

A CLOSER LOOK: CONDITION ISSUES IN ABSTRACT EXPRESSIONIST GROUND LAYERS

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ABSTRACT—In the middle of the 20th-century, experimentation in house paint formulation crossed paths with the experimentation of artists with house paint. A brittle and ineffective white house paint was being marketed during a period when the Abstract Expressionists were using house paint as a ground layer material. Paintings created during this brief period have the potential for hidden problems. This research examines a group of paintings from the collection of the Hirshhorn Museum and Sculpture Garden, and highlights a possible relationship between zinc oxide oil grounds and condition problems observed in these paintings. The goal of this research is to encourage discussion related to the preservation of works from this important period.

INTRODUCTION

In 2007, the Hirshhorn Museum and Sculpture Garden (HMSG), Smithsonian Institution, completed an inventory and condition survey of their paintings collection. During the review of approximately 4,600 paintings, a pattern of condition issues was observed within HMSG's mid-century holdings. In collaboration with the Museum Conservation Institute (MCI), Smithsonian Institution, a research fellowship was proposed to take a closer look at the situation. The project was initiated with funding through the Smithsonian Institution's Conservation of Museum Collections program, and completed with assistance from the Samuel H. Kress Foundation.

STUDY GROUP SELECTION

HMSG's permanent collection reflects Joseph Hirshhorn's close relationships with renowned mid-century artists. A list of potential candidates for this study was created following a review of conservation and survey records, and inspection of the works. This research project focuses on paintings from what is now called the Abstract Expressionist School, a group of artists known for their innovative techniques and materials. Paintings in this study group include works by New York-based artists Willem de Kooning (1904-1997), Hans Hofmann (1880-1966), Franz Kline (1920-1962), and Jackson Pollock (1912-1956), as well as contemporaneous works by European colleagues Karel Appel (1921-2006) and Antonio Saura (1930-1998). Artists were chosen based on similarities in technique and palette, as well as the potential for shared information regarding materials. Several paintings by each artist were chosen for inclusion in this study: some early works by de Kooning, on fabric and board, works by Hofmann, mostly from the period when his NY school was active, two early 60s paintings by Kline, some early work by Pollock, a number of paintings by Appel, including works that highlight the shift in his pallet inspired by his first trip to NY, and three late 50s paintings by Saura, one each from his female portraits, crucifixion, and self-portrait series. Damaged and undamaged works by each artist were included in the final study group of 20 paintings.

CONDITION

Early attention was paid to repeating condition patterns. Many of the works exhibit blind cleavage and lifting, which appears to be associated with an intralayer failure of the ground layer material. This failure is lamellar in appearance; a layer of ground material is attached to the lifting paint, while another layer of ground material remains attached to

