Roy Lichtenstein's Outdoor Painted Sculpture *Three Brushstrokes* (1984): Analysis of Paint Structure and Composition

Project Overview

In 2005, as part of a large donation of outdoor sculpture from the Ray Stark Revocable Trust, the J. Paul Getty Museum acquired a sculpture by Roy Lichtenstein (American, b. 1923; d.1997) entitled *Three Brushstrokes* (**Fig. 1**), which was created in 1984. In compliance with the gift agreement, the painted aluminum construction was quickly installed at the Getty Center leaving little time for in-depth study of the original materials and techniques of creation or its conservation history. It was clear from the beginning that a restoration had occurred in the past and the extant paint colors did not properly represent the original appearance.

Figure 1. Roy Lichtenstein, *Three Brushstrokes* (1984) (JPGM 2005.111) as installed at the Getty from 2006 to 2011. Photo: Alan Phenix, GCI. Sculpture: The J. Paul Getty Museum, Gift of Fran and Ray Stark. © Estate of Roy Lichtenstein.

The materials and techniques of Lichtenstein's indoor painted works, mostly canvas paintings, have been comparatively well studied (Cowart 1992; Cowart 1999; Crook and Learner 2000; Learner 2004), but less attention had been paid to the changing techniques and materials he used for his outdoor works. This gap in knowledge, in combination with the uncertainties surrounding the Getty piece, stimulated a collaborative endeavor between the Getty Conservation Institute (GCI), the J. Paul Getty Museum (JPGM), and the Roy Lichtenstein Foundation that was directed towards establishing a clear understanding of the evolution of the artist's original fabrication and painting techniques for his outdoor sculpture, with specific focus on *Three Brushstrokes*.

Contributing to that wider endeavor, scientific investigations of the paint on the sculpture were carried out by GCI Science in order to address particular questions raised by JPGM conservators about the original paints used by the artist and his studio in the creation of the work and about the subsequent restoration history of the piece. Documentary sources suggested that the sculpture had been subjected to a major conservation/restoration treatment in the mid-1990s, during which process some or all of the colors were re-painted. The present red, yellow, and blue areas, especially, were thought to be considerably different in color, in 2005, from the original intended

appearance of those areas. During treatment at the Getty of blisters in the paint, conservators had noticed a distinct layer structure to most areas of color, and the questions were raised as to whether, and to what extent, any of the original paint remained exposed at the surface or lay beneath the paint applied in the restoration of the 1990s.

Through conversations with Lichtenstein's studio assistant, James DePasquale, Getty Museum conservators had established that the paints originally used in the creation of the piece were probably of two kinds: commercial, two-part polyurethane automotive paints of the type produced by the company DuPont under the tradename Imron®, and some unusual studio-made paints which were prepared by mixing solvent-borne Magna acrylic paints, made by Bocour Artists' Colors, into clear polyurethane lacquer (clearcoat). The reason given for the use of the studio-made Magna polyurethane paints was to create particular colors which were not available, or could not be mixed, from the Imron® range, whilst maintaining a high degree of durability as required for exposure outdoors.

The scientific investigation conducted by GCI Science sought to provide substantive evidence that would clarify the conservation/restoration history of the sculpture and add to the understanding of the original materials and techniques used by Lichtenstein for his outdoor sculptures. The process involved in these investigations was essentially one of forensic paint analysis: looking for physical and chemical evidence in the various coatings on the sculpture as clues to the original fabrication materials and past restoration treatments.

The essential raw materials for the scientific study were small paint fragments taken from *Three Brushstrokes* by JPGM conservators during the sculpture's preparatory conservation treatment shortly after its acquisition by the Getty. The fragments came from areas of blistering paint that required treatment rather than having been intentionally sampled at strategic locations. To aid interpretation of the instrumental chemical analysis of the organic binders, in addition to samples from the Getty's *Three Brushstrokes*, analyses were also performed on samples of various reference materials (polyurethane paints and clearcoats) obtained from the Lichtenstein studio, JPGM and elsewhere.

