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Problem Children: Technical Analysis and Conservation Treatment of Two Works on Paper by Karel Appel

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Abstract

Analysis and treatment were performed on two works on paper by Karel Appel. *Yellow Animal,* a mixed media piece, was in poor structural condition due to flaking paint. *Mysterious Landscape,* a color lithograph, required aesthetic treatment for tide-line stains and overall discoloration. An unsigned lithograph discovered on the verso of *Yellow Animal* is also examined, and through art historical research of the lithography print shop where the work was made, is attributed to the Russian painter André Lanskoy. The media and papers used in *Yellow Animal* and *Mysterious Landscape* were analyzed with microchemical testing, FTIR, and XFR in order to identify the palette and materials. Similar works by Appel from the collection of the Albright Knox Art Gallery are also discussed as well as a literature review of treatment approaches for the consolidation of flaking matte paint. *Yellow Animal* was consolidated by brush and ultrasonic mist using isinglass in deionized water. Stains and discoloration on *Mysterious Landscape* were reduced through light and chemical bleaching with hydrogen peroxide. The works were reframed with museum quality materials to improve their stability while on permanent display in a private residence. Conservation treatment improved both the structural and aesthetic condition of the art.

1 Introduction

This paper documents the examination and treatment of two works by the Dutch artist Karel Appel (1921-2006). *Yellow Animal* was executed in 1958 and combines lithography ink, gouache, and crayon (see plate 1). The lithograph *Mysterious Landscape* was produced in 1959 (see plate 10). Both works were made in Paris at a transitional time when Appel's style was beginning to mature, and he was developing a visual language that would define his work for the duration of his long career. Technical analysis of these works, and of three others from the same time period, will aid in characterizing his use of materials.

Flaking paint and loss of media are persistent condition issues that are often associated with Appel's gouache paintings and mixed media works from this period. These issues likely relate to the artist's avid experimentation with media and willingness to use any available material. Treatment strategies for the two works will be developed based on the characterization of his materials, working methods, and the technical analysis of similar pieces.

During the years Appel lived and worked in Paris, when *Yellow Animal* and *Mysterious Landscape* were made, he produced lithographs at Atelier Pons. The studio was operated by French artist and master printer Jean Pons. An unsigned lithograph on the verso of *Yellow Animal* (see plate 2), that bears no resemblance to Appel's work, may be attributable to the Russian artist André Lanskoy, who also made work at Atelier Pons.[1] This paper will briefly investigate the work of Andre Lanskoy and the development of Atelier Pons, which connects the two artists.

1.1. Biography of Karel Appel

The artistic career of Karel Appel, spanning most of his 85 years, was distinguished by a prolific production of paintings, drawings, prints, and sculptures. Christiaan Karel Appel was born in Amsterdam on April 25, 1921 and began painting as a child. Between 1940 and 1943, during the German Occupation, Appel studied at the Royal Academy of Fine Arts in Amsterdam and

[1] Carlotta Owens, Assistant Curator of Modern Prints and Drawings at the National Gallery of Art, Washington, D.C. was key to helping make this attribution.

painted portraits, landscapes, and cityscapes in a prescribed academic manner. In 1944, after completing his studies at the Academy, Appel left Amsterdam and traveled around the Netherlands to avoid forced conscription by the German Police. Seeking temporary shelter, Appel stayed with a jewelry maker in Utrecht on a boat in the Vecht River. There he found copies of the French art journal *Cahiers d'Art,* and saw for the first time reproductions of works by German Expressionists. Appel eagerly studied the paintings by Max Beckmann, finding both kinship and inspiration in his bold use of line and color. In a twist of wartime irony, Beckmann was also in the Netherlands living in impoverished exile after being declared a "cultural Bolshevik" and degenerate by the Nazi party (van Halem, 2003). Captivated by Beckmann, Appel's work from this period marks a drastic stylistic shift away from academic naturalism and towards the bold rebellious distortions of Expressionism (van Halem, 2003) (see figure 1).

Figure 1. Karel Appel, *Siaantie*. 1944. Gouache and

Figure 2. Karel Appel *Organ Grinder,* 1947. Gouache.

The artistic culture of the Netherlands had been isolated and stifled by the censorship imposed by occupying forces. Art Historian Wilem Stokvis notes that the war "had created a kind of vacuum in art development" and with the end of the war "a whole new world opened up to many young artists…in which the old was completely obsolete" (2004, p. 152). The out-pouring of work by Appel in the years directly after the war reflects this opening-up as he traveled to Paris and Denmark and was invigorated by the work of Picasso, Matisse, Miro, and Dubuffet. Absorbing these popular influences, Appel began developing a simplified visual language of geometric shapes and heavy outlines that depicted a combination of abstract forms, figures, and animals in solid bright colors (see figure 2).

In 1948 Appel, along with several Danish and Belgian artists, founded the international art collective, Cobra. The name signified both the venomous snake, which symbolized the group's social and political defiance, and was an acronym for the cities where the founders originated (Copenhagen, Brussels, and Amsterdam). Formed in response to the oppression that many members endured during the war, Cobra was an "expression of freedom and resistance" (Stokvis, 2004). Collectively the group sought to produce works with a vitality and immediacy that broke with the formal traditions of European painting, or as stated by Appel, "two thousand years of Europe" (van Halem, 2003 p. 36). Desiring to strip away Western rationality and achieve a more purely creative expression, the group looked to Non-western, pre-historic, folk art and the playful creative process of children for guidance and inspiration (Stokvis, 1987).

As a leader of Cobra, Appel gained public attention by showing work at group shows in Copenhagen and Amsterdam. In 1949 he was commissioned to paint a mural in the cafeteria of Amsterdam's City Hall. Drawing on his memories of starving children begging for food during the war, the painting depicted wide-eyed children with gaping mouths rendered in simple shapes and blocks of color (see figure 3). After weeks of public outcry, the mural was covered, bolstering Appel's public persona and belief in the rebellious power of his rapidly developing style (Stokvis, 1987). Seeking creative refuge, Appel moved to Paris in 1950 where he found financial support from the French art critic, curator, and collector Michel Tapie. Throughout the 50's Appel generated a significant body of work, exercising a variety of media to produce frenetic compositions of humans and animals brashly rendered in layered, bold swathes of color that would come to define his career.

Figure 3. Appel painting *Questioning Children*, Amsterdam City Hall, 1949.

1.2. Biography of André Lanskoy

Like Appel, Russian artist André Lanskoy abandoned a war torn country and fled to Paris. Lanskoy is recognized as a member of the School of Paris, a term loosely applied to international artists who flocked to the city in the early-twentieth century and furthered the development of modern and abstract art (Friedman, 1959). The son of a Russian count, André Mikhailovitch Lanskoy, was born in Moscow in 1902. At the age of 16 he moved to Kiev where he began painting and studied with the set-designer Serge Soudeikine who was known for his use of Russian folk imagery. Though Soudeikine had little technical expertise to offer about painting, he sparked in Lanskoy an interest in color and form, which would persist throughout his artistic career. His study of painting was interrupted by the outbreak of the Russian Civil War when he enlisted to fight in the anti-communist Tsarist White Army. After suffering an injury in 1921 Lanskoy left Russia and moved to Paris. In a 1956 interview with art critic Dore Ashton in *Arts Magazine*, he stated, "I began to paint the very night I arrived, and I haven't stopped since." Energized by the city and its burgeoning art scene, he studied briefly at the Académie de la Grande Chaumière, where experimentation was valued and students were discouraged from following the traditional Beaux-Arts style. Under this tutelage and inspired by the work of Van Gogh and Matisse, Lanskoy began working from direct observation of the natural world painting portraits, still-lifes, and landscapes in an expressionist style (see figure 4).

Figure 4. André Lanskoy, *Portrait of a Man with a Pipe,* c. 1921, oil on canvas.

Struggling for money, he began showing in galleries with other Russian artists in the community. In 1924 the German art critic and dealer Wilhelm Uhde saw Lanskoy's work at Galerie Vavin-Raspain and changed the course of the artist's career. Speaking in an interview about this fortuitous meeting Lanskoy recalls, "I saw a man wearing a long-overcoat with a monocle standing in front of my paintings. It was a time of misery, and I hoped it would be a client. When I went home I found that a man of the same description had come during my absence and bought a painting. It was Uhde. The next day he bought out my entire studio"

(Ashton, 1956). Uhde's support and critical approval led to exhibitions at major Paris galleries and purchases by museums and private collectors. With financial security, Lanskoy traveled around France absorbing the light and color of the southern coast into his palette and loosening his style (Maisonnier, 1959). By the late 1930s, under the heady influence of Klee and Kandinsky, Lanskoy began exploring abstraction. Although direct observation of nature remained the basis of his compositions, by the 1940's his work had become increasingly abstract and graphic as he interrogated the interactions between form and color. Unlike the brazen primary hues favored by Appel, Lanskoy's palette emphasized a subtlety of tone as he carefully balanced airy pastels with saturated bold hues. Over time, he developed a vocabulary of soft-edged, brightly colored geometric shapes where color is rhymed with form. In some compositions the shapes float light and ethereal in space laced together by loops and arcing lines. In others they cluster in a dense array dissolving the boundaries between foreground and background (see figures 5 and 6). In an interview with Jean Grenier published in a catalog of his paintings, Lanskoy describes his working process:

> "I begin by sketching in the rough outlines with a charcoal pencil or pastel, this forms the skeleton of the picture, and it is always fairly flexible. The first waves of color modify it, but don't entirely efface it. Then I develop the forms, studying the relation of one to another, particularly from the point of view of color. Sometimes I introduce new lines, black or white, consistent with the original idea, if the rhythm of the picture or the evolution of the form requires it" (1960, p. 2).

Figure 5. André Lanskoy, Untitled composition, collage and gouache.

Figure 6. André Lanskoy, *Ghost Town*, 1959, oil on canvas.

Although predominately a painter, Lanskoy translated his graphic colorful compositions to lithography, collage, mosaics, and tapestry design. He continued to produce work until his death in 1972, including 150 collages and 80 lithographs illustrating the book *Diary of a Madman* by Russian novelist Nikolai Gogol (www.arasgallery.com, 2008).

1.2. Atelier Pons

The life of French artist Jean Pons's was shaped by the production of art. Although Pons never achieved broad international acclaim for his paintings, as a master printer at his lithography studio, Atelier Pons, he collaborated with many significant artists including Picasso. Pons was born in Paris in 1913 and later studied at the Ecole Estienne, a graduate school for the arts and printing industry. With the goal of establishing his own studio, Pons worked for a commercial printer making posters and advertisements to earn money and refine his skills. In 1938, with presses set-up in a cellar, Atelier Pons opened in the left bank neighborhood of Montparnasse, an artistic hub of the city (see figure 7). Steeped in the history of the French workshops that had revived lithography as a fine art medium in the late 19th century, Pons sought to help artists again "discover the traditional technique of lithography and find a new means of expression" (www.pons-litho.com, 2007). With his desire to collaborate with artists, Atelier Pons became a silent partner in the development of modern art in Paris. Nicknamed "the cave," the studio immediately attracted local artists, such as Jean Dubuffet, Jacques Villon, and Sonia and Robert Delaunay. Several prominent Russian artists living in Paris also worked with Pons in the early years of the workshop, including Wassily Kandinsky, Nicolas de Stael and André Lanskoy (http://www.mchampetier.com). Atelier Pons gradually developed a reputation with

Figure 7. Jean Pons printing at Atelier Pons in the Montparnasse cellar,

artists beyond Paris, and the demands of the studio outgrew "the cave." In 1955 Atelier Pons moved to a larger space in neighborhood of Le Marais, on the right bank of the Seine, formerly a Jewish neighborhood and known for its historic architecture. The works produced by artists at Atelier Pons follow the movements that defined the pre and post-war eras, as representation gave way to abstraction, and then to the reactionary movements of Art Informel where the action of painting and the materiality of the medium took precedence over form. Still in operation today, and run by Pons's daughter Babette, Atelier Pons is touted as one of the last hand-press lithography workshops in Paris and remains dedicated to collaboration with contemporary artists (www.pons-litho.com, 2007).

A history of the studio on their website notes that in the years after the war, Atelier Pons "took wonderfully to the sensibilities of young artists…like the tormented expressionism of the Cobra…and the formal and chromatic exploits of Lanskoy" (www.pons-litho.com, 2007). As a permanent resident of Paris, Lanskoy produced work at Atelier Pons from its opening in 1938 until his death in 1976. While living in Paris between 1957 and 1962, Karel Appel created over 35 lithographs at Atelier Pons. Many of these works were made for the French publisher L'Oeuvre Gravée who contracted Pons to print the editions (Personal correspondence with Karel Appel Foundation, 2011). It was during this period that both *Yellow Animal* and *Mysterious Landscape* were produced.

1.3. Working Methods & Condition Issues

In an appreciation of Appel's work and long career published in *Arts Magazine*, author Alan Jones writes, "the sheer volume of Appel's work makes a statement in itself," and his "dogged insistence upon the primal radicalism of individual recalcitrance---joyous, hearty, and uncontrollable…places him at the barricades of social resistance: a problem child" (v. 65, 1991 p. 22). Jones's cheeky labeling of Appel as "a problem child" can be aptly applied to not only his brutish style, but also to the condition of the works themselves, as many of the his early mixed media and gouache paintings are now in a state of disrepair. Their unstable physical condition stems from both the artist's "joyous, hearty, and uncontrollable" use of incompatible materials, and from their subsequent exposure to poor environmental conditions in storage or on display.

In the 1940's and early 50's, having little income but a rabid need to paint, Appel used low-quality gouache, pastels, and cheap machine-made papers. His application of pigment however, was far from economical as he favored thick, heavy applications, building layers of media that he scraped, scratched, and re-worked (Van Dalen and Beentjes, 2002). Speaking about his working conditions and the techniques he employed in his early career, Appel described painting in the dark when he couldn't afford to keep the lights on in the studio,

> "I kept my gouache in jars. I knew roughly where the red, the blue, the yellow, the green, and the black all were…and I painted on cardboard...It all became virtually abstract. Then I put the light on, a candle…I finished them off my own way by covering them with an extra bit of white or by adding a red mark. If a sheet got dirty, I turned it into a red mark and then it was finished so far as I was concerned" (van Halem, 2003 p. 48).