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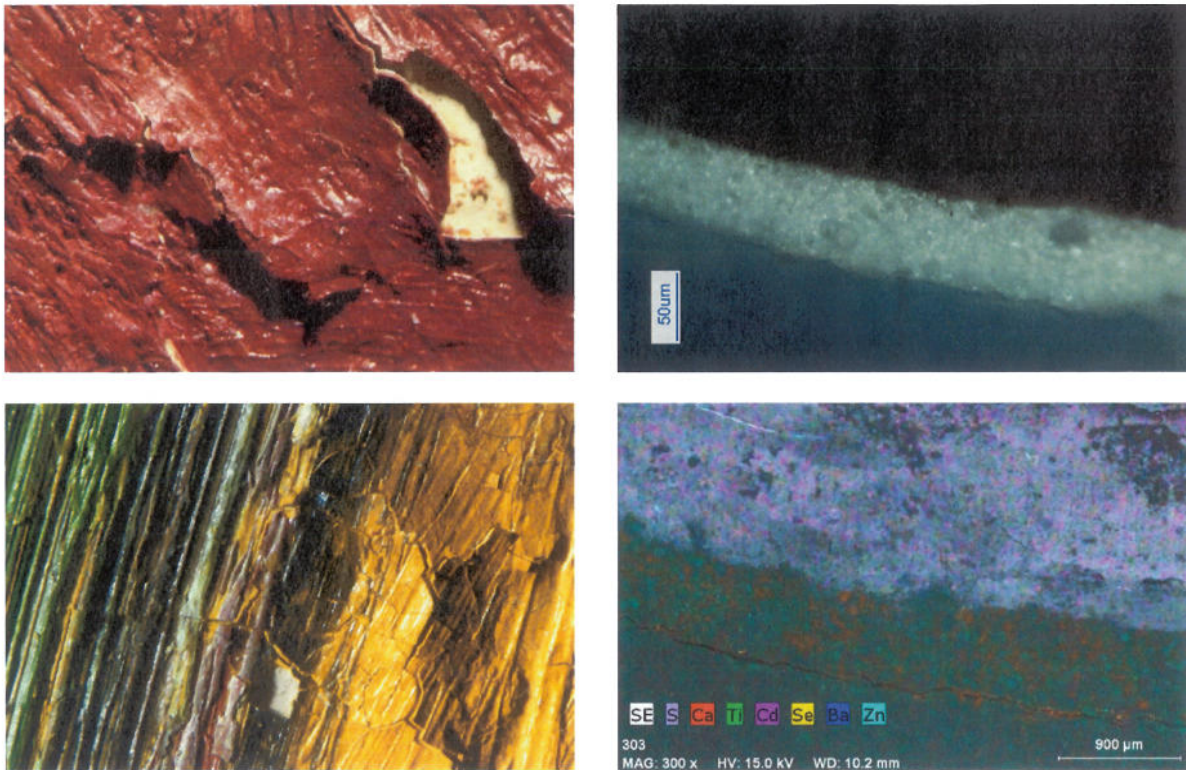


Figure 1 Hans Hofmann, *Trophy/Verso: Untitled*, 1951 (HSMG acc. no. 66.2483)

Left: cleaving ground/red layer (T 2.5 x L 3.4 cm) and cleaving ground/mixed layers (T 9.5 x R 25.0 cm), photomicrographs, 6x focus, 10x lens, 0.32x factor; Right: cross section no. 303, sample of cleaving ground/red layer, 50x magnification (dark field with cover slip) and BSE elemental map

the primary support. There are examples of this type of failure in cleaving cadmium colors in several of the works by Hofmann and Appel (fig. 1). In the case of Kline and Saura, we see a location-specific cracking of carbon blacks. Works by both artists contain multiple whites (visible to the unaided eye); the black remains intact where it is painted over one of the whites, but exhibits widespread cracking when it passes over a second white (fig. 2).

During XRF analysis, zinc was consistently found in the damaged areas in these paintings. Samples from several works were examined to obtain further information about the composition of the artists' painting materials.

ANALYSIS

Microscopy of samples from damaged areas of the paintings indicated the presence of zinc particles in the white layer beneath the damaged cadmium and black paints; the distinctive auto-fluorescence is visible under UV illumination when viewed with the appropriate UV filter. Scanning Electron Microscopy-Energy Dispersive Spectroscopy of the samples confirmed the presence of a zinc oxide white layer under a layer of either cadmium red or carbon black (figs. 1 and 2).

Based on the SEM results, paint samples from a select number of the works were sent to the National Gallery of Art for Pyrolysis-Gas Chromatography-Mass Spectrometry analysis. Py-GC-MS results indicated an oil-based binder for all samples. The chromatogram plots also exhibited unusually high peaks related to unsaturated fatty acids. For comparison, Py-GC-MS analysis was performed on a range of oil-based white paint samples from the Materials Study Collection at MCI. The zinc oxide comparison samples exhibited the same excess fatty acid peaks visible in the zinc oxide-containing study group paints. These samples include a 30-year-old drawdown sample of Grumbacher zinc white, a 20-year-old control sample of zinc white (prepared by Gamblin Artists Oils), and a