Analytical Methods

The samples originally obtained from JPGM conservators were examined and analyzed by various methods, including:

- visible light and ultraviolet fluorescence microscopy of cross-sections to show paint layer structure (stratigraphy) and pigment content;
- environmental scanning electron microscopy with energy-dispersive x-ray spectroscopy [ESEM-EDS], for spatially-resolved elemental analysis of pigments and extenders;
- Raman microspectroscopy, for identification of specific pigment compounds;
- laser desorption mass spectrometry [LDMS], for identification of selected organic and inorganic pigment compounds (conducted by Dan Kirby at the Straus Center for Conservation, Harvard University Art Museums);
- Fourier-transform infrared [FTIR] spectroscopy, for identification/characterization of organic binding media and selected pigments/extenders; and
- pyrolysis gas chromatography–mass spectrometry [Py-GCMS] for identification of organic polymer binding media.

Conclusions

Figures 2, 3, and 4 summarize the overall findings of microscopical examination and chemical analysis of the various coatings observed, respectively, in the red, yellow and blue samples from the sculpture.

Taken as a whole, the stratigraphic examination and chemical analyses of the paint and coating materials indicated the following:

- The original paint and clearcoat layers in the black, white, red, and large yellow color fields, applied by the Lichtenstein studio in 1984, remained largely intact on the sculpture (at least at the locations from which the samples analyzed derived), but were completely overpainted in a restoration treatment, presumably the one carried out in 1995 that is recorded in archival material. In each of these cases, the layers corresponding to the 1995 restoration can be seen to overlay a highly fluorescent clearcoat layer which contains talc as matting agent. Chemical analysis of the organic polymer of the intermediate clearcoat showed that it was similar in composition to the reference sample of AKZO polyurethane semi-gloss clearcoat Code 683-3-7 provided by Lichtenstein's studio assistant, James DePasquale. In all likelihood, the now intermediate talc-containing clearcoat layer was applied by the Lichtenstein studio as a final protective coating for the sculpture on its completion in 1984.
- The black and white sections of the sculpture appear to have been painted originally entirely in automotive type paints.
- The original color layers of the red and large yellow color fields consisted of paints of two distinct types: opaque lower layers (basecoats) of very fine granularity (typical of industrial/automotive type coatings) that are overlaid by unusual inhomogeneous paints featuring zones of clear binder material and zones where pigment is concentrated in discontinuous bands. The principal pigments in the unusual red and yellow paints are, respectively, cadmium red and cadmium yellow, both of which occur in the color range of Bocour Magna artists' acrylic paints. Taken together with the findings of py-GCMS analysis of these paints, which indicated a butyl methacrylate polymer and polyester urethane similar to AKZO clearcoat, plus ricinoleic acid (from castor oil), these observations point very strongly to the unusual inhomogeneous paints being the Lichtenstein studio's self-made paints composed of Bocour Magna artists' acrylic paints mixed with polyurethane clearcoat, as reported in interviews with DePasquale. Py-GCMS analysis of the automotive type paints forming the opaque lower layers (basecoats) of the red and large yellow color fields showed that the binders are acrylic polyester urethanes with a relatively high content of styrene and are similar to reference samples of DuPont Imron® enamel. The presence of lead chromate pigments—which are now restricted in use for environmental and health reasons—in the opaque lower layers (basecoats) of the red and large yellow color fields point to these paints being part of the original (i.e., 1984) paint system.
- The blue color field and the small section of the yellow brushstroke that protrudes through the blue stroke had somewhat different stratigraphies to the black, white, red and large yellow sections: these first two areas lack the intermediate fluorescent clearcoat and the unusual inhomogeneous studio-made paints (Magna acrylic paints + polyurethane clearcoat). In the case of the blue color field, the opaque lower layers (composed mainly of copper phthalocyanine blue [PB 15:3], quinacridone red [PV19] and rutile titanium dioxide in a binder of polyester urethane) are almost certainly original to the sculpture,

but the discrete layers of black, white, and blue paint and red filler above them are not and appear to derive from the 1995 restoration treatment. The presence of a few isolated particles of ultramarine blue pigment with associated fluorescent organic material at the interface between the original opaque lower layers and the overlying restoration layers suggests that an ultramarine blue Magna acrylic + polyurethane clearcoat may have originally constituted the upper paint stratum of the blue color field, and that this paint was almost completely removed during the restoration treatment, or else had flaked off at that location.