Art by the Cobra group forms the core of the collection at the Stedelijk Museum in Schiedam, the Netherlands. The collection also includes 29 of Appel's gouaches on paper, which all date from 1948. Several works in the collection have been treated in order to stabilize flaking paint. Paper conservators Piet van Dalen and Gabrielle Beentjes published an article about the treatment of two gouaches in the book *The Broad Spectrum*. Many of the 29 gouaches were purchased by the Museum from Appel between 1955 and 1958. They write that of the 29 works "20 are so deteriorated that they can only be stored flat and any exhibition is out of the question" (p. 155). Their technical analysis of the objects found that Appel frequently combined incompatible materials, like gouache and crayon, and recycled his own works by painting on the

Figure 8. Karel Appel, *Flying Bird*, 1949, gouache. Both sides of the support art painted. Left image is the recto, right is the verso.

backs of supports or over previous compositions. A catalog of the works at the museum shows that nearly a third have compositions by the artist on both sides of the sheet (see figure 8). However, none show Appel reclaiming a support previously used by another artist, as in the case of *Yellow Animal.*

In the two works that were treated for the Stedelijk Museum, adhesion problems occurred because of the layered structure of the media. *Three Heads* (see figure 9) was painted over another composition, causing the thickly applied top layer to flake off of the under layer, while the under layer was separating from the paper support. Study of the crack pattern reveled that large open cracks in the top layer may have occurred shortly after the work was painted because the gouache contained a large amount of filler and was under-bound. Over time the cracked paint began to flake. *Figures in the Forest* (see figure 10), where Appel applied crayon over a ground of gouache, also showed a loss of adhesion between the layers due to the incompatibility of the media (van Dalen, et al, 2000). In the intervening years before the Museum moved to a building with climate control, the works were stored in attics and cellars which exacerbated cracking in the paint and dimensional changes in the support resulting in media cleavage, flaking, and loss (van Halem, 2003).

Figure 9. Karel Appel, *Three Heads,* 1948, gouache.

Figure 10. Karel Appel, *Figures in the Forest,* 1949, gouache and chalk pastel.

The severely flaking gouaches (*Three Heads* and *Figures in the Forest*) were consolidated with Methocel A-15 (low viscosity) and A4C (medium viscosity). A 2% solution of A4C in water was applied with a brush and wooden skewer to large flakes and a 0.25% solution of A-15 in water and a combination of water and ethanol was sprayed overall with an ultrasonic mister. The conservators also experimented with conditioning the art in a humidity chamber before consolidation to encourage even penetration and absorption of the adhesive (Van Dalen and Beentjes, 2002). The results varied as the methylcellulose applied overall did not fully penetrate the support and therefore did not resolve the adhesion issue between the bottom paint layer and the paper. On *Figures in the Forest,* the consolidant darkened the crayon, however, this was a desired effect since it was felt the color had lightened due to migration and loss of the binder (van Dalen, et al, 2000).

2 Project Presentation

Appel's artistic development as an international artist working in Paris echoes Lanskoy's, although the two were separated by differences in age and style. There is no evidence to suggest that the two men ever met, however they are connected historically under the broad umbrella of the School of Paris, and physically through their collaborations with Atelier Pons. Jean Pons was critical to each artist as the skills of the artist and printer are of equal importance in the lithographic process. The artist supplies the idea and the artisan brings it to fruition through technical knowledge of the medium (Knigin and Zimiles, 1974). Painters favor lithography because it perfectly translates a broad range of marks made on the stone and offers the lucrative ability to print large original editions. With the popularity of School of Paris artists in the 1950s, like Appel and Lanskoy, editions of lithographs were often made as a way to satisfy collectors who could not afford high-cost paintings (Knigin and Zimiles, 1974). Printers like Pons who strove to share the medium with artists could have worked independently or been commissioned by a large publisher, such as L'Oeuvre Gravée to print an edition.

It is without question that Appel and Lanskoy produced work at Atelier Pons during the same time period and that an active workshop would have been filled with discarded artist proofs and test prints. With Appel's penchant for using any scrap of available material to work out his compositions, it is not unprecedented that he would use a previously printed sheet, and he was known to frequently paint over or work on both sides of a support (though usually his own). Taken together, Appel's habit of recycling materials, and the stylistic similarity of the geometric composition rendered in a distinctive color palette, it is probable that the unidentified print on the back of *Yellow Animal* is by Lanskoy.

The late 1950's were a period when Appel's style was crystallizing into a visual vocabulary that would define his work for the majority of his career. During this time in Paris, Appel digested the influences of his contemporaries, like Dubuffet and members of the Cobra group, and began to emerge from the long shadows of Modernism cast by Matisse and Picasso. His vivid, layered compositions of bold gestural lines juxtaposed with blocks of pure, bright color began to achieve a tactile look that was distinctly Appel's. Stylistically *Yellow Animal* can be understood as a working sketch for later lithographs, such as *Mysterious Landscape.* The combination of printed layers mixed with gouache and crayon suggests Appel was working out a composition. Rather than continuing to develop the image through the intensive process of working the stone, he used the immediate and familiar materials of gouache and crayon to quickly clarify the image. The overall look achieved by the layering of the media and interplay of line and shape in *Yellow Animal* is accomplished in *Mysterious Landscape* through only the use of lithography. Together they represent the working process of an artist refining his style through the repetition of forms and learning to translate his visual vocabulary from painting to lithography.

2.1. Description and Condition of *Yellow Animal* (Recto)

For the collector, *Yellow Animal* is a two-for-one stroke of luck with an interesting back-story. However, for the conservator it presents a challenge of inherent-vice, with the water-based gouache cleaving from the underlying layers of waxy crayon and oil-based lithography ink. The situation is further complicated by the multiple layers of ink printed on both sides of the support, which effect how the sheet responds to airflow and changes in relative humidity, as the paper fibers are sealed and restricted by the media.

The work, executed with a combination of lithography, gouache, and crayon, depicts an animal loosely defined by swathes of bright color and heavy black lines (see plate 1). The image is made fluid and energetic by the interactions between the flat printed colors, the quick brushwork of the gouache, and the dark playful contours of the crayon. The wild presence of the animal is conveyed less by a recognizable form than the overall dynamism of the composition that chases the viewer's eye around the paper.

The basis of lithography is the inherent incompatibility of grease and water. In traditional stone-based lithography, an image is created by applying a greasy hydrophobic material to the porous, hydrophilic surface of the limestone. Limestone, which is a mixture of calcium carbonate with a small amount of silica, alumina, iron oxide, and other trace substances, is naturally alkaline. When it comes into contact with the greasy drawing materials, it reacts to form an oleomanganate of lime that provides a durable base for the printing ink that is insoluble in most solvents (Saff, 1978). The stone is then etched, often with a solution of gum Arabic and nitric acid. The solution penetrates the surface of the stone (where there is no greasy drawing material) and calcium, potassium, and magnesium salts present in the gum bond with the stone to form a tough insoluble film. The film is hygroscopic, and any part of the stone treated with the solution will repel the oil-based lithography ink (Saff 1978).

An image can be rendered on the stone through a variety of techniques, including drawing with greasy crayons or painting with a liquid called tusche. Crayons and tusche contain a mixture of wax, tallow, soap, shellac, and lampblack, in variable amounts depending on the desired consistency. Tallow and wax are acid-resistant and supply the greasy component, shellac provides hardness to the crayons, lampblack is the colorant, and soap emulsifies the mixture (Saff, 1978). Like drawing on paper, the lithographic crayons are sensitive to the surface texture of the stone, and the quality of line produced varies with the amount of hand pressure applied and the hardness of the crayon. Applying liquid tusche with a brush produces painterly effects. Different tones of washes are achieved by diluting the tusche with turpentine or distilled water. The grainy quality of crayon lines and the painterly brushwork of the tusche are preserved during etching and imparted to the paper when the stone is printed. However, despite the method of application to the stone, all printed marks sit on the surface of the support and have a distinctly flat planar quality that is indicative of lithography. When viewed under magnification, the ink often exhibits a reticulation pattern that derives from the surface grain of the stone (see figure 11). This pattern will be independent from the texture of the paper that it is printed on (Gascoigne, 2004).

In *Yellow Animal* it is difficult to determine the exact order in which the media were applied, and knowledge of Appel's freewheeling working habits would suggest that he alternated between the techniques of printing, painting, and drawing. Examination of the work revels a complex layered structure of overlapping media. The pale red, bright red, and blue colors display both a painterly and drawn quality but sit on the surface of the paper and have a flat appearance that suggests they were transferred to the sheet through printing. The marks were likely made on the stone with a combination of lithographic crayon and multiple dilutions of tusche applied with a wide brush for broad washes of color. Under magnification, these colors show a reticulation pattern in the ink that confirms they were printed rather than drawn directly on the sheet (see figure 12).

Figure 11. 40x Photomicrograph of characteristic ink reticulation pattern in a lithograph.

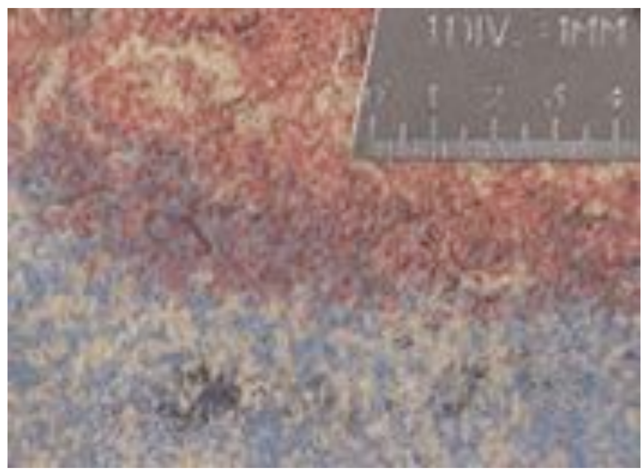

Figure 12. 40x Photomicrograph of ink reticulation pattern in *Yellow Animal*.

Green, purple, yellow, and maroon gouache was painted directly on the sheet and, as evidence of Appel's alternating process, are found both below and overlying the printed areas. Application of printing ink over the gouache seems to show no ill effect, such as where the bright red ink was printed on top of the yellow gouache. However layering gouache over the oil-based lithography ink resulted in beading of the pigment. This is clearly seen where purple gouache overlaps the blue ink and the yellow gouache overlaps the red ink and black crayon (see figure 13). Beading occurs because when applied as a wash, gouache is a colloidal dispersion of pigment particles suspended in water. The pigment particles are held in a state of suspension by surface tension and the mechanical reaction of the particles as they move and collide with each other and water molecules in the system (Cohen, 1977). As the paint dries, the pigment particles become evenly distributed on the surface of the support. However, if a wash is applied to a surface that is non-absorbent or too smooth, such as the waxy surface of the crayon or an oil-based paint film, the attraction of the colloidal dispersion to itself will be stronger than its attraction to the surface. This lack of friction will result in the pigment coalescing into droplets (Cohen, 1977).

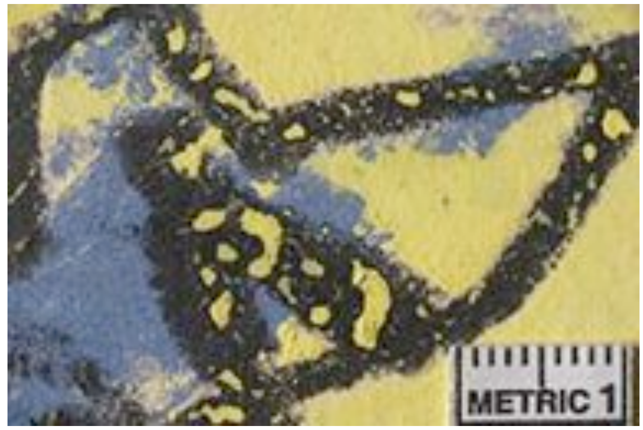

Figure 13. Detail of flaking gouache on recto of *Yellow Animal.*

The beading of the yellow paint also indicates that the black crayon lines were added to the composition just before the final layer of paint was applied. The irregular variation in thickness and tone of the black crayon confirms that it was applied directly to the sheet. However, since the work was probably produced in the lithography workshop, perhaps the crayon used was a lithographic crayon. The powdery matte appearance of the gouache overall indicates that the paint is under bound. This is particularly noticeable in the yellow gouache, which was more thickly applied and may be the result of Appel using low-quality paints that contained large amounts of filler and an insufficient quantity of binder.

The image was executed on a machine-made wove paper of moderate thickness that measures 15 x 20-3/8 inches (Perkinson and Lunning, 1996). The sheet has a slight surface texture and is slack sized with alum and rosin, which was likely applied to the pulp during manufacturing. These qualities suggest it was manufactured as an artist paper suitable for drawing or printing. The paper has no watermark, one deckled edge, and three torn edges indicating that it was cut from a larger sheet. When the work was received for conservation treatment, it was hinged with gummed paper and glassine tapes to a poor quality paper-faced mat board and was housed in a wooden frame.

The work is in poor condition overall due to the severe flaking of the gouache applied over the waxy crayon and oil-based lithography ink and crayon. In these areas the thickly applied under-bound paint is cupped, lifting, and flaking off the surface. This is due to the inability of the water-based gouache to adhere to the underlying layers of crayon and lithography ink. The flaking is most active where the yellow paint overlaps the black crayon. However there are also smaller areas throughout the composition where the maroon, green, and purple paint are also cleaving from the surface of the sheet. The cupped paint is extremely fragile and susceptible to loss. Under magnification detached flakes of paint (mostly yellow) are visible scattered around the surface of the image. Though the paint is beaded where it overlaps the oil-based lithography ink, there is less flaking because the application tends to be a thinner wash of color.

Dull washed-out areas in the center of the sheet that appear blotchy and pinkish may indicate that some media has been lost or faded. There are passages of maroon gouache throughout the image and some occur in conjunction with the same pinkish color. Poor quality gouache paints, especially those made from organic pigments or dyes are prone to fading. Because the work has received many hours of direct sunlight it is likely that any sensitive pigments would display loss of colorant. The maroon paint film is also extremely brittle, making it vulnerable to flaking, especially if the support was flexed or distorted during handling or expansion and contraction from changes in temperature and humidity.