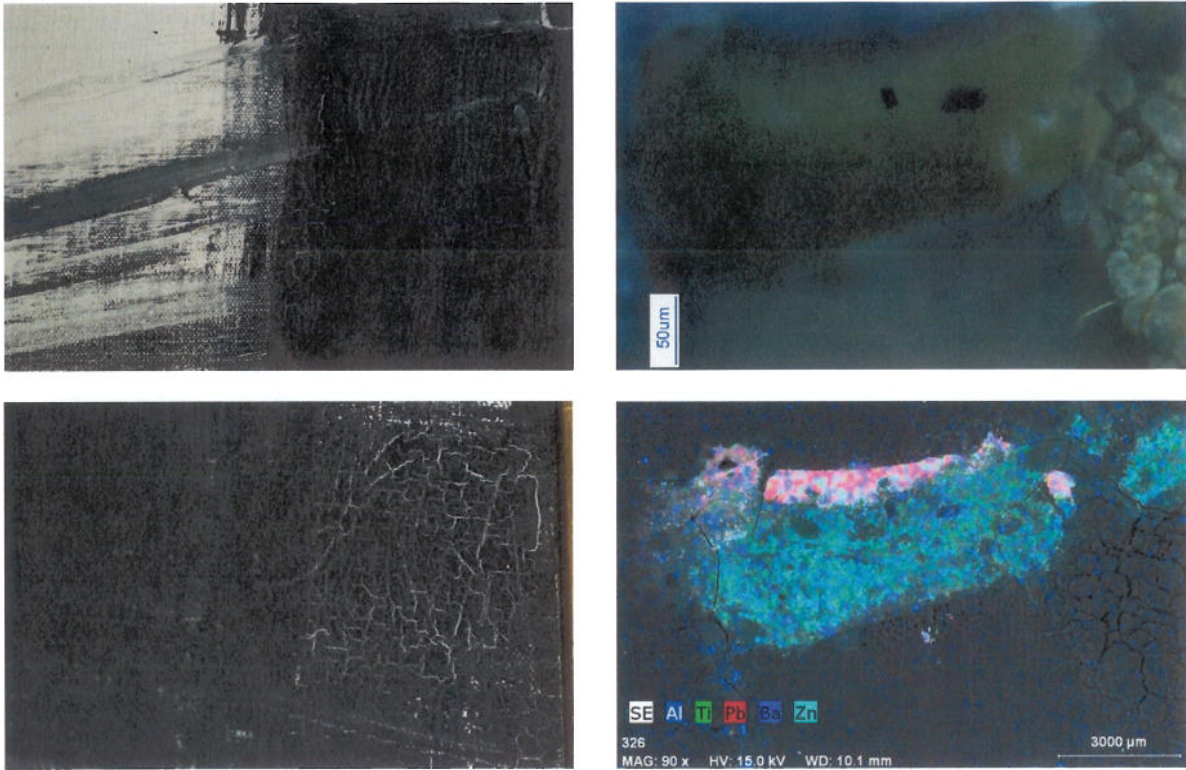


Figure 2 Franz Kline, *Palladio*, 1961 (HSMG acc. no. 66.2754)
 Left: cracking black layers, digital photographs, Nikon D70, macro lens; Right: cross section no. 326, sample of proper left tacking edge (B 132.8 cm), 50x magnification (dark field with cover slip) and BSE elemental map

10-year-old drawdown sample of Speedball zinc white (fig. 3). The zinc oxide-free comparison samples showed no excess unsaturated fatty acid peaks.

Fourier Transform Infrared false color imaging (performed at the Institute for Atomic and Molecular Physics in Amsterdam) of zinc oxide layers from both the study group paintings and the Materials Study Collection comparison samples also revealed an unexpected, widespread distribution of unoxidized fatty acids throughout the zinc oxide paint layer.