- With the exception of the blue color field, the uppermost paint layers, which almost certainly correspond to the 1995 re-painting of the sculpture, have the typical characteristics of industrial/automotive type paints: fine granularity and opacity. The uppermost paint layer in the blue color field, however, is different: it is extremely transparent and contains almost exclusively ultramarine, with little in the way of opaque white (e.g., titanium dioxide) or other colorless extenders. The colored pigments in the uppermost paint layers of the red and large yellow color fields are organic (respectively, red: quinacridone red PV19 + benzimidazolone PO36; yellow: benzimidazolone PY151) compared to the original (i.e., 1984) automotive type paints which include both red and yellow lead chromates. The appearance of organic red, yellow, and orange pigments as the primary colorants in the uppermost paint layers of these sections of the sculpture is reflective of their more recent date than the original automotive-type paints. In the 1995 re-painting of the sculpture, the red brushstroke was painted, by spray application, before the main section of the yellow brushstroke.
- The sculpture is primed with a gray epoxy-based primer.
- On arrival at the Getty in 2005, the sculpture had an overall application of styrene-containing acrylic polyurethane clearcoat; this non-original clearcoat, probably also applied as part of the 1995 restoration, was very brittle and poorly adhered to the underlying paint.

Examination and chemical analysis of the samples from the Getty *Three Brushstrokes* have provided important documentary evidence of the paint systems used by Lichtenstein for his early works of outdoor sculpture. It is rare to find such physical evidence still remaining on these pieces because they have often been subjected to major restoration treatments, and the findings have helped to solidify the understandings obtained from oral evidence about Lichtenstein's techniques and materials that has come from his assistant, James DePasquale.