The paper is mechanically stable but has darkened in color from medium cream to dark beige. This shift is attributable to light exposure while on display in a private residence and prolonged contact with acidic mat and framing materials. In simplified terms, paper discoloration is caused by both internal and external sources and derives from the creation of organic molecules that absorb visible light. With internal sources, poor quality components within the pulp, such as lignin, can degrade the cellulose chains (Banik and Bruckle, 2011). Darkening occurs as light catalyzes the breakdown of the cellulose and causes internal chemical residues found in some paper, such as alum that is added to the pulp during processing, to corrode (Ellis, 1987). Externally, discoloration can result from exposure to acidic matting materials. Protected areas in the top left and right corners, where paper tapes adhered to the back shielded the support from the acidic mat board and prevented darkening are evidence of the discoloration (see plate 3).

The extent of this discoloration is most visible when the work is viewed with near ultraviolet radiation (see plate 4). On the front, small reddish-brown foxing stains are concentrated along the edges of the sheet and may be the result of impurities in the pulp or indicate mold growth activated by exposure to a hot humid environment. Undulations in the sheet were also likely caused by the expansion and contraction of the paper in response to humidity while it was adhered to the mat board (see plate 5).

2.2. Description and Condition of Unsigned Print (Verso)

The print on the back of *Yellow Animal* is an unsigned 6-color lithograph (see plate 2). Exposed paper tone in non-printed areas creates a seventh color. The print depicts soft-edged geometric shapes on a solid plane of bluish-green. As in other published abstract works by Lanskoy, elongated triangles, arcs, and lines populate the composition. The palette mixes bright warm tones with rich dark colors. Pink, yellow and orange shapes appear to emerge from the background while dark burgundy and black shapes recede. White areas of un-printed paper create visual tension by disrupting the relationship between positive and negative space.

The diffuse edges of the shapes suggest the artist composed the image by painting on the stones with tusche. The placement of the shapes on the background was defined by painting tusche around them on the stone, so when the first layer was printed, they would be left open. This requires that all subsequent layers be properly registered so the inks print over the exposed paper rather than on the green background. In several areas the pink and yellow inks appear uneven where they overlap the background instead of plain paper. Some unprinted shapes are also streaked with droplets of green ink. This may indicate that when the first layer was drafted on the stone open areas meant to repel the ink picked up grease, which caused them to print. The opaque underlying layer of green caused the translucent pink and yellow inks to appear splotchy (figure 14).

Figure 14. Detail of the unsigned print on the verso of *Yellow Animal.*

The pink and black shapes appear slightly misaligned and show slivers of white along the edges. However, this may have been intentional or indicates that perfect registration was not required.

The image conveys a sense of being unfinished or "in-process." The unprinted areas in the composition contribute to this feeling. It is probable that the image is a proof made before all the colors had been printed. However, other lithographs made by Lanskoy at Atelier Pons also have a loose quality and contain white shapes that resemble those in the unidentified print (see figure 15). Lanskoy was known to sign his prints, however the only writing on the sheet relates to collection marks and numbers for *Yellow Animal.* While making attribution more difficult, the lack of Lanskoy's signature supports the notion that the print is an unfinished working proof. As such, it might have been abandoned in the workshop, relegated to a scrap pile for re-use.

Figure 15. André Lanskoy, untitled lithographs printed at Atelier Pons (dates not known).

The media is in good condition, but the print is soiled overall. A layer of is dark grime and blue pencil marks mar the composition. The image is much smaller than the sheet and is surrounded by a 2-1/2 to 3 inch border that is smudged with printing ink and grime. Despite not receiving direct light exposure, like the font, the support has darkened overall. This is likely due to close prolonged contact with the poor quality acidic mat board. The creases and handling dents noted in the previous section are also visible on this side of the support. Fragments of glassine and gummed paper tape hinges are adhered in the corners and along the edges of the support. There is adhesive residue in one corner of the sheet. The paper is also skinned in the corners where hinges were previously removed.

2.3. Description and Condition of *Mysterious Landscape*

Mysterious Landscape is a 9-color lithograph printed on a 19-1/8 x 24-3/4 inch sheet of Johannot paper (see plate 10). It is hand numbered "37/120," and a blind stamp on the front indicates it was published by L'Oeuvre Gravée (see figure 16). Though the title alludes to a landscape, the composition is an abstract swirling mass of amorphous shapes and scribbled lines with no discernable foreground, background, or horizon line. As in *Yellow Animal,* painterly strokes of pure bright colors are overlapped, loosely outlined, and knitted together with gestural drawn lines. Yet, the use of a single medium that is uniformly planar lends the composition a resolved formal quality that *Yellow Animal* lacks.

Figure 16. Detail of publisher's blind stamp on recto of *Mysterious Landscape.*

Like *Yellow Animal*, the image was composed on the stone with a combination of liquid tusche and crayon creating both painterly and drawn effects. To produce a multi-color lithograph, a different stone is used to print each color. Often a master drawing is made and used to transfer each color found in the image to separate stones (Hughs and Vernon-Morris, 2008). Because the image is constructed by building up the individual layers of ink, the order in which the colors are printed must be taken into consideration. Generally the lightest color is printed first, such as the tan ink in *Mysterious Landscape.* Variation in the opacity of the inks allows additional colors to be made by overlapping areas. In *Mysterious Landscape* purple is achieved by printing a translucent blue over an opaque red.

Lithography inks are primarily composed of pigment and medium, typically linseed oil, which are ground together into a smooth paste that can be evenly dispersed on the roller (Cumming, 1946). In addition to holding the pigment particles and forming the paint film, linseed oil gives inks an inherent gloss. Building up multiple layers of ink increases glossiness. This effect is visible in *Mysterious Landscape* where single layers of color appear more matte than areas with multiple layers of printing. The differential gloss in the image is most noticeable when the print is viewed in oblique specular light (see figure 17). Gloss can also be increased by adding extra medium to the ink or printing a separate layer of varnish over a color. Lithography inks are described in terms of length and tack. Length refers to its elasticity and whether it will stretch out in a long string when pulled away from a surface. Tack refers to the stickiness and how it will transfer from the stone to the paper (Saff, 1976). Printing large solid areas of color, like those in *Mysterious Landscape,* requires a heavy deposit of ink that is short and tacky.

Figure 17. Karel Appel, *Mysterious Landscape,* oblique specular illumination, before treatment.

Mysterious Landscape is printed on a mould made, wove, medium weight, lightly textured sheet of Johannot paper (Perkinson and Lunning, 1996). Johannot was a French manufacturer located in Fayas that produced artist papers for printing and drawing. In 1956 the four leading French mills that produced high-quality artist papers, Arches, Johannot, Marais, and Rives merged forming the group ARJOMARI. Although Johannot paper continued to be produced after this merger, their watermark was discontinued until 1980 (Walsh, 2001). The presence of the Johannot watermark (see fig. 18) indicates that the sheet was several years old when the lithograph was made. The sheet is hard sized, likely with an internal sizing applied when the sheet was manufactured.
The print is structurally in good condition. The lithography ink is stable and most colors remain vibrant and saturated. Only the yellow ink appears slightly dull, which may indicate fading and loss of colorant. The print is marred by severe overall darkening and water stains along the left edge. The extent of the discoloration is indicated by two areas on the front of the print where the

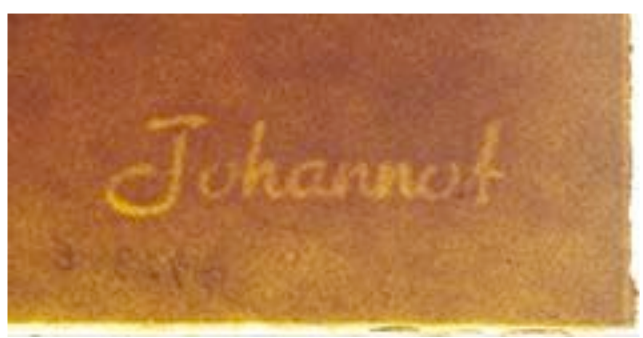

Figure 18. Detail of Johannot watermark on *Mysterious Landscape.*

paper was protected by linen tape hinges adhered to the back. The original paper color was likely a warm cream and has darkened to beige. Because the print is privately owned and was permanently displayed, it has received many hours of direct sunlight.

Paper is susceptible to acid hydrolysis or oxidative degradation reactions that can break the cellulose chains causing loss of strength and producing colored compounds that discolor the sheet. These reactions can be induced by light exposure, which cause photochemical reactions. Darkening can also result from close contact with poor quality acidic framing materials. Colored compounds in acidic materials, such as a mat board, can migrate to adjacent areas. They move as volatile gases in the air between the materials or are transferred by direct contact through water diffusion. Environmental conditions such as high temperature or humidity increases the likelihood of this transfer (Banik and Brukle, 2011). Because the overall darkening of the sheet occurs slowly over time it can go unnoticed for many years. However, the discoloration significantly alters the contrast between the paper tone and the media. In *Mysterious Landscape,* the paper has darkened to a color that is similar to the base layer of tan ink, causing that color to recede into the sheet. The beige color of the paper also reduces the saturation of the yellow and gives it a green pallor. Based on Appel's body of work, it can be assumed that all the colors were meant to be vibrant and the darkening of the sheet disturbs the artist's intent for the composition.

The print has been damaged by water resulting in brown tide-line stains along the left edge of the sheet. Tide-lines may form when water invades the cellulose matrix of the paper, causing soluble acids and degradation products to migrate and be re-deposited in the sheet. As capillary action draws the water through the cellulose, stains form at the interface between the wet and dry portions of the sheet. Recent study of tide-lines has also shown that chemical reactions, including peroxide formation and oxidation at the wet-dry interface that may be initiated by stress of localized, differential swelling of the fibers.[2] Fortunately the water that invaded *Mysterious Landscape* did not reach the medium, but the presence of the dark tide-lines in the blank margin of the sheet distract the viewer's eye from the image (see figure 19).

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[2] Based on tide-line research done by Elmer Eusman at the Library of Congress.

The movement of soluble components in the sheet and the formation of local degradation products at tide-lines often produce fluorescence that is visible in ultraviolet radiation (Banik and Brukle, 2011). Plate 11 shows the bright tide-line stains that are visible when the print is viewed under
UV-A radiation.

Figure 19. Detail of tide-line stains on *Mysterious Landscape.*

The lithographic printing process often imparts distinctive characteristics to the support. On the front of the print, the surface texture of the paper is smoother and slightly burnished where it was compressed against the stone during printing (see figure 20). Because the paper was larger than the stones it was printed from, there are draws in the center and corners where it was stretched over and distorted by the stone during printing. These draws in the sheet are not apparent when viewing the front of the print under normal lighting conditions but are very pronounced when the back is viewed with a raking light (see plate 12). These artifacts of the printing process are generally considered to be part of the artwork and effort is made to retain them during treatment.

Figure 20. Detail of burnished and unburnished paper texture on *Mysterious Landscape.*

2.4. Comparison with works in Albright-Knox Art Gallery Collection

Three works in the collection of the Albright Knox Art Gallery were examined to compare the materials, techniques, and condition with *Yellow Animal* and *Mysterious Landscape.* The two gouaches date from the early 1950's, placing them between the works at the Stedelijk Museum (1948), and *Yellow Animal* (1958). A print made in 1960, the year after *Mysterious Landscape,* shows Appel's continued exploration of lithography. The works also represent three media types: gouache, mixed (gouache and crayon), and lithography. Examination of the individual types helped clarify and confirm how condition issues seen in other works relate to a specific medium. Further, all three pieces were in good condition, and despite employing the same media, did not exhibit the mechanical and aesthetic issues that affect the other discussed works.

Executed in 1950, *Man and Beast* (K1963:8) combines gouache and crayon and depicts two large heads rendered in bold black lines and broad strokes of paint (see figure 21). It is on a mould-made wove, thick, slightly textured, dark cream-colored sheet of Canson and Montgolfier paper (Perkinson and Lunning, 1996). Like in *Yellow Animal* and the works treated at the Stedelijk Museum, gouache was freely applied over the crayon. Predictably, the paint beaded on the waxy surface. Under magnification, the paint beads are cracked and slightly cupped, however they are not loose or cleaving from the surface (see figure 22). This indicates that flaking is activated when the sheet and media undergo cycles of expansion and contraction that are induced by environmental fluctuations.

Figure 21. Karel Appel, *Man and Beast,* 1959, gouache and crayon.

Figure 22. Detail of beaded gouache over crayon on *Man and Beast.*

The 1951 composition *The Cat* (1974:8.1) was produced using only gouache (see figure 23). The painting occupies the entire sheet and was executed on a machine-made wove, thick, slightly textured, dark cream-colored sheet of paper (Perkinson and Lunning, 1996). No watermark is visible. The gouache was thickly applied and was built up in layers. The Stedelijk Museum has also noted cracking and flaking in works that only contain gouache. In these instances, adhesion issues stemmed from Appel's use of cheap under bound gouache, application of paint over a thick layer that had not fully dried, or repurposing a support with an already cracked paint film (van Dalen, 2003). Though *The Cat* has passages of thickly applied and layered paint, the gouache is stable and does not exhibit cracking.

Figure 23. Karel Appel, *The Cat,* 1951, gouache.

The painterly lithograph *Personage* (P1999:6:10) made in 1960 shows Appel's foray into action painting and Art Informel, the European equivalent of Abstract Expressionism (see figure 24). The composition is loose and conveys a greater confidence in and understanding of the lithographic medium than *Mysterious Landscape.* The work was printed on a mould-made wove, moderately thick, slightly textured, sheet of Rives BFK paper (Perkinson and Lunning, 1996). There is a BFK waster mark in the lower right corner. The sheet has darkened from light and is beige in exposed areas and dark cream colored along the edges where the paper was protected by a window mat. Similar to

Figure 24. Karel Appel, *Personage,* 1960, lithograph.

Mysterious Landscape, the base layers of printing ink are light shades of tan and gray. However, the paper discoloration is less severe and doesn't overwhelm the lighter ink colors. This suggests that the work has been stored in more stable conditions and has had less overall light exposure. The print was also made in an edition published by L'Oeuvre Gravee as indicated by the blind stamp in the lower left corner. Based on the time period and publisher, it is likely that *Personage* was also printed at Atelier Pons.