A large amount of extant unsaturated fatty acids is unexpected in paintings that are nearly 60 years old. This phenomenon is the result of the unique drying process of zinc oxide oil paint. In an oil medium, zinc oxide forms a tightly packed crystalline structure, but with a highly ordered lamellar distribution that orients layers of unsaturated fatty acid chains between layers of the fatty acid carboxyl groups and the zinc matrix. This layered structure makes the paint very stiff, and the highly ordered packing of the hydrocarbon chains makes the unsaturated bonds more difficult to oxidize. The excess unsaturated fatty acids in zinc oxide paint remain trapped within the paint layer years after oxidation of the paint should have been completed. It is as if the paint has prematurely “frozen” into position, without the structural stability afforded by the cross-linking that would accompany the natural drying process. Shortly after application, zinc oxide has formed an unusually stiff and brittle oil paint. [1]

1. In a similar manner, the matrix restricts the movement of the zinc soaps, which have remained distributed throughout the paint layer in the study group paintings. While fatty acids will typically saponify in the presence of metal salts, it is unusual to find such high concentrations of unreacted unsaturated fatty acids, which is directly related to the unique failure characteristics of zinc oxide paints.

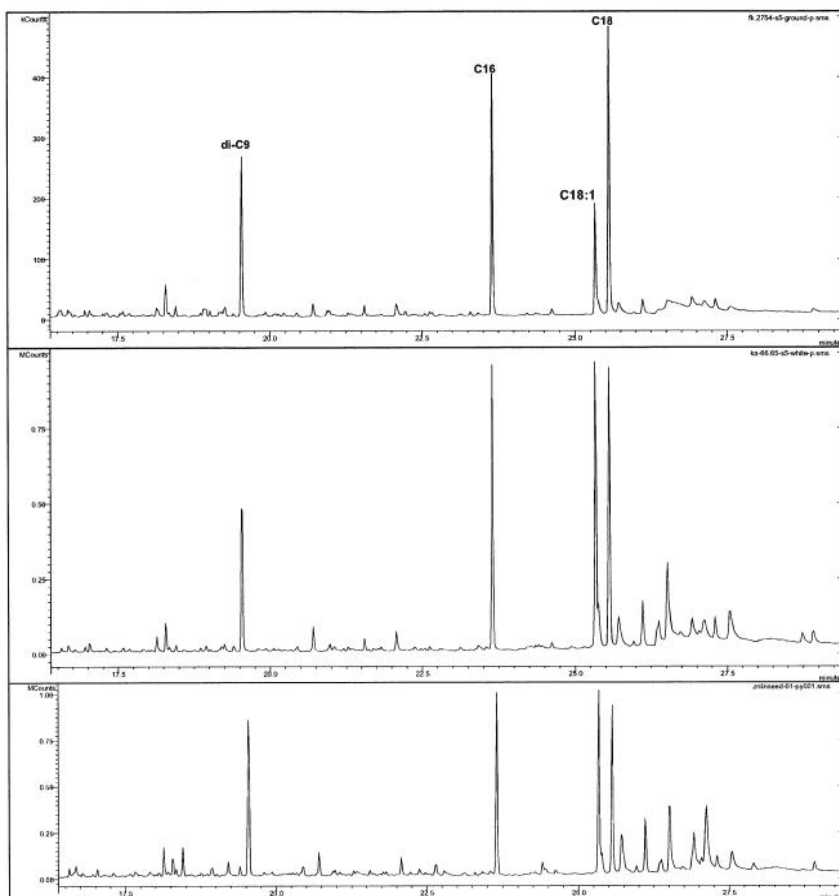


Figure 3 Gas chromatogram plots, areas related to fatty acids

Top: zinc oxide ground layer, Franz Kline, *Palladio*, 1961 (HSMG acc. no. 66.2754, cross section no. 326, proper left tacking edge, B 132.8 cm); Center: zinc oxide ground layer, Karel Appel, *Magic Doll with Pig's Head*, 1961 (HSMG acc. no. 66.65, cross section no. 295, T 30.5 x L 16.6 cm); Bottom: control sample zinc white in cold-pressed linseed oil, cast 4/23/1990, Materials Study Collection

Labeled peaks:
 C16=methyl palmitate
 C18=methyl stearate
 C18:1=methyl oleate
 di-C9=dimethyl azelate

Recent research has hypothesized that anomalous bond formation within the zinc matrix further disrupts the structure. This weakness, along with the zinc – hydrocarbon – zinc layering, may explain the plate-like intralayer cleavage present on the paintings.