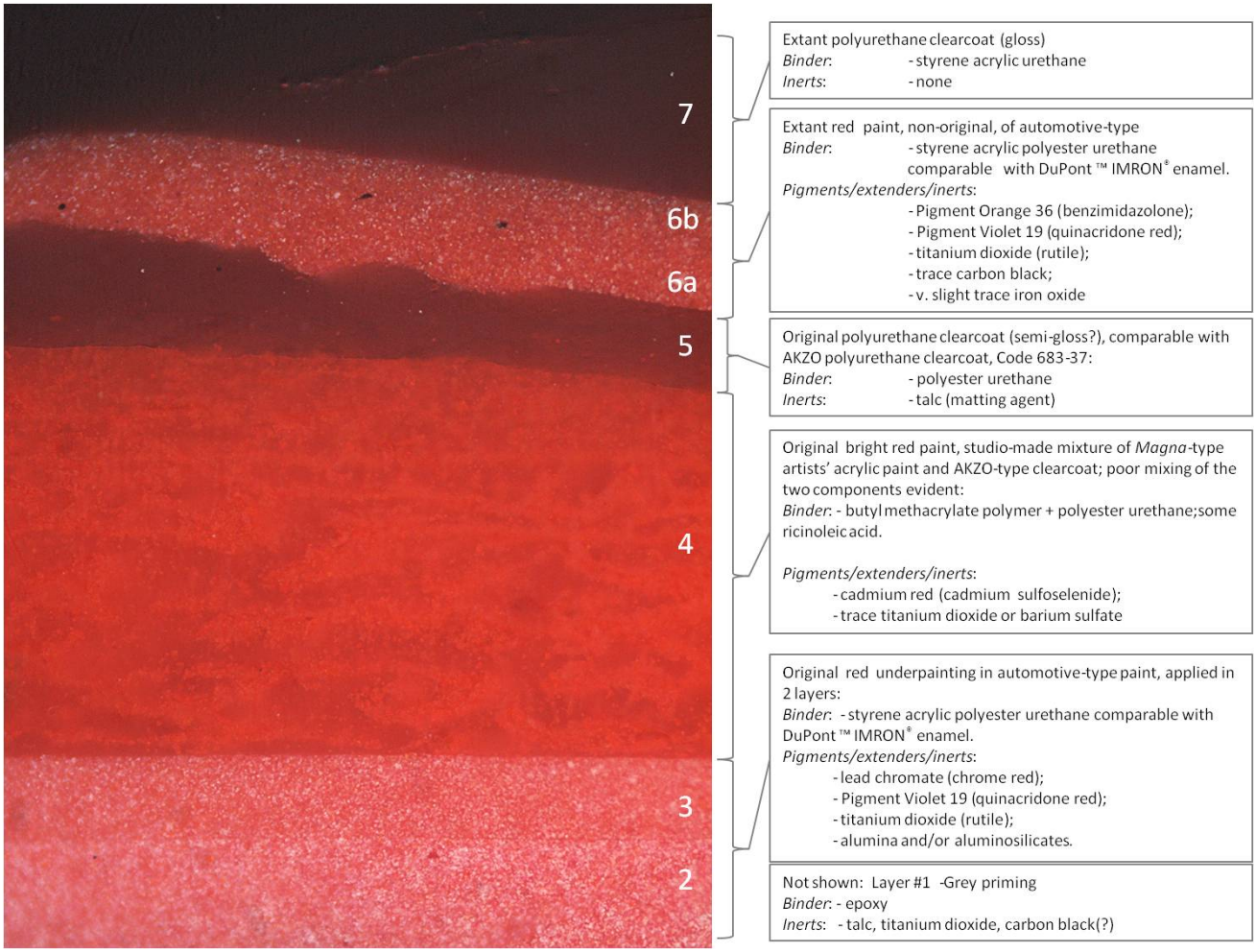

Figure 2. General summary of the findings of microscopical examination and chemical analysis of the various coatings observed in the red sample from *Three Brushstrokes.*