Appel's technique and working methods were fraught with inherent vice. Contrasting works made in the same decade with similar materials and potential for damage but now display vastly different physical conditions illustrates the critical relationship between storage environment and the stability of art. The works in the Stedelijk Museum, housed in attics and cellars for years, were subjected to extreme fluctuations of temperature and humidity. Displayed in a private residence, *Yellow Animal* and *Mysterious Landscape* exhibit damage incurred from years of unregulated climate conditions and prolonged light exposure. The pieces in the Albright Knox are fortunate examples of Appel's work and provide insight into how environmental conditions induce damage, particularly in works with unstable combinations of materials.

3 Materials and Analysis

Analysis was performed on *Yellow Animal* and *Mysterious Landscape* in order to identify characteristics of the papers and media that were used in their manufacture. Understanding the individual components of the art works, such as the type of sizing on the paper or the pigment, used aids in making informed decisions about the course of treatment. The stability of the object limits and determines what types of scientific analysis can be performed. A combination of analytical techniques were used on *Yellow Animal* and *Mysterious Landscape* to identify organic and inorganic compounds in the materials: microchemical testing, Fourier transformed infrared spectroscopy (FTIR), and x-ray fluorescence spectroscopy (XRF). Additionally, microfade testing was performed on *Mysterious Landscape* to determine the stability of the colored printing ink when exposed to light.

3.1 Method of Analysis and Instrumentation

Microchemical tests are a simple cost-effective way to characterize the composition of a material, and can be coupled with other more advanced analytical tools. Following the procedures outlined in *Material Characterization Tests for Objects of Art and Archeology* by Nancy Odegaard, Scott Carrol, and Werner Zimmt (2000), five spot tests were performed on the fibers from the papers. The tests for aluminum ions and rosin were performed to determine if either sheet had an alum-rosin size. Tests for protein and starch were also performed to see if either sheet had been sized with gelatin or starch. A test for lignin was done to determine if poor quality fibers contributed to the overall discoloration of the papers.

Fourier Transform Infrared Spectroscopy (FTIR) uses infrared radiation to excite organic molecules in order to produce translational, rotational, and vibrational motion. The energy required to excite molecules and produce these movements are characteristic of specific organic compounds and relate to atomic structure. The measurement of characteristic energy and motion produces a spectrum. The spectrum reflects a molecule's freedom of motion, functional groups, and vibrational energy detectable by IR. Because functional groups, such as O-H or C=O produce absorptions around the same frequency despite the rest of the molecule, their presence can be identified in an IR spectrum (Derrick, Stulik, and Landry, 1999). Determining the composition of an unknown material through the analysis of spectra and identification of characteristic peaks is aided by comparison with published library spectra of common artist materials and compounds. The technique is semi-destructive for works of art on paper because, when done in situ, it can leave a small burnished impression on the sheet or requires a small sample for analysis.

X-ray fluorescence spectroscopy is a non-destructive analytical technique that is used to detect inorganic elements in a material. When a material is exposed to high energy x-rays, atoms within the material become excited and eject one or more electrons from the inner orbitals. The removal of inner electrons makes the atom very unstable, so electrons in higher orbitals must fall into lower orbitals to fill the gaps. This process of excitation emits fluorescent radiation, which has an energy that is characteristic of the atoms present in the material. The characteristic radiations are sorted by a detector and the intensities are related to the amount of each element in a material, producing a spectra that can be visually analyzed. Spectral interpretation was performed using the Artax Control software.

The papers and media on both works were analyzed *in situ* with XRF. Destructive tests, such as microchemical, were performed on small samples removed from the art works. In *Yellow Animal,* samples of the gouache and black crayon were collected from loose flakes on the surface of the art or small samples (1 x 1 mm) were removed mechanically. To minimize the amount of sample needed, FTIR analysis was performed with a Continuum microscope coupled to a Nicolet 6700 FTIR spectrometer (Thermo Scientific). Samples were prepared by flattening them in a diamond compression cell (Thermo Spectra Tech), and analyzing the thin film in transmission mode on the bottom diamond window (2 mm x 2 mm surface area).[3] Paper samples were removed mechanically from the edges of the sheets by teasing out individual fibers at several locations with tweezers under low magnification. No samples of the lithography inks were taken from either work because it was felt that disrupting the smooth thin paint film would result in visible damage.

3.2. Paper Analysis

The papers used for both works were analyzed with microchemical testing and attenuated total reflection (iTR ATR) FTIR spectroscopy on a Nicolet 6700 FTIR spectrometer (Thermo Scientific) with a Thermo Scientific Smart iTR ATR accessory. Tests were preformed in order to characterize the fiber content and identify the type of sizing to better understand the condition of the papers and their responsiveness to treatment.

Through microchemical testing it was determined that neither sheet contains lignin. Because lignin tends to darken from light exposure, its presence would have prevented light-bleaching treatments. *Yellow Animal* was found to contain alum. Analysis of the paper with FTIR produced peaks that may correspond to rosin. The spectrum also indicated that the paper contains a wax (see figure 25). The methylene stretches characteristic of wax are clearly pronounced in the paper spectrum at 2917 and 2849 cm^{-1}.

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[3] See appendix for additional information on equipment settings and testing procedures.

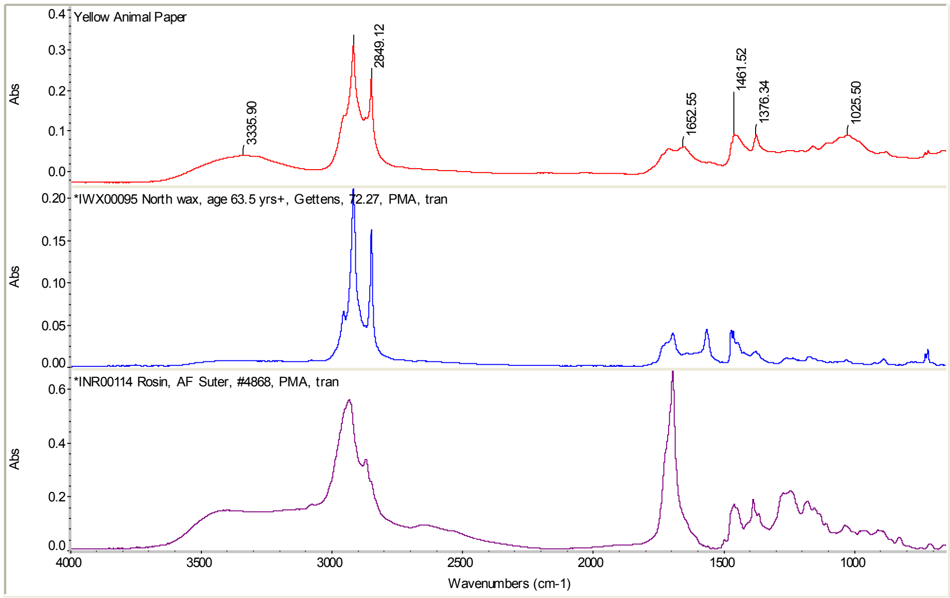

Figure 25. FTIR spectrum of *Yellow Animal* paper compared with library spectra of wax and rosin.

The *Paper Conservation Catalog* notes that as a sizing, rosin was sometimes delivered in modified forms such as rosin wax (Henry, 1988). The presence of aluminum ions in the paper was detected with both microchemical testing and XRF analysis. Together this suggests that the paper was internally sized with alum and rosin when it was manufactured. Alum-rosin size was introduced in Europe in 1835 as was used to prevent ink feathering on writing papers. Alum-rosin was typically an internal rather than surface size, and was added to the pulp during manufacture. In the size, large aluminum rosinate aggregates are anchored to the fiber by interactions between the alumina and the hydroxyl groups on the cellulose chains. Rosin is derived from wood or exudates of pine trees. Alum-rosin size is highly acidic and causes deterioration of the cellulose, which can result in discoloration and loss of mechanical strength in the sheet (Henry, 1988).

The paper on *Mysterious Landscape* was also analyzed in an attempt to identify the sizing agent, but the tests were not conclusive. Microchemical tests did not detect the presence of alum, rosin, or gelatin in the sheet, which are the most common types of size used on artist papers in the mid-twentieth century. Because the microchemical test for protein gave an ambiguous result, FTIR was also performed. Proteins form a recognizable pattern of absorption peaks characterized by amide I, II, and III bands near 1650, 1550, and 1450 cm^{-1} in a stair-step pattern (Derrick, Stulik, and Landry, 1999). However, these bands are clearly absent in the paper spectrum indicating the sheet was not sized with gelatin. The spectrum, which closely resembles flax fiber, shows no sizing agent responsive to FTIR, despite the fact that the sheet has clearly been hard-sized (see figure 26).

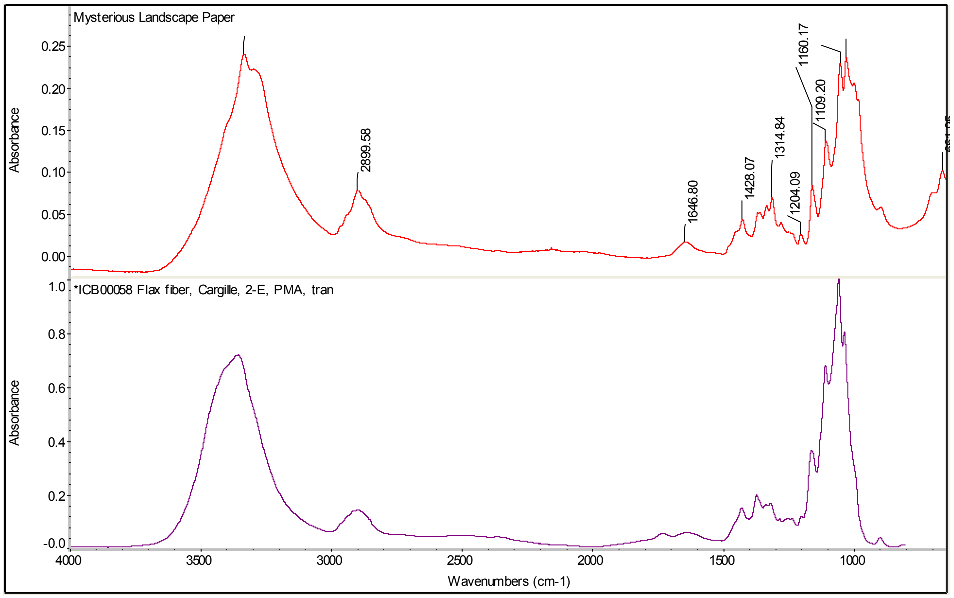

Figure 26. FTIR spectra of *Mysterious Landscape* paper fibers compared to a library spectrum of flax fiber.

3.3. Media Analysis

Results of the media analysis performed on *Yellow Animal* are summarized in table 1. XRF and FTIR confirmed that the work was executed with an unstable combination of underbound gouache, lithography ink, and lithography crayon. FTIR detected very little gum binder in the gouache paints. Gums are long-chin polymers of sugars (polysacchrides) that have a high proportion of O-H groups bound to the carbons. In the spectrum, gums show strong broad bands of equal intensity at 3300 cm^{-1} due to the O-H groups and 1080 cm^{-1} from the C-O bond. C-H stretches around 2900 cm^{-1} tend to be weak and unresolved (Derrick, Stulik, and Landry, 1999). In the spectra of the gouaches, these characteristic peaks are very small and less defined indicating that the gum is only present in trace amounts (see appendix 2.1). This confirms that the flaking and cleavage is partially due to the under bound quality of the paint. The spectra also showed no characteristic peaks for linseed oil, like those found in the gouache samples tested by the Stedelijk Museum. Linseed oil produces a sharp, strong carbonyl band at 1750-1740 cm^{-1}, which is clearly absent in the gouache spectra. This indicates that Appel was not altering the gouache with extra binder, or introducing oil by accidental means from dirty brushes or palettes.

The gouache spectra are dominated by strong peaks around 1400 cm^{-1} or 1100 cm^{-1} that correspond to calcium carbonate and barium sulfate. Gouache is a mixture of ground pigment (slightly coarser than watercolor), binder (usually gum Arabic), and inert filler, such as precipitated calcium carbonate or barium sulfate that renders the colors opaque. Zinc or titanium whites may also be added to bring out undertones in deeper colors (Mayer, 1991). Comparison of the three colors shows that the yellow gouache contains significant amounts of calcium while the green and purple paints contain large amounts of barium sulfate. These findings were reinforced by the XRF spectra of the paints.

Table 1. Results of XRF, FTIR, and microchemical testing on *Yellow Animal.*

Results of Analytical Testing on Yellow Animal Media					
	Pigment	Filler/ extender	Binder	Drier	Other Additives
Yellow gouache	Cadmium Yellow ($Cd(Zn)S$) + Titanium White (TiO_2)	Calcium carbonate ($CaCO_3$)	Extremely underbound (likely gum arabic)	-	-
Purple gouache	Synthetic organic pigment. Contains: Zn, S, and P.	Barium sulfate ($BaSO_4$)	Extremely underbound (likely gum arabic)	-	-
Green Gouache	Chrome Green ($PbCrO_4 \bullet Fe_4[Fe(CN)_6]_3$) Contains: Zn (possibly from zinc white)	Barium sulfate ($BaSO_4$)	Extremely underbound (likely gum arabic)	-	-
Maroon Gouache	Possibly an earth pigment mixed with a synthetic organic pigment. Contains: Zn, Fe, Sr, K	Barium sulfate ($BaSO_4$)	Extremely underbound (likely gum arabic)	-	-
Red Ink	Possibly a mixture of a synthetic organic pigment and titanium white. Contains: Ti, S, Al, Ca, Fe, Zn	-	Likely linseed oil	Pb	-
Blue Ink	Synthetic Ultramarine ($Na_{8-10}Al_6Si_6O_{24}S_{2-4}$) + Titanium White ($TiO_2$)	-	Likely linseed oil	Pb	-
Black Crayon	Lampblack Contains: S, Ca, Fe, Zn	Wax	Stearic acid/ tallow	-	Resin (shellac)

The spectra for the black crayon represents a complex mixture of materials including wax, resin, stearic acid, and an organic pigment. Waxes are long-chain hydrocarbons, and the multiple methylene groups show characteristic stretches around 2926 and 2850 cm^{-1}. The weak C=O stretching band at 1736 cm^{-1} and the C-0 bands around 1165 cm^{-1} are due to the ester groups. Stearic acid is a saturated fatty acid found in vegetable and animal fats and oils. In the spectrum, aliphatic C-H bonds create characteristic bands visible around 1464 and 1379 cm^{-1} (Derrick, Stulik, and Landry, 1999). The composition of the black crayon is consistent with a lithography crayon, which typically contains wax, soap, resin, tallow, and lampblack pigment.[4] Comparison of the black crayon's spectrum with a contemporary Korn's brand lithographic crayon indicates that they are of similar composition (see figure 27). This suggests that the black crayon used in drawing was a lithographic crayon, and supports the theory that the work was made while Appel was working at Atelier Pons. The red and blue lithography inks were not analyzed with FTIR because they cannot be easily sampled, and in situ testing would damage the print.