INDUSTRIAL LITERATURE

There is generous documentary and anecdotal evidence of the Abstract Expressionists' use of house paints in their work. Due to similarities in formulation during this period, in the absence of alkyds, there is little that can be done analytically to determine if a mid-century artist was using an oil-based house paint or a similar, commercially-prepared artists' paint. Yet this similarity in formulation can work in the conservator's favor. Before the introduction of titanium dioxide substitutes, the commercial paint industry struggled to fashion a zinc oxide paint that could replace lead white, and fill the need for an opaque and durable white coating. Industrial literature from the period directly addresses the behavior and characteristics of zinc oxide oil paint.

Frustrations from within the industry can be found as early as a 1907 treatise on the merits and defects of zinc white that begins: "Zinc white covers poorly. It dries poorly. It stands the weather badly." From the earliest articles, zinc oxide oil paint is acknowledged as reactive, brittle, and difficult to use.

There is a wealth of industrial literature from the same period as the study group paintings, including a 1949 Oil & Colour Chemists' Association symposium devoted entirely to the discussion of zinc oxide. One presenter at the symposium noted that "zinc fails by checking and cracking with flaking... and erosion which seems fairly severe," but added the optimistic comment that "paints containing zinc pigments have, however, a natural useful life of at least

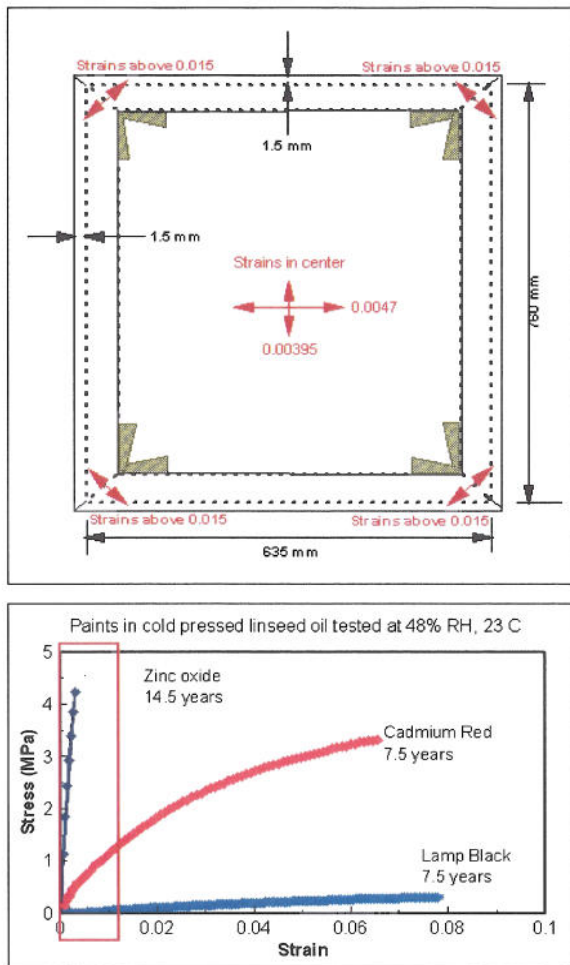


Figure 4 Strain and materials
 Top: illustration of strain imposed on 760 x 635 mm painting. Overall keying out by 1.5 mm creates 0.015 strain at corners, 0.00395-0.0047 strain at center;
 Bottom: tensile test results for control samples from Materials Study Collection; highlighted portion represents illustrated corner strain

three and a half years.” With its regular anticipated repainting, it is clear that the industry definition of “useful” differs significantly from that of the artist and conservator considering the long-term stability of a work of art.