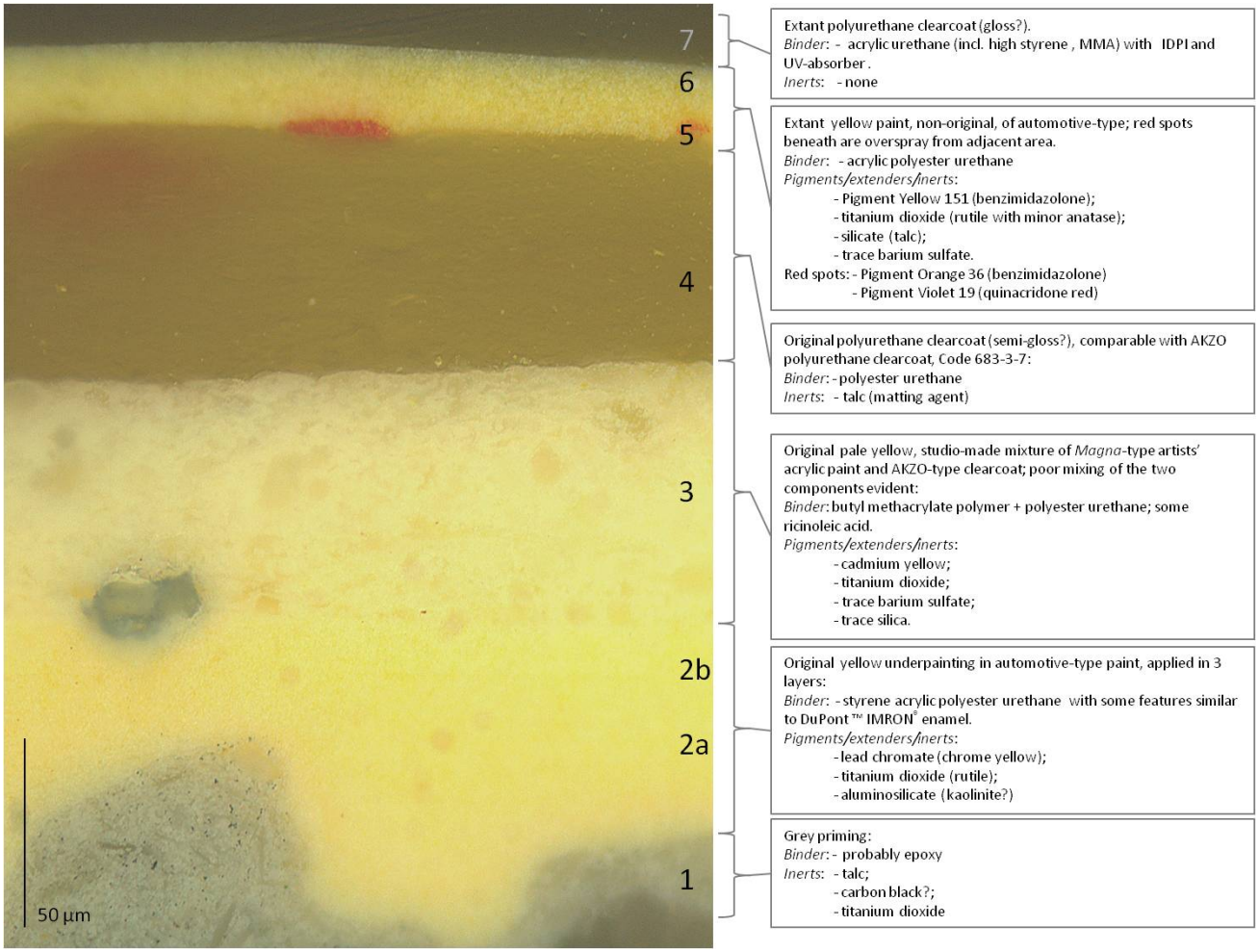

Figure 3. General summary of the findings of microscopical examination and chemical analysis of the various coatings observed in the yellow sample from *Three Brushstrokes*.

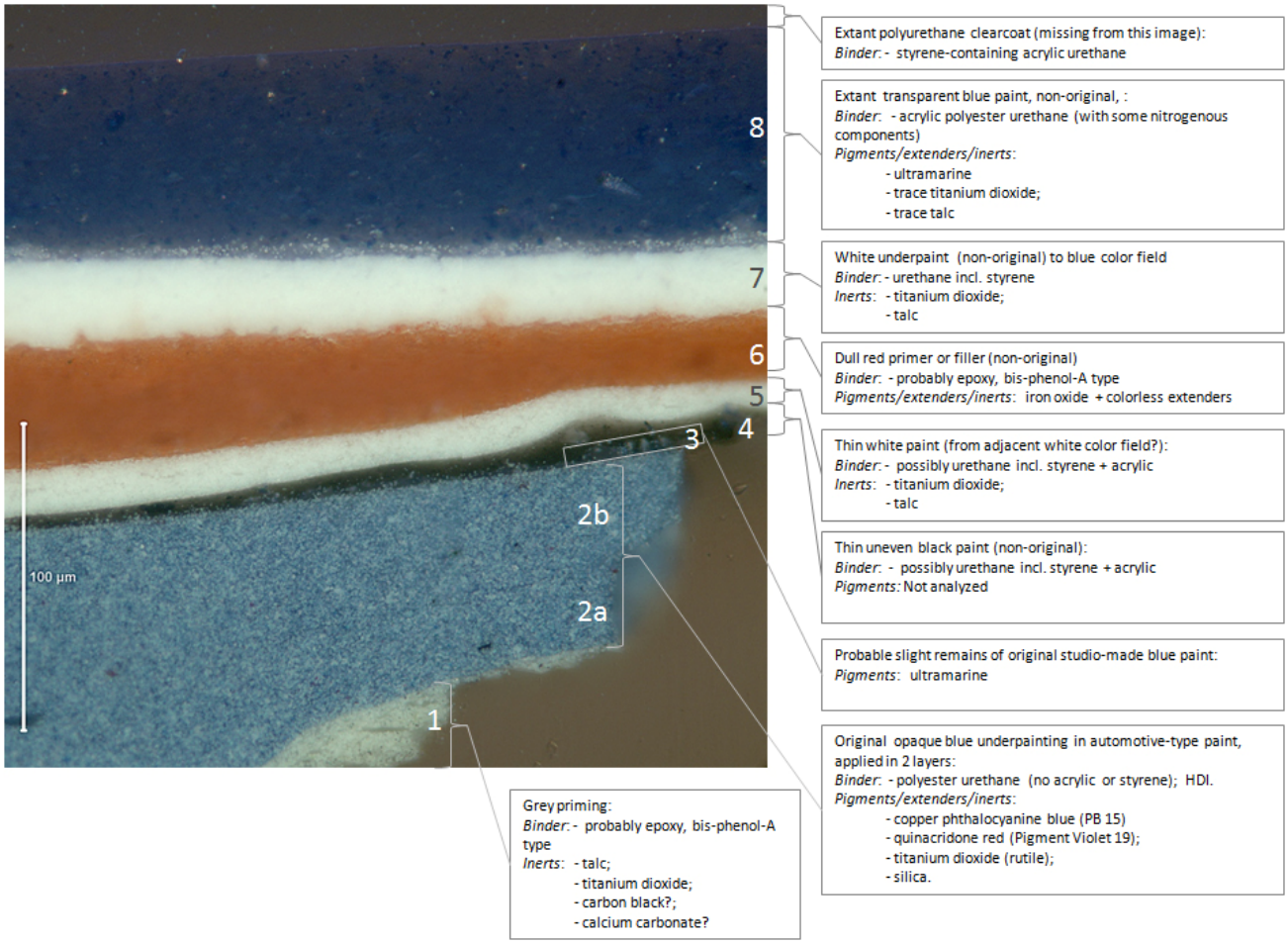

Figure 4. General summary of the findings of microscopical examination and chemical analysis of the various coatings observed in the blue sample from *Three Brushstrokes*.