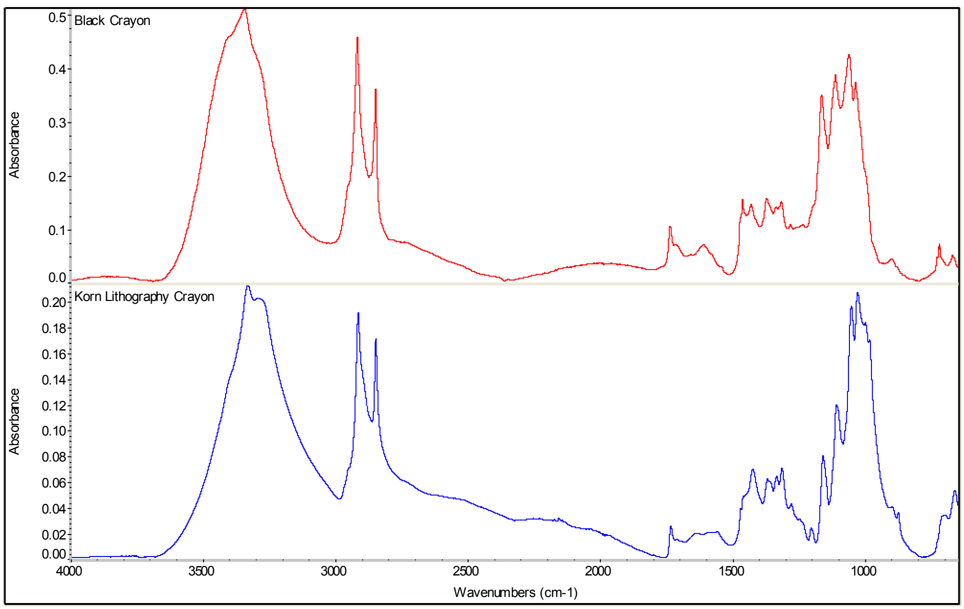

Figure 27. FTIR spectra of the black crayon on *Yellow Animal* compared to a library spectrum of Korn brand lithography crayon.

Mysterious Landscape was analyzed with XRF to identify pigments and components in the inks. This was done in order to help assemble an understanding of Appel's palette and whether the inks were consistent with those listed in lithography and printing industry literature from the

4 See appendix 3 for the complete spectra.

mid-nineteenth century. Results of media analysis are summarized in Table 2. Though the presence of heat-bodied linseed oil was not confirmed through analysis, literature suggests that it was most commonly used as the vehicle for inks in the 1950's (Hartsuch, 1961). All the colors analyzed contained lead, which would have been added as a metallic soap to the oil-based inks as a drier to increase the rate of oxidation. The amount of lead added depended on the pigment. The variable amounts of lead seen in the spectra of the inks corresponds to print industry literature, which states that inks containing lead, such as Chrome yellow, need little extra drier while red lake pigments often require much more. Like in gouache paints, inert pigments such as barium sulfate or titanium dioxide can be added to lithography inks as extenders to improve the working quality of the paint, or as a filler to increase opacity (Wolfe, 1967). These compounds were also found in nearly all of the inks. The print was found to contain Prussian blue, synthetic ultramarine, chrome yellow and orange, synthetic organic red lake pigments, and titanium white. Chrome yellows and oranges were frequently used by lithographic printers because they were easily manufactured, readily available, and produced dense, opaque, bright colors with good permanence (Cumming, 1946). Period literature notes that titanium pigments are among the best for white inks due to the exceptionally small particle size and high oil absorption, which produces a dense ink film (Wolfe, 1967).

Comparison of the XRF spectra of the red and blue lithography inks used in *Yellow Animal* shows that they are chemically similar to those in *Mysterious Landscape.* In both works the blue was identified as synthetic ultramarine and the red as a synthetic organic dye. Though these are both common printing inks, it also suggests a consistency of materials use at Atelier Pons.

Table 2. Results of XRF, FTIR, and microchemical testing on *Mysterious Landscape*

Results of Analytical Testing on Mysterious Landscape Lithography Inks			
	Pigment	**Binder**	**Drier**
Dark Blue	Prussian Blue ($KFe[Fe(CN)_6]_3 \cdot xH_20$) Contains: Fe, K, Ca, Zn	Likely linseed oil	Pb
Blue	Synthetic Ultramarine ($Na_{810}Al_6Si_6O_{24}S_{2\text{-}4}$) + Titanium Dioxide ($TiO_2$) Contains: Ti, Si, S, Zn	Likely linseed oil	Pb
Light Blue	Synthetic Ultramarine ($Na_{810}Al_6Si_6O_{24}S_{2\text{-}4}$) + Titanium Dioxide ($TiO_2$) Contains: Pb, Ca, Ba, Ti, and Si	Likely linseed oil	Pb
Green	Possibly a mixture of Chrome yellow ($PbCrO_4$) + Monastral Blue ($C_{32}H_{16}N_8Cu$) Contains: Cr, Cu, and Ca	Likely linseed oil	Pb
Red	Synthetic organic pigment Contains: Ca, Ba, Ti, and Pb	Likely linseed oil	Pb
Pink	Synthetic organic pigment Contains: S, Zn, Pb, Ba, and Ti	Likely linseed oil	Pb
Orange	Chrome Orange Contains: Cr, Zn, Pb, Ca, Ba, and Ti	Likely linseed oil	Pb
Yellow	Chrome Yellow ($PbCrO_4$) + Titanium Dioxide (TiO_2) Contains: Cr, Pb, Zn, and Ba,	Likely linseed oil	Pb
Tan/Gray	Possibly Sienna + Barium Sulfate ($BaSO_4$) Contains: Ba, Ti, Ca, and Zn	Likely linseed oil	Pb

3.4. Microfade Testing for Lightfastness of Pigments

Before light bleaching the front of *Mysterious Landscape*, microfade testing was performed on the pink lithography ink to determine if it could withstand treatment. Microfade testing was developed by Dr. Paul Whitmore, director of the Research Center on the Materials of the Artist and Conservator at Carnegie Mellon University, and allows for direct assessment of the light stability of media on a work of art. In testing, the material is exposed to a small beam (less than 0.4 mm in diameter) of visible light (400-700 nm). A fiber-optic spectrophotometer collects reflected light at a 45° angle to the beam and produces reflectance spectra at set time intervals (Whitmore, P.M., Xun Pan, and Catherine Bailie, 1999). The overall color change (ΔE) is calculated from the collected data using the CIE 1976 L*a* b* equation. The test is generally run until $\Delta E= 5$, indicating that a "just noticeable" color change has been reached. Though testing is destructive and results in a faded spot on the artwork, it is considered acceptable because the spot size and amount of fading is so small that it cannot be seen with the naked eye under normal viewing conditions.

To correlate the fading rate of a material blue wool standards are analyzed in addition to the object. The blue wool system was developed by the International Standards Organization (ISO) and consists of 8 dyed wool bands, which fade at characteristic rates with 1 being the most fugitive and 8 the most stable. Each blue dye requires about 2-3 times longer to fade than the previous band (Rogge, 2012). The pink lithography ink was suspected to be fugitive because it was thought to contain a synthetic red dye, which can be prone to fading upon light exposure. To approximate this light sensitivity, blue wools 1-3 were run as standards.

Testing was performed with an Oriel microfade tester, which uses a 75-watt xenon arc lamp as a light source and is focused onto the sample using a silica optical fiber. A pen camera was used to ensure that the light was focused on the correct spot and to aid in proper focusing of the beam. The blue wool standards were each measured twice in different locations. The pink ink was measured seven times in two areas of the print, in a different location each time to avoid fading the same spot twice. Areas were selected where the pink ink was applied in a consistent layer and did not overlap any other colors. Fading rates of the pink ink during the seven trials varied significantly. Of the seven trails performed, four showed rates of fading much faster than blue wool 1. These results are shown in figure 28. The remaining three trials varied between fading at a rate similar to blue wool 1 and displaying better lightfastness similar to blue wool 3. This extreme variation suggested that the pigment was not homogenous and had differential sensitivities to light exposure. Based on these results, it was determined that the brightly colored inks could be damaged during light bleaching and the areas would have to be masked for treatment.

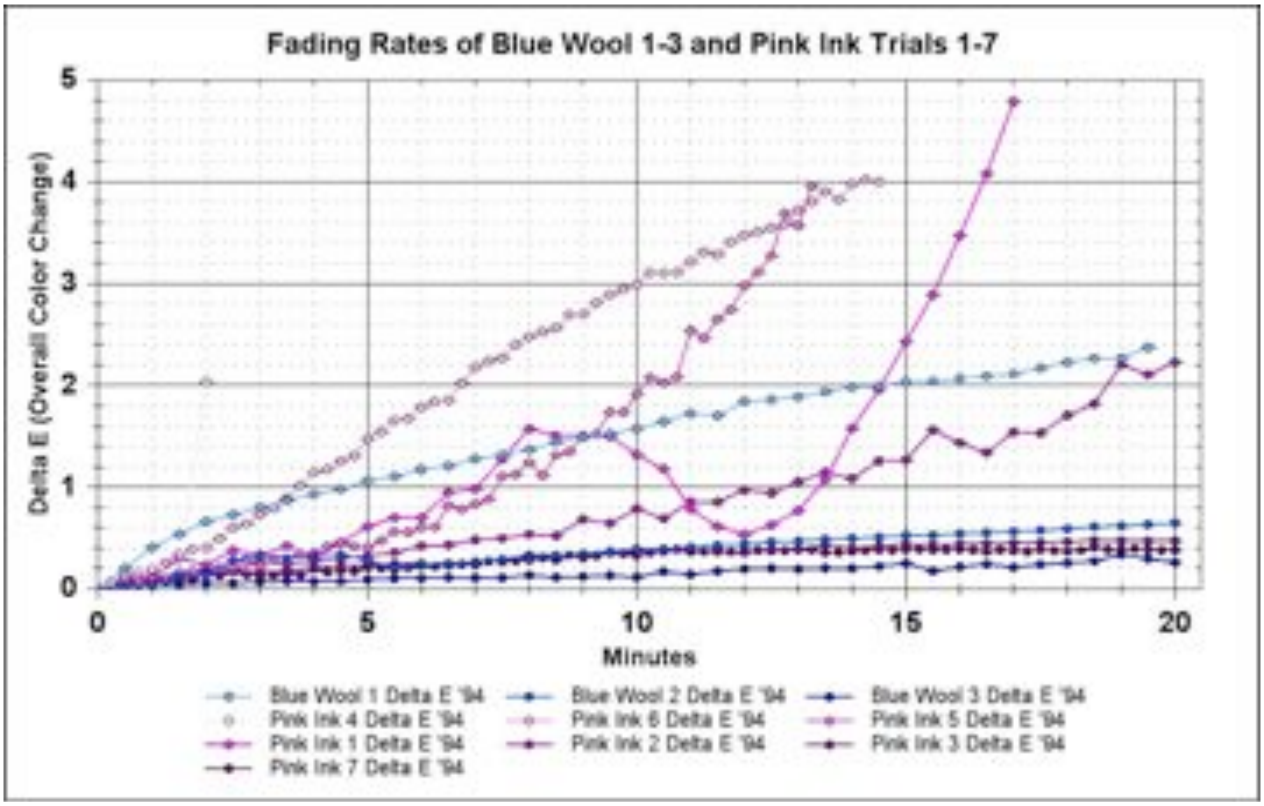

Figure 28. Results of microfade testing of the pink ink on *Mysterious Landscape* compared to blue wool standards 1-3.

4 Conservation Treatment

The course of treatment chosen for a work of art is guided by the object's physical condition and intended function or use. As works of fine art, *Yellow Animal* and *Mysterious Landscape* are primarily aesthetic objects. Like many fine art objects, they are constrained by a paradox of ephemerality as they must be seen to be experienced and fully appreciated, but it is the conditions of display that often induce deterioration. The physical conditions of *Yellow Animal* and *Mysterious Landscape* reflect years of beloved constant use, displayed without rotation or environmental monitoring in a private residence. The varied conditions of the two works necessitated different treatment approaches, but the overall goal was to reduce signs of wear and improve the frame packages to minimize damage and better facilitate continuous display. The treatment of *Yellow Animal* focused on the physical stabilization of the flaking gouache by improving the adhesion between the layers of media. This was a preservation intervention made in order to prevent further loss and strengthen the media, an essential component of the art. In contrast, *Mysterious Landscape* reflects a restoration approach as the treatment addressed only aesthetic issues of staining and discoloration. Because the works are functional objects, they will likely be returned to the same environmental conditions, and the treatments performed are temporary interventions into the reciprocal cycle of display, aging, and deterioration.