The industrial literature is particularly useful when it addresses the use of zinc oxide oil-based house paint as a priming layer. The author of a 1935 article from the *Official Digest of the Federation of Paint & Varnish Production Clubs* states that “it is possible that too little thought has been given as to how a primer might work under different paints.... In some cases there is a marked increase in checking and cracking of the finishing coats and in others an actual decrease in adherence of the whole system... for satisfactory durability, adjacent applications must not differ too greatly from one another in distensibility or hardness.” A 1941 article in *Industrial and Engineering Chemistry* notes that “complete elimination of zinc oxide from primers is recommended by one school of thought on the subject and is opposed by another... Conclusions about the use of zinc oxide in primers must be subordinated to the more fundamental problem of compatibility between primer and finish paint... Leaders of both schools of thought

concerning the place of zinc oxide in primers agree that compatibility is a dominant consideration.” The authors of a 1936 study in the same journal conclude that “there is a direct relationship, in terms of performance, between relative hardness of undercoat and top coat, and that certain combinations are incompatible.”

MECHANICS

One way to examine issues of compatibility within the layered structure of the study group paintings is to compare the mechanical properties of each individual layer. For this portion of the project, representative data were culled from previous mechanics research performed over a period of 30 years, on control samples from the Materials Study Collection at MCI. Control samples from the collection were chosen based on similarity in pigment composition and analytical testing profile. In addition, the simple formulation of the control samples limited the potential effect of anomalous materials.

Stress-strain plots from a series of tensile tests highlight the stiffness and brittleness of zinc oxide oil paint. This is especially significant when compared to the tensile test results for other types of oil paints found in the study group paintings, such as cadmium red and lamp (carbon) black. At even the small amount of strain created by keying out a painting, the zinc oxide layer has failed before any significant strain is placed on the other pigmented layers (fig. 4).

Customized force-strain projections (based on stress-strain data) were created for the materials found in the study group paintings. The first set of projections was calculated using the average thicknesses of the materials in one of the Kline paintings, including the canvas and size layers. In those areas of the artist-primed canvas where

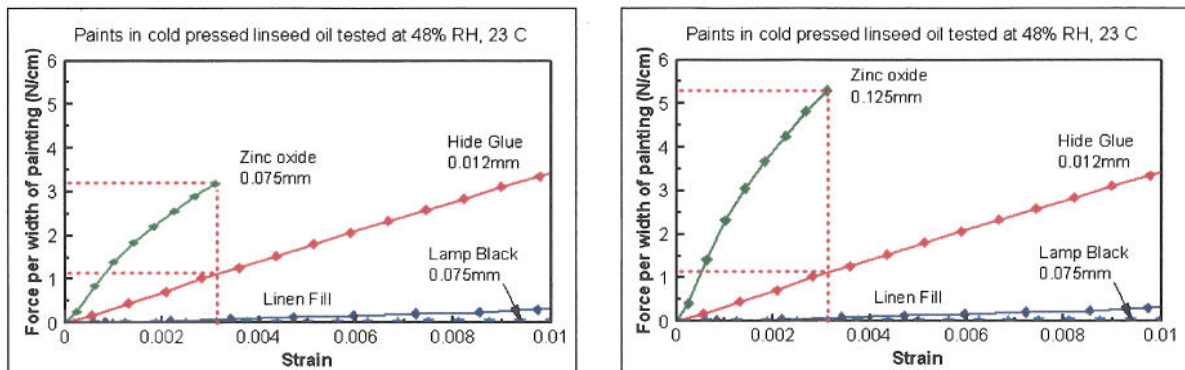


Figure 5 Force-strain projections, calculated from tensile testing data.
 Left: projection based on average thickness of materials in Franz Kline, *Palladio* (HMSG acc. no. 66.2754);
 Right: similar projection, with increased thickness of ground layer (zinc oxide failure point highlighted in both examples)

the ground layer is thicker, the force on the zinc oxide layer increases (fig. 5).