Postscript: Additional sampling prior to conservation treatment in 2011. Clarification of the treatment history of the blue color field.

Examination and analysis of the original set of samples received from JPGM conservators showed that the stratigraphy in the blue color field was different to that observed with the other colors. The presence of a few isolated particles of ultramarine blue pigment with associated fluorescent organic material at the interface between the original opaque lower layers and the overlying restoration layers provided some trace clues that a studio-made paint, made from Magna acrylic and clearcoat lacquer, similar to that observed on the red and yellow brushstrokes, may have been present originally on the blue, but this paint layer no longer remained at the site from which the sample came. Whether this situation was representative of the larger blue color field was an outstanding question that could not be answered from the original sample set.

However, in early 2011, when the sculpture had been de-installed and was being examined by JPGM conservators in preparation for its major conservation treatment, an opportunity arose to take an additional cross-section sample from the blue stroke from an area that coincided with a micro-excavation exploring the paint stratigraphy. That sample is shown in **Fig. 5**, together with a photograph of the micro-excavation to show the correspondence between the layers and the surface appearance. Two important observations could be drawn from this sample. First, a

studio-made paint layer (layer #3 in **Fig. 5**) did indeed remain at this location on the sculpture: the pigment is ultramarine (which occurs in the Bocour Magna range) and the paint shows the same distinctive internal structure (the presence of two distinct phases, evident especially by UV fluorescence) as the studio-made paints observed on the red and yellow strokes. This studio-made paint was overlaid with a strongly fluorescent, particulate-containing clearcoat (layer #4 in **Fig. 5**), again, similar to those observed in the red and yellow samples. Secondly, in the layers (#5- #11) connected with the 1995 restoration of the sculpture, an additional ultramarine paint layer (#6) was observed compared to the earlier sample (**Figs. 4 and 5**). This first ultramarine paint of the 1995 restoration effort overlaid black paint (layer #5), and the combination of the transparent ultramarine over black resulted in a very dark appearance (see micro-excavation, **Fig. 5**, right) that would not have been an acceptable rendition of the color required for that stroke. It might be postulated, therefore, that the later layers of white paint/primer and red priming (layer #7, #8, and #9) are associated with an attempt to re-prepare the surface of the blue color field and provide a better, light foundation for the final, very transparent ultramarine paint (#10), which would have been necessary with this pigment to provide the appropriate combination of color saturation and lightness. Coincidentally, difficulties in the re-painting of the blue stroke were hinted at in anecdotal accounts of the 1995 restoration of the sculpture.