4.1. *Yellow Animal*

The primary conditions issues with *Yellow Animal* stem from Appel's application of water-based media over wax and oil based media. The gouache paint is not able to form sufficient bonds with underlying waxy/oily layers and is merely sitting on the surface, making it vulnerable to loss. In the paint industry, the concentration of binder and pigment in a coating is described in terms of volume and is called the "pigment volume concentration (PVC)." Matte paints have a high PVC, which results in voids between the pigment particles that causes the film to be weaker and appear lighter in color (Hansen and Lowinger, 1990). Because the gouache has very little binder (high PVC), there is inherent vice in both the cohesion of pigment particles to each other and adhesion to the wax and oil coated support. This is particularly noticeable in thickly applied passages of yellow where the paint appears very matte and has a dry, crumbly texture. Successful treatment of the print requires that both the cohesion of the paint with itself and adhesion with the underlying layers be strengthened and improved. A brief literature review of consolidation treatments was performed to gain an understanding of the techniques and consolidants that have been previously used by other conservators.

Matte and underbound paints are difficult to consolidate because they are prone to visual darkening or increased glossiness after treatment. This results from the consolidant filling the voids between the pigment particles and producing a film that is smoother and more reflective (Hansen and Lowinger, 1990). In a study on the consolidation of matte paint on wooden objects, conservation scientist Eric Hansen and objects conservators Rosa Lowinger and Eileen Sadoff determined that consolidation is best performed in a vapor saturated atmosphere because this allows for better penetration of the consolidant into the paint film. In treating mock-ups of painted wood, they also found that multiple applications of a dilute low viscosity consolidant results in the least amount of color change overall (1993). In paper conservation, an ultrasonic mister that delivers a fine spray of consolidant is frequently used for matte paint consolidation. Because ultrasonic mist delivers very small droplets, the consolidant is better able to disperse evenly and penetrate into the media then other methods of delivery, such as by brush. This treatment is most effective when the object is humidified to increase its absorbency, and placed on a suction table so the consolidant is drawn through the media and support to increase adhesion between the layers (Weidner, 1993 and Maheux and McWilliams, 1995). However, the use of the suction table was not possible with *Yellow Animal* due to the multiple layers of oil-based printing ink that cover large sections of the support on both sides of the sheet. This was determined by placing the work on a suction table and masking the surrounding areas to increase airflow. Very little draw occurred through the printing ink, particularly in areas where the two images overlay each other on the support.

Various adhesives are recommended in the literature for consolidating gouache paint including, gelatin, Methocel A4C, JunFunori, and isinglass. Because Methocel A4C was used in the treatment of the two Appel gouaches for the Stedelijk Museum and was found to have only moderate penetration and adhesion, this adhesive was eliminated as a possibility. Because the most significant cleavage was occurring between the gouache and wax/oil based media, the consolidant used must be able to adhere well to both materials. To test methods of application (ultrasonic and brush) and possible adhesives mock-ups were made of *Yellow Animal* using similar materials.

Mock-ups were constructed by layering black Korn's brand lithographic crayon over a single-color (lampblack) lithograph that was printed from a stone on Rives BFK paper. Cadmium yellow and red gouache was squeezed onto blotter paper in order to reduce the amount of binder. They were painted over the top of the lithographic crayon and ink layers in passages of thin and thick applications. To roughly simulate aging, exposure to temperature and humidity

Figure 29. Mock-up for ultrasonic consolidation and detail of flaking gouache.

Figure 30. Mock-up for brush consolidation and detail of cleavage in the gouache paint film.

fluctuations, and handling, the mock-ups were thermally aged in an oven at 60° C for two weeks. During aging the mock-ups were periodically removed the supports were flexed by gently bending the paper. After aging the paint on both mock-ups was cracked and actively flaking (see figures 29 and 30). Like in *Yellow Animal,* the flaking was the most severe between the gouache and the lithography crayon.

Four adhesives were selected for consolidation testing on the mock-ups: 1% gelatin in deionized water, 1% funori in deionized water, 1% isinglass in deionized water, and a 1:1 mixture of the isinglass and funori solutions. These materials were selected because they are commonly used for paint consolidation of water or oil-based media. Funori and isinglass have been used on both water and oil-based paints. All three have good wetting properties, maintain high tack at low concentrations, and have low viscosities that allow for brush or ultrasonic applications.

The 1% solutions of gelatin, funori, and isinglass in deionized water were each applied to a section of one mock-up using an ultra-sonic mister. The mock-up had been humidified in a chamber for 3 hours prior to treatment and was relaxed. Mist application was relatively easy to control and dispersed an even layer of consolidant. However, the ultrasonic mister produced unacceptable results for consolidating the gouache cleaving from the wax and oil layers. This occurred because the adhesive could not penetrate into the support, and instead pooled on the surface of the paint. As the adhesive dried and contracted, it pulled the gouache flakes resulting in more cupping and cleavage (see figure 31). The misted gelatin and isinglass also increased the gloss of the gouache. Based on these results, it was determined that the ultrasonic mister could only be used where the gouache was applied directly on top of the paper, and not the crayon or printing ink.

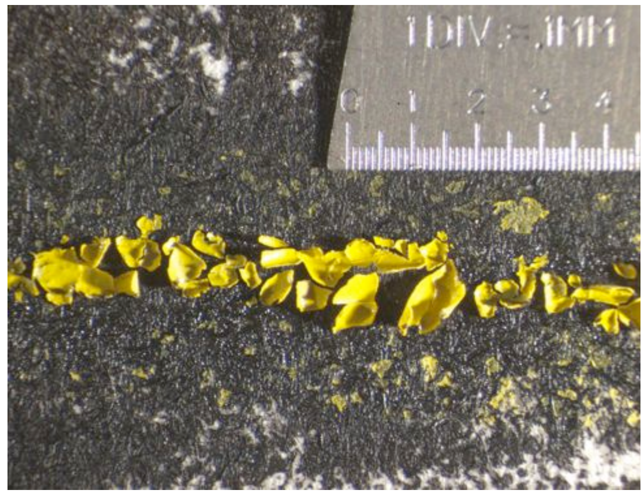

Figure 31. 40x photomicrograph of flaking gouache after ultrasonic consolidation.

Brush application of the consolidants was effective but time consuming. Isinglass in deionized water was found to have the best adhesive, viscosity, and wetting properties and produced minimal changes in gloss. Ethanol was used in combination with the isinglass to first saturate the area for consolidation to improve the penetration and flow of the adhesive into the media and support. Gelatin caused a greater increase in gloss and funori was found to not wick well into the gouache and support. The 1:1 mixture of isinglass and funori was not found to have any benefit over plain isinglass.

Based on the results of testing, it was determined to consolidate *Yellow Animal* predominately by brush with two dilutions of isinglass in deionized water: 0.5% for general consolidation and 3% for adhering large loose flakes to the surface. 0.5% isinglass in deionized water was also applied with the ultrasonic mister to sections of thickly applied, crumbling, under-bound gouache that was painted directly on the paper. Light coats of the mist were absorbed by the paint and strengthened the cohesive bond, facilitating further consolidation by brush to improve adhesion to the support.

Before each session of consolidation, the work was humidified in a cold humidity chamber for a minimum of 3 hours. The work was placed on a sheet of non-woven polyester and set on a screen. The screen with the art was placed in a tray on top of damp blotters and covered with a sheet of acrylic to retain the moisture. This was done to relax and increase the absorbency of the sheet during treatment. Consolidation was performed under magnification with a fine brush. A consolidation map that divided the work into 30 small sections was made to track the progress of the treatment. The work underwent two complete rounds of consolidation. During consolidation, ethanol was first applied to the area in order to improve saturation of the adhesive, and was immediately followed by warm isinglass. Some deformation of paint flakes was observed during consolidation, which was likely due to the moisture solubilizing components in the gouache. This was most noticeable in the red gouache. Brush consolidation sometimes caused paint flakes to shift or fracture, as they became saturated with the adhesive. A slight increase in gloss was also observed during consolidation (see figure 32). However, none of these changes are noticeable under normal viewing conditions, so it was felt they were acceptable.

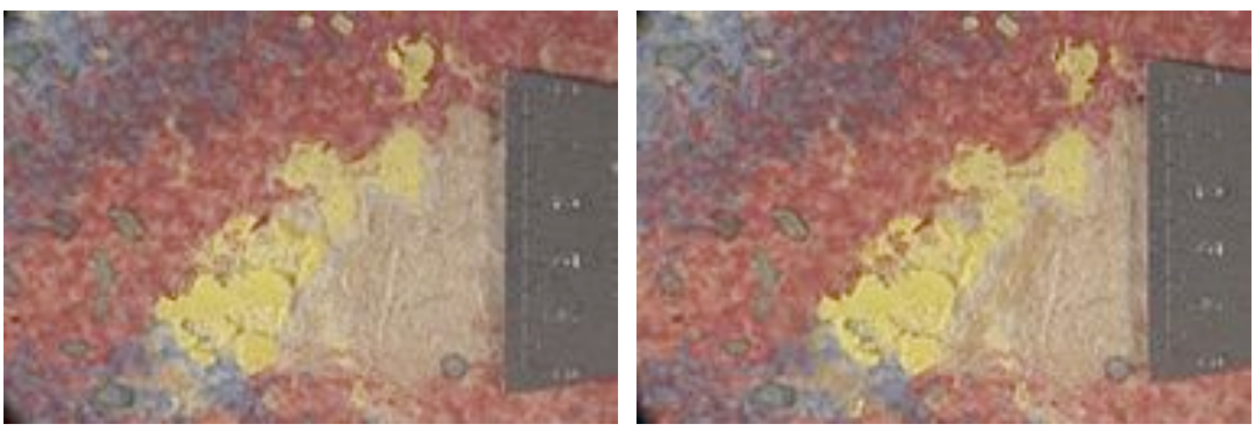

Figure 32. 40x photomicrograph of flaking gouache before and after brush consolidation with ethanol and 0.5% isinglass in deionized water.

After consolidation, the work was surface cleaned with vinyl eraser crumbs by gently rubbing them over the surface. Because no aqueous treatment could be performed due to the sensitivity of the media and consolidant to water, surface cleaning was the only opportunity to reduce soiling. Only areas without media were surface cleaned. Surface cleaning gave the sheet a fresher appearance but did not effect the overall discoloration or the brown foxing spots along the right edge of the sheet.

To reduce planar distortions, the work was humidified in a cold humidity chamber for 3 hours. Once the paper was supple and relaxed, it was removed from the chamber and the perimeter of the sheet was restrained under strips of blotter, Plexiglas, and moderate weight. This lateral restraint-drying method was selected because it does not place weight directly on the fragile gouache paint film, like drying by pressure in a stack would. Also, restraining the perimeter when the paper is expanded with moisture helps correct distortions in the center of the sheet by focusing shrinkage to this area as it dries. Because of this, lateral restraint or "stretch" drying can result in a slight dimensional increase in the overall sheet size (Banik and Bruckle, 2011). Stretch drying reduced the planar distortions without completely flattening the sheet, which was not necessary and would put unwarranted stress on the sensitive areas of gouache. Some gentle undulations remain in the sheet and are visible in raking light (see plate 6).

To unify the color of the support, the light spots in the top left and right corners, where the paper was locally protected from discoloration by the hinges on the verso, were toned (see plate 7). Retouching was done with *furuhon,* a color made by boiling and reducing the wash water of discolored rag papers. This is a traditional Japanese technique that produces a residue containing short-chain sugars from the degradation of sizing and cellulose that is remoistened with water and used like a watercolor (Schenck, 1994). The *furuhon* was diluted with deionized water to a transparent wash and was applied with a fine brush in short strokes to slowly build up the color.

Though consolidation treatment by brush was very time consuming due to the extensive amount of flaking paint, the treatment greatly improved the structural stability of the work. Consolidation did result in minor alternations of the gouache, but in normal viewing conditions, these changes are imperceptible and were necessary for stabilization (see plate 8). After consolidation, the work could be safely turned over in order to examine, perform photo documentation, and treat the unsigned print on the verso.

4.2. *Unsigned Print*

Because the work had been too fragile to turnover, the print had not been closely examined. There were several fragments of glassine tape and linen tape hinges adhered along the edges of the sheet. The adhesive on the glassine tapes had oxidized and was very brittle, allowing them to be mechanically removed with ease. However the glassine tape left some yellow stains where the adhesive migrated into the paper fibers. The linen tape hinges were thinned mechanically with a microspatula until only the adhesive layer remained. A poultice of 3% methocellulose A4M was thickly spread on the remainder of the hinge and was allowed to sit for 15-20 minutes. Once the moisture had reactivated the adhesive, the hinge was slowly peeled off the sheet. Several campaigns of hinges are visible on the print, and there are “L” shaped sections where the paper has been skinned during pervious hinge removal treatments. The linen tape hinges were adhered to previously skinned areas, and removal of the hinges resulted in further minor skinning of the paper due to the fragility of the short, fuzzy exposed fibers. Loose tabs of paper around the skinned areas, that likely occurred when previous hinges were removed, were re-adhered with wheat starch paste and were dried under blotter, acrylic, and lightweight.

Surface dirt and smeared media were present on the print overall. Ink smears likely occurred when the print was made, or when the sheet was repurposed by Appel. However, general soling may have resulted from subsequent handling and framing. There are multiple graphite notations that were written by framers. To reduce surface dirt and soiling, the print was cleaned with grated vinyl eraser crumbs. Cleaning was focused on the border around the image. The printed area was gently cleaned. Minimal pressure was used on the surface in order to not disturb the brittle paint on the recto, or pick up any pigment from the colored printing inks. The graphite inscriptions were avoided. Cleaning with the eraser crumbs visibly improved the appearance of the print, particularly in the borders around the image. However the print still retains the look of an in-process, unfinished proof (see plate 9).

4.3. *Mysterious Landscape*

Because the media and support were in good physical condition, the treatment of *Mysterious Landscape* focused on the reduction of the brown tide-line stains caused by water damage and the overall discoloration of the paper. In an article discussing light-bleaching and stain reduction in modern rag papers, conservator Terry Trosper Schaeffer notes, “the most challenging conservation treatments are those which consider issues of connoisseurship and artists’ intent in addition to appropriate conservation procedures and the limitations imposed by the object itself (Schaeffer, et al., 1997, p.1).” The decision to perform stain reduction treatments was based on the distracting severity of the tide-lines, and the negative visual impact of the darkened paper on the light colored inks. Visual examination of other works by Appel and study of his working techniques led to the assessment that the loss of saturation and tonal alteration of some inks by the darkened paper did not represent the artist’s intent. This was most evident in the lack of contrast between the light grey/tan ink in the background and the darkened paper tone. The extent of the discoloration was determined from areas in the top left and right corners where linen tape hinges locally protected the paper from the acidic mat board. These light areas were considered to more closely represent the original paper tone and were used as a benchmark to determine the progress of stain reduction treatments.