It is also worth remembering that many of these paintings are on hygroscopic supports. Though the glue and canvas respond to changes in relative humidity, the zinc oxide oil paint layer is practically non-responsive to changes in humidity, and cannot adapt to dimensional changes in the other materials.

Mechanical stresses and forces throughout the layers of this painting structure can result in widespread cracking and delaminations throughout the ground layer. Resultant fissures within the ground layer will increase the potential for subsequent damage.

CONCLUSIONS

Abstract Expressionist compositions often include thick layers of paint. The brittle and inflexible characteristics of zinc oxide oil paint are not ideal properties for an intermediary layer between a thick oil paint composition and a flexible and hygroscopic support. The mechanical properties of the zinc oxide oil paint are incompatible with the requirements of a ground layer for these works. The mid-century artist's choice of an oil-based house paint ground may have compromised the painting structure.

The study group artists did not use zinc white oil paint as a ground layer for all of their paintings; it is recommended that collections from this period be reviewed to determine which paintings might contain zinc oxide oil grounds or underlayers. Works with zinc oxide oil grounds should be carefully observed, particularly during periods of mechanical stress, or changes in the environment. Areas of flaking paint in these works may indicate a compromised ground layer, and should be closely examined. The possibility of blind cleavage and delamination should be considered.

QUESTION AND ANSWER

Have you seen examples of paintings extruding excess fatty acids (as has been reported in some works by van Gogh)? No, I have not seen any examples of extruding materials in the study group paintings. This may be due to the high pigment volume concentration in zinc oxide oil-based house paints. Not only does this create an extremely strong matrix that restricts the movement of the materials, but it supplies an excess of pigment material for any reaction. Even if the fatty acids could move, they wouldn't need to.

Are you familiar with the zinc-related problems in pre-Raphaelite paintings? As I understand it, pre-Raphaelite painters covered their lead white grounds with a layer of zinc oxide white, in order to create a brighter foundation for their compositions. From a mechanics perspective, this would create essentially the same problem that we're seeing in the AbEx works: a brittle, ineffective support layer. The zinc is the weak layer in the painting structure.

Did the use of zinc oxide phase out in Europe at the same time as in the U.S.? The U.S. industrial literature seems to link the replacement of zinc oxide in house paint with its poor performance in weathering tests. Several of the articles mention that while weathering conditions vary across the U.S., these are generally worse than conditions in Europe. DuPont introduced titanium dioxide commercially in the U.S. in the mid-1950s, but I don't know when titanium white became generally available in Europe. It's something to keep in mind when reviewing mid-century collections.

ACKNOWLEDGMENTS

The authors wish to express their gratitude for the support of many people and institutions. This was a truly collaborative effort. Smithsonian Institution: Lynn Brostoff, former Research Chemist, Museum Conservation Institute; Roland (Ron) H. Cunningham, Senior Paintings Conservator, Museum Conservation Institute; Melvin Wachowiak, Senior Conservator, Museum Conservation Institute; Judy Watson, Physical Scientist, Museum Conservation Institute; Ellen Alers and Mary Markey, Smithsonian Institution Archives. Other institutions: Jaap Boon, FOM Institute for Atomic and Molecular Physics, Netherlands Organisation for Scientific Research; Stuart Croll, Professor and Chair, Department of Coatings and Polymeric Materials, North Dakota State University; Mark Golden, CEO, Golden Artist Colors, Inc.; Mark Gottsegen, Materials Research Director, Intermuseum Conservation Association; Michael Skalka, Art Materials Collection and Study Center, National Gallery of Art. Funding: The Samuel H. Kress Foundation, and The Smithsonian Institution Fellowship Program.

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Presented at the AIC annual meeting in Los Angeles, California, May 19-22, 2009.

This paper has not undergone a formal process of peer review.