating and generally the final product contains more discrete layers than the photographer-fabricated processes. The processes included in this study include silver gelatin prints (Figures 5 and 6), and cellulose nitrate (Figures 7 and 8) and cellulose acetate plastic supports.

Each photomicrograph is accompanied by a labelled diagram. These are presented to assist the non-specialist in interpreting the photomicrographs. The cyanotype was the easiest to interpret, because the characteristic color served as a marker for orienting the section on the slide. The albumen cross section included tiny cracks in the emulsion which were clearly seen in cross section.

Gum Bichromate Sample

This section (Figures 1 and 2) includes the paper support at the bottom with the individual paper fibers visible. The pigmented gum layer partially penetrates the paper support but most of it lies on top of the support. This example does not have an exposed/unexposed interface, as the section was taken from an exposed area. The gum arabic binder minimizes penetration of the pigment/coating layer into the paper support. A paper with texture or "tooth" helps to hold the pigmented layer and therefore gum prints are matte surfaced. The limited contrast range of the process also means that several registrations and printing may be necessary -- each with a development step -- therefore the paper must also have good wet strength. These factors became important in our cross sectioning because the heavy, coarse papers tended to shred when cut on the microtome, thereby distorting the shape of the paper support.

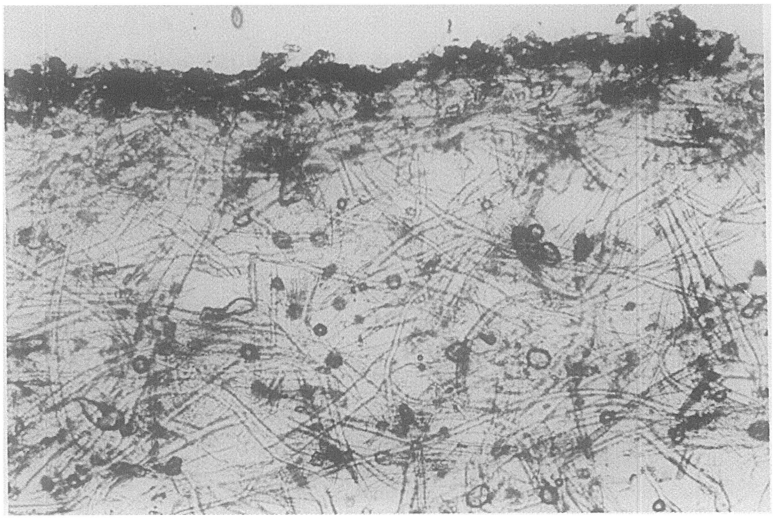

Fig. 1. Photomicrograph of gum bichromate sample

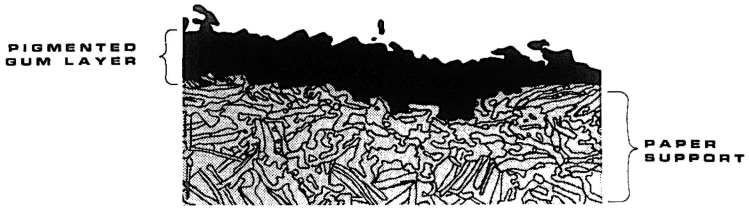

Fig. 2. Line drawing based on Figure 1. The pigment-bound layer is clearly visible as a dark surface sitting on and lightly penetrating the upper paper support

The carbon print cross section (Figures 3 and 4) shows that the exposed areas consist of deposits of gelatin binder with incorporated pigment, present on the top of the paper support. The unexposed areas immediately adjacent to the exposed area contain no pigment or binder. This occurs because of the thin gelatin layer coated on the transfer paper and the gelatin binder, which prevent the carbon transfer layer from penetrating into the paper fibers. This thin, unpigmented gelatin support layer is an important component in the fabrication process. It provides the exposed tissue with a receptor, a layer to hold on to when transferred to the support. This interface between the exposed and unexposed areas is particularly good because of the conspicuous thick pigment marker. A print made by this process would not be matte surfaced; in fact, shadow areas would have a definite lustre, while highlights would show a bit more texture or paper support features. The three dimensionality of a carbon print which can be seen in raking light and utilized as a visual identification tool is revealed in this cross section.