Two forms of stain reduction were used to treat the discoloration and the tide-line stains: overall light-bleaching and local bleaching with dilute hydrogen peroxide. Though bleaching is sometimes considered a “last resort” treatment due to the possibility of damaging the cellulose chains, it is often the only way to adequately reduce severe staining in a sheet (Schaeffer et al, 1997). Paper conservator Cathleen Baker defines bleaching as “a ‘restoration’ measure, which does not prolong the life span of paper, but improves its appearance,” and conservators must “weigh the potential risks, disadvantages and benefits of a treatment” (Baker and Bruckle, 2006).

Light bleaching was introduced by paper conservator Keiko Keyes in 1980 and is recognized as one of the most effective and least detrimental forms of bleaching, as it does not subject the art to harsh chemicals. The treatment is generally performed with the art immersed in an aqueous bath and exposed to either natural or artificial light. In light bleaching, stains are reduced through the oxidation of chromophores, which are generated during degradation reactions, into a colorless product. Photo-oxidation occurs as the chromophores absorb light energy and are converted into a reactive peroxide or free-radical (Edwards, 2010). Unlike the use of chemical bleaches, light bleaching occurs slowly over a period of several hours and often requires multiple exposures, which affords the conservator more control over the process and outcome. Chemical bleaching of stains, such as with hydrogen peroxide, also occurs by increasing the oxidation state of the discolored compound into a colorless product (Edwards, 2010). In both forms of bleaching, this newly formed colorless product may be soluble and can be washed out of the paper or is left as an insoluble compound within the sheet. Compounds left in the sheet may increase the likelihood that color revision will occur overtime.

Before treating the tide-lines and overall discoloration, steps were taken to ensure that the print was prepared for aqueous treatment and that no components of the print were soluble in water. To reduce soiling and remove any loose debris that could become ingrained in the fibers during washing, the front and back of the print were surface cleaned with grated vinyl eraser crumbs. The crumbs were gently rubbed or brushed over the surface of the print, taking care to not abrade or disrupt the ink. Water solubility tests were performed on all the printing inks and the various graphite and ink inscriptions. As expected, the oil-based printing inks were stable in water and showed no bleeding or offset. The artist's signature and edition number, written in graphite, were also unaffected. However three inscriptions made by framers on the back of the sheet, written in red, blue, and green inks, were readily soluble in water. When exposed to a small droplet the inks bled and offset on to blotting paper when dried. To prevent the inks from migrating in the sheet during washing, the soluble components were removed. One inscription was partially obscured by a gummed linen tape hinge. To allow for access to the ink, the hinge was mechanically removed. To activate the adhesive but restrict the amount of moisture introduced, saliva, which contains a mixture of water and enzymes, was applied on a fine brush to the interface between the paper and the hinge. As the saliva softened the adhesive, the hinge was slowly peeled off. A second hinge in the top left corner was activated with steam and was mechanically removed.

To reduce the inks, the print was placed face-up on a suction platen covered with Whatman filter paper. A mask of thin Mylar was placed over the print so only the area corresponding to the ink on the back was exposed. Deionized water was applied with a brush to the paper and was drawn through the sheet by suction, rinsing out the soluble components of the inks. This treatment was performed until no ink was visible on the filter paper. After rinsing, the inscriptions appeared lighter but remained legible. However, the repeated movement of water through the paper created small light spots where degradation products had been removed from the sheet. Though local uneven removal of discoloration is not desirable, this did confirm that the paper tone could be brightened with aqueous washing.

The sheet of Johannot paper is hard sized. When a droplet of water was applied to the surface on both the front and back, it beaded and remained unabsorbed after 1 minute. This indicates that the sheet was likely internally sized during manufacture, however neither analytical or microchemical testing could identify the specific type of sizing. Hard sized papers are often selected for printing because they allow an image to be printed with crisp lines and fine detail without the ink feathering or sinking into the sheet. This quality is evident in the sharpness and clarity of the image and the saturation of the colors in *Mysterious Landscape*. Regardless of type, sizing agents function by blocking polar groups on the surface of the paper to prevent them from interacting with water. Internal sizing, where the sizing agent is added to the pulp-stock, was developed for machine paper making in the early 1800's. Internal sizing distributes particles throughout the fiber network, altering the wetting properties of the paper by reducing the interactions between individual fibers and water (Banik and Brukle, 2011). The effectiveness of the internal size complicated aqueous treatment of the print because the sheet was so resisted to wetting.

Before washing the print, the sheet was misted overall with deionized water, however the sizing and large surface area of oil-based printing ink prevented the sheet from readily absorbing the water. The damp print was immersed in a bath of deionized water adjusted to pH 8.5 with a saturated solution of calcium hydroxide to increase the extraction of soluble degradation products from the sheet. Uneven wetting was observed in the bath as the areas that were locally treated with water on the suction disc became dark, indicating that they were absorbing more moisture than the rest of the sheet. The print was washed for 1 hour, and was allowed to air dry. The clear color of the water showed that very little discoloration had been removed from the sheet. The minimal success of the washing resulted in part from the inability of the sheet to absorb water. Washing occurs through diffusion as soluble degradation products that are in high concentrations in the sheet are drawn outward to the clean wash water (Banik and Brukle, 2011).

If moisture does not penetrate into the matrix of the cellulose, then the internal fibers do not swell and enable the release of soluble degradation products. The rapid drying of the print further confirmed that water had not been fully absorbed into the interior of the sheet. The tide-line stains appeared unaffected by the washing and the paper tone showed only minimal brightening (plate 13).

To increase the activity of the stain reduction treatment, the back of the print was light bleached. Light bleaching the back minimized the exposure of the colored inks to intense light while reducing the discoloration on both sides of the sheet as it passed through the paper. Because light bleaching is performed with the art immersed in a bath of deionized water, the success of the treatment remained dependent on the ability of the paper to absorb moisture. To improve the wetting of the sheet before light bleaching, the print was humidified in a warm humidity chamber for 2 hours. The sheet, resting on a piece of non-woven polyester, was placed in a tray on a screen above a thick, blotter saturated with warm deionized water. An acrylic sheet sealed the top of the tray and was observed to ensure that condensation did not form droplets that could fall on the print. Upon removal from the chamber the sheet was relaxed but not appreciably damp. For light bleaching, the print was immersed facedown in a bath of deionized water conditioned to pH 8 with a saturated solution of calcium hydroxide. The light source in the bleaching unit was a 1,000 Watt metal halide bulb that emits a full spectrum of light. The height of the unit was adjusted so the print was evenly and fully illuminated. The back of the print was bleached for 2-hours, receiving a total exposure of 15,000 foot-candle hours. To remove any soluble degradation products generated during bleaching, the print was washed for 1 hour in a bath of deionized water conditioned to pH 8 with a saturated solution of calcium hydroxide. After air-drying, the paper tone on both sides of the sheet appeared slightly brighter, however the tide-lines remained unaltered. This increased the contrast between the brown stains and the lighter paper tone, which made the tide-lines more visible (see plate 14).

Further reduction of the overall discoloration and the tide-line stains required that the front of the print also be light bleached. Because micro fade testing showed that the pink ink was highly fugitive, a mask was cut from thick blotter that would cover all the colors except the tan/light grey ink. The print was humidified in a chamber overnight to increase the absorbency of the sheet. To enhance the effect of light bleaching on the dark tide-lines, the stains were locally treated with a 0.5% solution of hydrogen peroxide in deionized water. The dilute peroxide introduces enough oxygen to speed up the rate of the photo-oxidation reaction. The peroxide was applied to the humidified print with a fine brush before it was submerged in the bath for light bleaching. During light bleaching, the mask was placed on the art and was moved every 15 minutes to prevent the development of a hard line along the edges (see figure 33). The front of the print was light bleached for 2 hours and received a total exposure of 16,000 foot-candle hours. The print was rinsed for 1 hour in a bath of deionized water adjusted to pH 8.5 with a saturated solution of calcium hydroxide.

Upon drying, the paper tone was significantly brighter but the tide-line stains were not appreciably reduced (see plate 15). After light bleaching the paper tone was a warm medium cream color that closely matched the light areas in the top left and right corners of the sheet. The contrast between the paper and the light colored inks was greatly improved, as they appeared more saturated and consistent with Appel's vibrant palette.

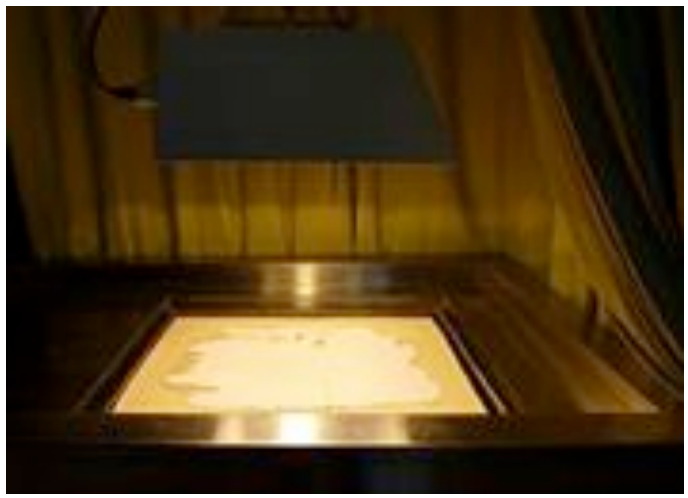

Figure 33. Recto of *Mysterious Landscape* covered by a mask during light bleaching.

To achieve visual continuity between the tide-lines and the paper tone, the stains were further reduced by bleaching with a 1.5% solution of hydrogen peroxide in deionized water adjusted to pH 9 with ammonia hydroxide. Ammonia hydroxide both increases the power of the solution by raising the alkalinity and causes the paper fibers to swell more, which allows for better penetration of the bleach. The solution was sparingly applied to the stains with a fine brush. The bleach was applied in three rounds allowing time for the solution to react and to assess the color change. During the third round two light halos began to form around the tide-lines in the center of the left edge. Formation of halos indicates that the bleach is migrating in the sheet to unstained areas causing local lightening. To remove the peroxide and soluble degradation products from the sheet, the print was washed in a bath of deionized water adjusted to pH 8.5 with calcium hydroxide for 1 hour. The peroxide treatment reduced the overall appearance of the tide-lines to an acceptable level. Though the stains are still visible, they do not immediately draw the viewer's eye and instead recede into the sheet. Plate 16 shows the progression of the stain reduction treatments.

The sheet was humidified in a chamber and flattened between blotters under moderate weight for 2 weeks to reduce distortions in the sheet from washing. Halos around the center tide-line stains and the light areas in the top left and right corners were toned with *furuon* (paper dirt). The *furuon* was diluted with deionized water to a transparent wash and was applied with a fine brush in short strokes to slowly build up the in color and unify the paper tone.

To improve the appearance of the art and more closely represent the artist's intent, treatment steps were made incrementally, constantly weighing the potential outcome against the potential risk of a technique. Though light bleaching and chemical bleaching are aggressive techniques that should be used judiciously, they can also be extremely effective. Overall, the treatment of *Mysterious Landscape* resulted in the reduction of dark tide-line stains, achieved a brighter more even paper tone, and increased the contrast between the light colored inks and the paper (see plate 17).

4.4. Re-housing

Because *Yellow Animal* and *Mysterious Landscape* are functional objects that are continuously displayed, it is essential that the frame package protects and does not contribute to the degradation of the art works. The final step of treatment for both works was hinging, matting, and returning the art to their frames. Mats and frames perform a dual function: to house and protect the object, and to aesthetically enhance it (Andrews, 2012). A properly constructed mat and frame package can protect art from dust, pollutants, and buffer it against minor short-term climate changes. However, it is important that only high quality archival materials be used for matting and framing, especially if they are in direct contact with the art. Many woods, cardboards, tapes, and adhesives commonly used in the past, or by uninformed commercial framers, can cause damage over time due to the migration of acids and the generation of volatile gases.

Figure 34 shows a diagram of a common matting and framing package for a work of art on paper. Because both prints have compositions that occupy the full sheet, they were floated rather than over-matted. The works were hinged with Japanese tissue and wheat starch paste to a 4-ply rag mat board. The rag mat board has a neutral pH and is buffered with calcium carbonate to resist acid migration or oxidation over time. A second piece of rag mat board was included in each frame as a backing board (behind the board on which the art is mounted) to provide physical and thermal protection. Previously the works were framed with acidic cardboard backing boards that released chemicals as they aged which likely contributed to the discoloration and degradation of the paper. A sheet of Marvelseal, a laminate of aluminum foil and inert plastic, was inserted behind the secondary backing board as a moisture barrier.

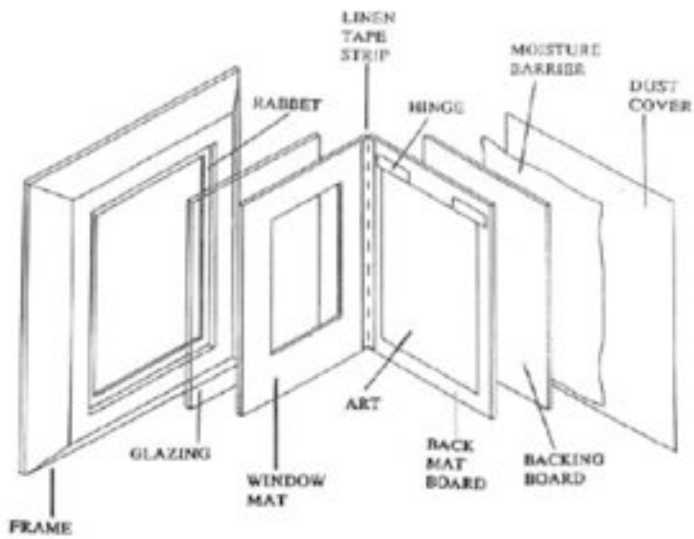

Figure 34. Diagram of a mat and frame package for a work of art on paper.