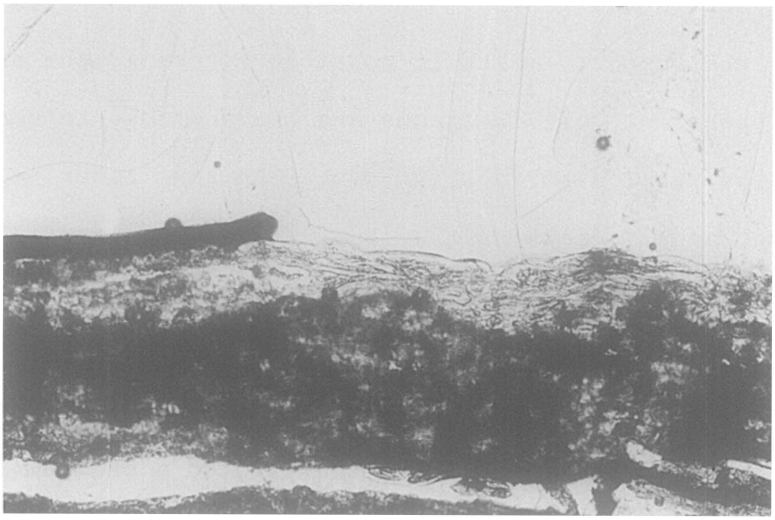

Fig. 3. Photomicrograph of carbon transfer sample

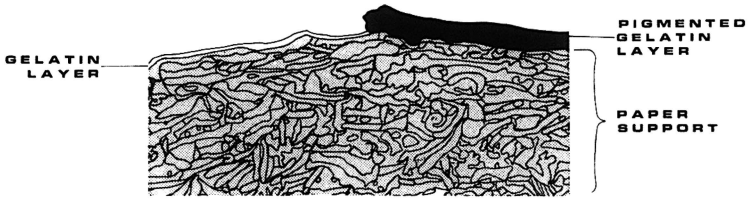

Fig. 4. Line drawing based on Figure 3. The gelatin print transfer sits on the surface of the gelatin-coated transfer paper and the shadow/highlight interface is visible as a cliff-like drop off.

Silver Gelatin Sample

The difference between the silver gelatin print (Figures 5 and 6) and the gum bichomate print is immediately apparent. There are numerous layers in the former. The baryta layer, the first layer coated onto the support, makes it possible to change the surface texture of the print. It is opaque and heavy enough to completely smooth out the paper's surface texture. The next layer is the gelatin emulsion, and it contains the image. The exposed/unexposed interface is present, but it may not be readily discernible, since the silver grains making up the image are very fine. The protective gelatin supercoat can be seen in spots along the surface.

The presence of so many layers constituted a problem for the glass knife, which cut through the sample differentially, and the section is somewhat skewed. The opaque baryta layer can be seen shifted from its proper position on top of the support.

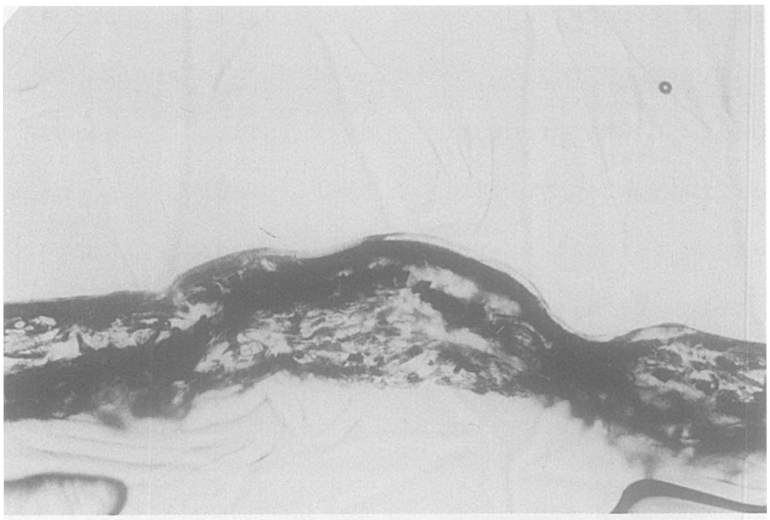

Fig. 5. Photomicrograph of silver gelatin sample

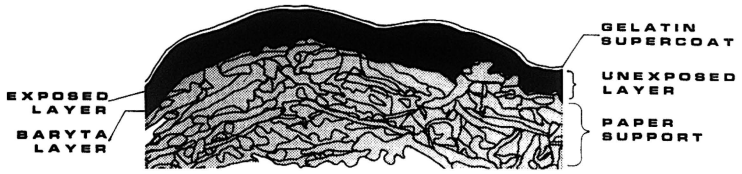

Fig. 6. Line drawing based on Figure 5. The various layers of this sample have moved over one another during cross sectioning and present a distorted view of the succession of the individual layers. The opaque band is the baryta layer coating the paper base to segregate the image-carrying gelatin layer from the paper fibers. The thin upper-most layer represents the gelatin binder and the silver image provides a grainy pattern toward the left side of the photomicrograph.