Spacers constructed from strips of rag board were added to the frame to provide a sufficient barrier between the art and the glazing. Without a barrier, the art is at risk of coming into contact with the glass, which can lead to media adhesion. Condensation can also form on the inside of the glazing, so sufficient airspace between the glazing and art is essential (Brown, 2007).

The lithograph *Mysterious Landscape* was glazed with a UV-filtering acrylic sheet to protect the colored inks and minimize the risk of damage from light exposure. Because *Yellow Animal* also showed evidence of media fading and overall paper discoloration, it also required UV protective glazing. However acrylic glazing carries a static charge that can attract media particles from works with delicate friable surfaces. Even though the gouache had been consolidated and the loose flakes were set down, the paint remains underbound and sensitive. UV glazing for friable media is more expensive because it requires either coated glass or an acrylic sheet with anti-static coating. UV glazing options will be presented to the client and the decision will likely be made based on budget.

To make the frame as airtight as possible, in order to reduce pollutants and buffer the microclimate, the frame package was sealed. This was done by making a sandwich out of the contents (glazing, spacers, mat, object, and backing layers) and sealing the edges with tape. The unit was then inserted into the frame and held in place with non-rusting brads. A dust cover of brown paper was attached to the back of the frame as a final layer of protection.

5 Conclusions

Yellow Animal and *Mysterious Landscape* represent a transitional moment in Appel's career as he was developing his method of abstraction, use of color, and lithographic technique. *Yellow Animal* can be seen as a working sketch illustrating Appel's thought process as he translated his use of gouache and crayon into lithography. Appel frequently recycled his supports and used an unstable combination of gouache and crayon. However the additional use of lithography in a mixed media work is unusual, as well as repurposing a sheet used by another artist. These anomalies support the notion that *Yellow Animal* was made while Appel was working on other prints at Atelier Pons.

It is known that Andre Lanskoy printed at Atelier Pons throughout his career and residency in Paris. In his transition to abstraction, Lanskoy developed a particular language of forms and geometric shapes. Along with his distinctive bright pastel color palette, his style quickly becomes recognizable, and the similarity to the unsigned print on the back of *Yellow Animal* is striking. Stylistic comparison of the unsigned print with other works by Lanskoy, particularly other lithographs printed at Atelier Pons, strongly suggests that it is his composition.

Study of Appel's style and working methods guided the treatment of both *Yellow Animal* and *Mysterious Landscape.* Appel's works are fraught with inherent vice due to his exuberant haphazard use of materials. Knowledge of his working methods and reviewing literature about the treatment of other early works by the artist aided in selecting a consolidant and method of application for the treatment of *Yellow Animal.* Developing an understanding of Appel's artistic intent regarding his use of vibrant saturated colors provided a foundation for making aesthetic decisions during the treatment of *Mysterious Landscape.*

Treating works that are privately owned and continuously displayed present unique issues due to the conservator's lack of control over the objects once completed. Despite knowing what the art needs in order to maintain stability, those conditions are unrealistic and at odds with how the works are actually used and displayed in a private home. It is unreasonable to expect that they would receive the same close attention as objects in a museum collection. Treatment stabilized, aesthetically improved, and allowed the works to more closely reflect the artist's intent. However inherent vice cannot be reversed, and so in the inevitable cycle of time and degradation, the works will likely remain "problem children."

6 Future Research

During the after treatment photo documentation of *Mysterious Landscape,* it was observed that the fluorescence of the pink ink when viewed with UVA radiation had radically changed. Before treatment the pink ink showed no distinct fluorescence (see plate 11). However after treatment, portions of the ink fluoresced bright orange (see plate 18). Materials absorb ultraviolet energy and re-emit it as lower-energy radiation in the visible region. The color and intensity of the emitted fluorescence is determined by the nature and amount of material, extent or degradation, and the excitation energy of the UV source (Warda, 2011). Similar orange fluorescence was observed in the pink ink on the unsigned print (see plate 19) and seems to correspond to the black lithography crayon on the recto. Additional analysis will be performed on the pink inks in order to more fully determine the compositions and understand the source of the fluorescence.

Heavy internal sizing, like that on *Mysterious Landscape,* is commonly found in lithography papers from this period and complicates aqueous treatment. Poor wetting of the sheet indicates the internal fibers are not being fully penetrated by moisture. This restricts how much discoloration can be drawn out of the sheet during aqueous washing and bleaching treatments. Further research will also be conducted on types of sizing used in the production of artist papers during the 1950's.

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9 Autobiographical Statement

Laura is focused on working with modern and contemporary art collections and is currently a Mellon Fellow in Paper Conservation at the Museum of Modern Art. She has completed internships at the Legion of Honor, Fine Arts Museums of San Francisco, the Solomon R. Guggenheim Museum, and the Albright Knox Art Gallery where she worked with paper, photographs, and electronic media. Prior to her graduate studies, Neufeld was a conservation technician at the Field Museum of Natural History and earned a Bachelors of Fine Arts from the School of the Art Institute of Chicago in art history and printmaking.

10 List of Illustrations

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19. Unsigned print (verso of *Yellow Animal)*, UVA visual fluorescence, before treatment.

11 Image Plates

Plate 1. *Yellow Animal*, recto, normal illumination, before treatment.

Plate 2. Unsigned print, verso of *Yellow Animal*, normal illumination, before treatment.

Plate 3. *Yellow Animal*, detail of light areas in top left and right corners, normal illumination, before treatment.

Plate 4. *Yellow Animal,* recto, UVA visual fluorescence, before treatment.

Plate 5. *Yellow Animal*, recto, raking illumination, before treatment.

Plate 6. *Yellow Animal*, recto, raking illumination, after treatment.

Plate 7. *Yellow Animal*, recto, detail of light areas in top left and right corners, normal illumination, after retouching.

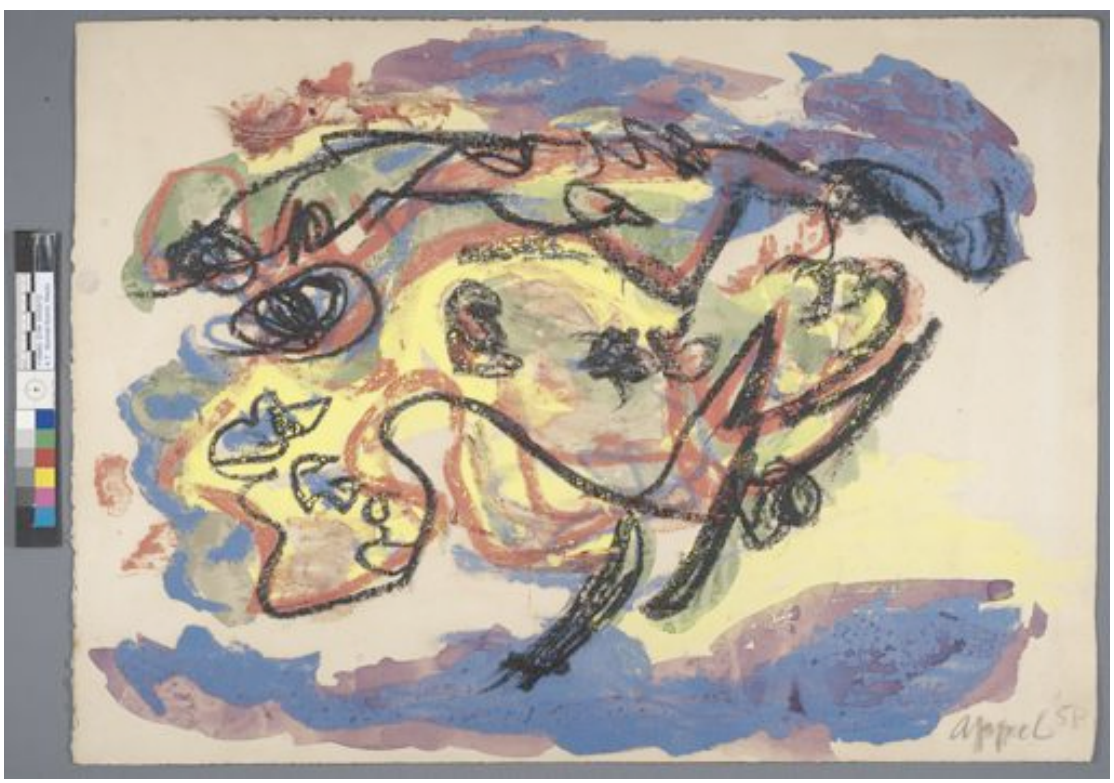

Plate 8. *Yellow Animal*, recto, normal illumination, after treatment.

Plate 9. *Yellow Animal*, verso, normal illumination, after treatment.

Plate 10. *Mysterious Landscape,* recto, normal illumination, before treatment.

Plate 11. *Mysterious Landscape,* recto, UVA visual fluorescence, before treatment.

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Plate 15. *Mysterious Landscape,* recto, during treatment, after light 0.5% H_20_2 catalyzed light bleaching of the recto.

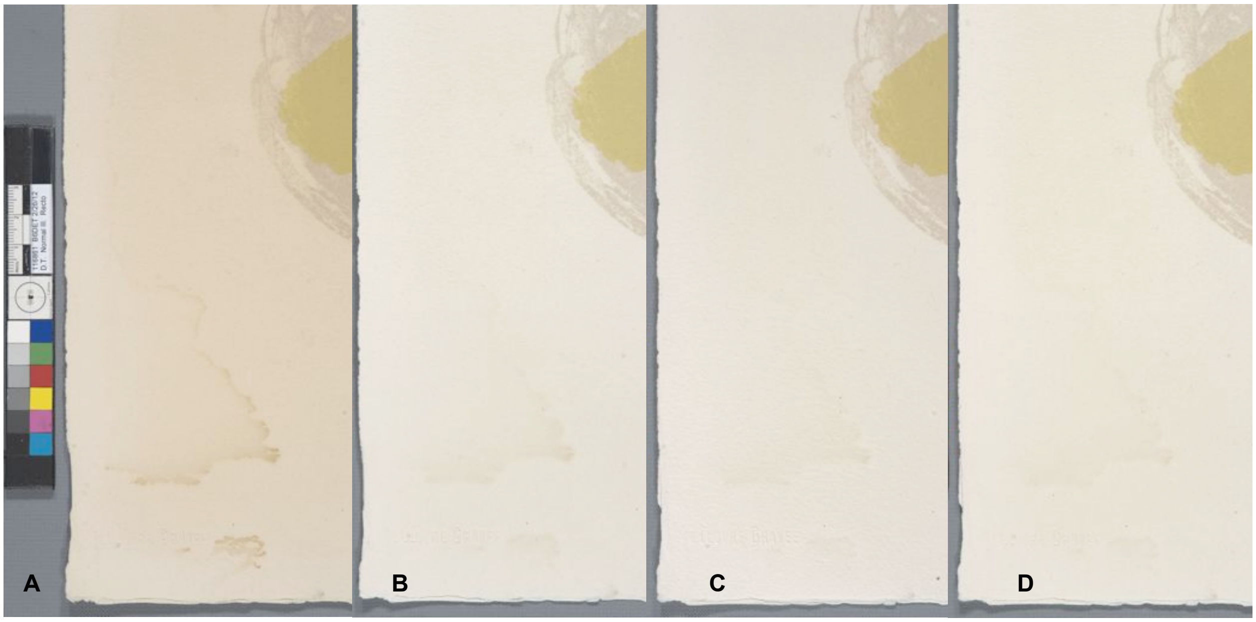

Plate 16. *Mysterious Landscape,* progression of tide-line stain reduction. **A.** After immersion washing. **B.** After 0.5% H_20_2 catalyzed light bleaching of recto. **C.** After 1.5% H_20_2 local bleaching of stains, and immersion washing. **D.** After retouching.

Plate 17. *Mysterious Landscape,* recto, after treatment, after 1.5% H_20_2 local bleaching of stains, immersion washing, and retouching.

Plate 18. *Mysterious Landscape,* recto, UVA visual fluorescence, after treatment.

Plate 19. Unsigned print, verso of *Yellow Animal*, UVA visual fluorescence, before treatment.

12 Appendix: Analytical Equipment Settings

FTIR Spectroscopy

Transmission FTIR Microscopy

Infrared spectra were collected using a Continuum microscope coupled to a Nicolet 6700 FTIR spectrometer (Thermo Scientific). Samples were prepared by flattening them in a diamond compression cell (Thermo Spectra Tech), removing the top diamond window, and analyzing the thin film in transmission mode on the bottom diamond window (2 mm x 2 mm surface area). An approximately 100 mm x 100 mm square microscope aperture was used to isolate the sample area for analysis. The spectra are the average of 32 scans at 4 cm^{-1} spectral resolution. Correction routines were applied as needed to eliminate interference fringes and sloping baselines. Sample identification was aided by searching a spectral library of common conservation and artists' materials (Infrared and Raman Users Group, http://www.irug.org) using Omnic software (Thermo Scientific).

Attenuated Total Reflection (iTR ATR) FTIR Spectroscopy

Infrared spectra were collected using a Nicolet 6700 FTIR spectrometer (Thermo Scientific) with a Thermo Scientific Smart iTR ATR accessory. Samples were analyzed by pressing them against the Diamond ATR crystal. The spectra are the average of 16 scans at 4 cm^{-1} spectral resolution. An ATR correction routine was applied to compensate for variations in penetration depth with wavenumber. Sample identification was aided by searching a spectral library of common conservation and artists' materials (Infrared and Raman Users Group, http://www.irug.org) using Omnic software (Thermo Scientific).

X-ray Fluorescence Spectroscopy

X-ray fluorescence spectra were collected using a Bruker Artax 400 energy dispersive X-ray spectrometer system. The excitation source was a Rhodium (Rh) target X-ray tube with a 0.2 mm thick beryllium (Be) window, operated at 40 kV (high energy) or 15 kV (low energy) and 1000 mA (high energy) or 1200 mA (low energy) current. The X-ray beam was directed at the artifact through a masked aperture of 1.5 mm in diameter. X-ray signals were detected using Peltier cooled XFlash silicon drift detector (SDD) with a resolution of 146.4eV. For low energy analysis, helium purging was used to enhance sensitivity to light elements. Spectral interpretation was performed using the Artax Control software. Spectra was collected over 90 seconds.