Cellulose Nitrate Sample

The last photomicrograph (Figures 7 and 8) is of a cellulose nitrate film. The upper layers of the plastic support are the various gelatin layers, a filter layer, and a gelatin supercoat. The image in this case was produced by dyes, since the sample was taken from a color-transparency film. A small problem was encountered with this sample as well as the cellulose acetate sample: the plastic support began to dissolve when embedded in the media. However, the gelatin anticurl layer, on the opposite side of the support from the image, did *not* dissolve and its outline is still visible.

Conclusion

The preparation of the sample blocks and the cutting of the cross sections were the most time-consuming activities. Once the basic preparation techniques were mastered, the desired cross sections could be obtained by churning out a sufficient number of sections to choose from. The following factors played a major role in sectioning: the thickness and/or heaviness of the paper, the type of support (plastic or paper), and the number of layers that made up the sample. Gum bichromate prints on heavy paper shredded rather than cutting cleanly. Plastic-supported processes tended to soften in the embedding medium making them easier to section, but this also allows the different layers to separate. Finally, the greater the number of layers in the print, the harder it became to obtain an undistorted section.

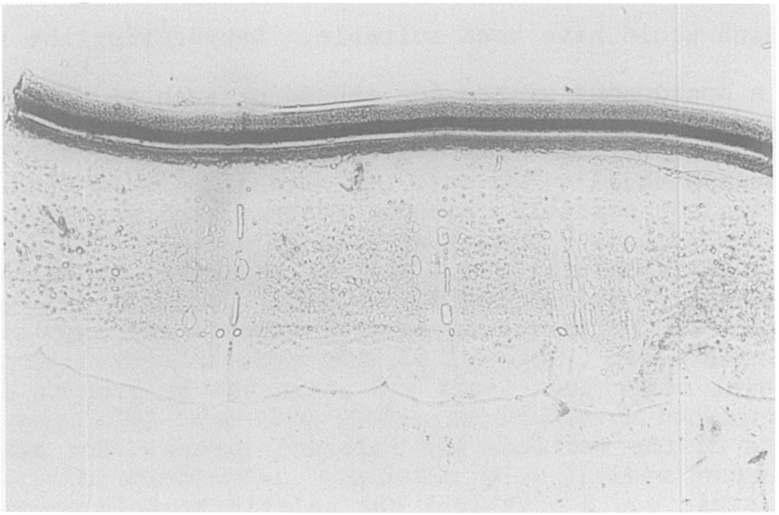

Fig. 7. Photomicrograph of cellulose nitrate sample

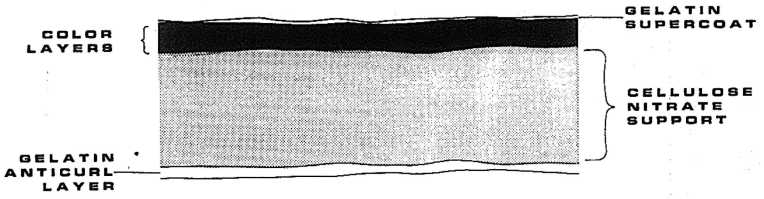

Fig. 8. Line drawing of Figure 7. The sample is from a color positive and reveals several layers including (from the top down): a clear gelatin overcoat (anti-abrasion) layer, two color layers, a clear (filter) layer, an additional color layer, and a very thick support layer. The support is cellulose nitrate which has begun to dissolve (due to embedding medium solvents) resulting in air bubbles. The last (bottom-most) layer has no air bubbles in it. It is a gelatin anti-curl material approximately equal in thickness to the gelatin image-carrying layers.

Other embedding and sectioning methods should be considered. There are other systems for thin sectioning (less than fifty microns) which would have been suitable. Dehydrating the samples and use of a nonaqueous system for embedding such as Epon, methacrylate, or a polyester might improve the cross-section quality. If dehydration is not possible, aqueous systems such as hydroxyethyl methacrylate could be utilized. The various other knife techniques were not explored, primarily because of expense and complexity. Finally, stains other than Graff's C stain can be used to delineate other aspects of the sections and internal layers. For example, cotton blue stain would highlight the gelatin/protein components within the different sections.

This is the first in a series of projects aimed at refining the cross-sectioning technique for use in supporting other analytical techniques. Because cross sectioning is a destructive technique, it cannot be advocated for artifacts. As a reference tool, however, cross sections of historic photographs clarify their compositions and help us to understand their processes.

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