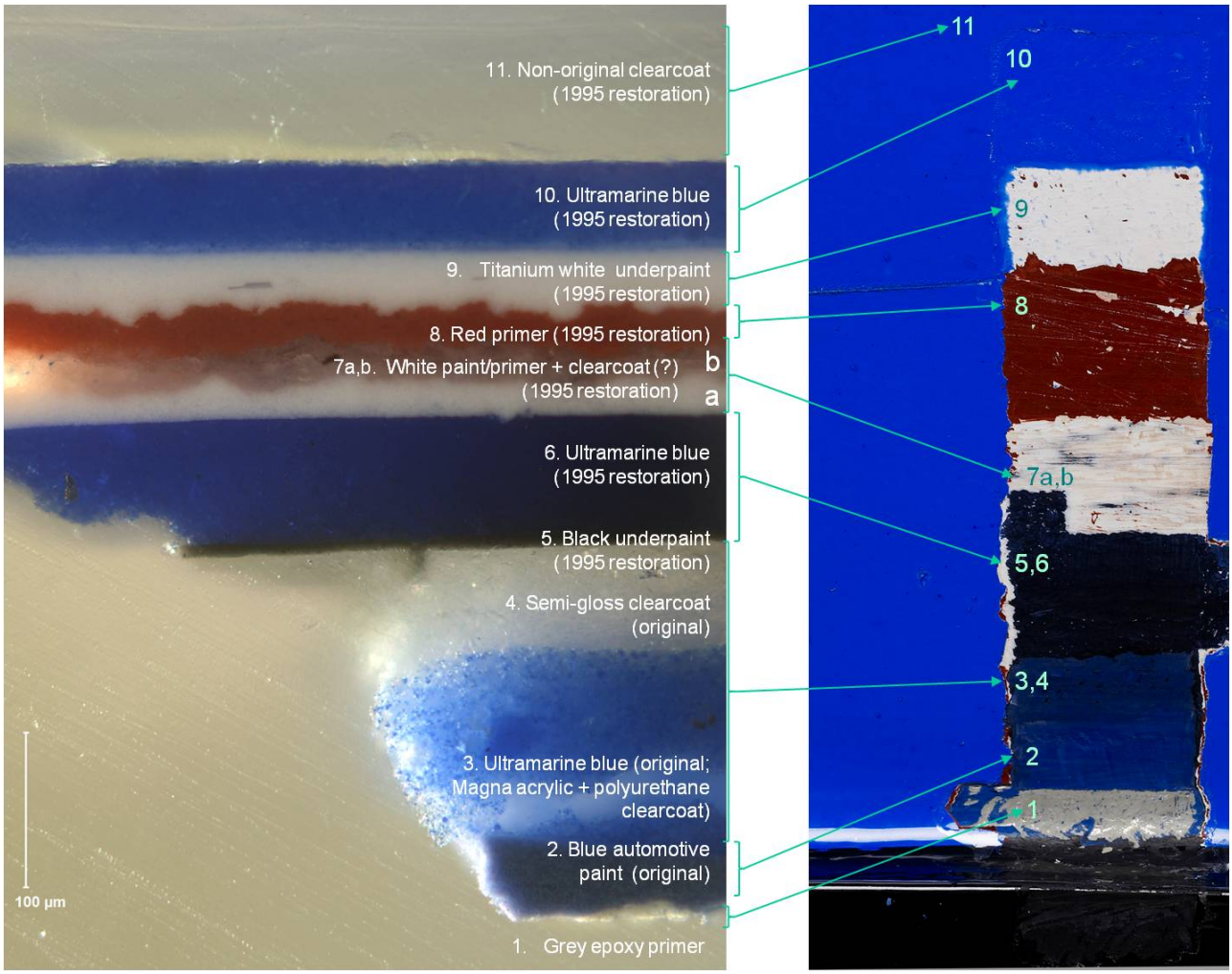

Figure 5. Cross-section (left) from the blue brushstroke of *Three Brushstrokes* taken in March 2011, and correspondence of layers with those observed in a micro-excavation of the same area (right).

Project Participants

Alan Phenix, Scientist, Getty Conservation Institute: microscopical examination of paint stratigraphy and pigment identification by spectroscopic methods.

Rachel Rivenc, Assistant Scientist, Getty Conservation Institute: instrumental chemical analysis of organic polymer paint binders and coatings.

Michel Bouchard, formerly Assistant Scientist, Getty Conservation Institute: micro-Raman spectroscopic analysis of pigments.

Lynn Lee, Assistant Scientist, Getty Conservation Institute: metal analysis and metallography.

Julie Wolfe, Associate Conservator, Decorative Arts and Sculpture, J. Paul Getty Museum: responsible for initial examination, conservation, and installation of the sculpture on acquisition in 2005 and later major conservation intervention (2011).

Dan Kirby, Straus Center for Conservation, Harvard University Art Museums: analysis of selected pigments by laser desorption mass spectrometry.

Bibliography

Buxbaum, G. 1998. *Industrial Inorganic Pigments*. Weinheim: Wiley-VCH.

Burns, D. and Doolan, K. 2005. "A comparison of pyrolysis-gas chromatography-mass spectrometry and Fourier transform infrared spectroscopy for the characterization of automotive paint samples", *Analytica Chimica Acta* 539: 145-155.

Cowart, J., ed. 1992. *Roy Lichtenstein: Three Decades of Sculpture*. East Hampton: Guild Hall.

Cowart, J. 1999. "Lichtenstein sculpture: Multiple personalities: A quick survey of five decades". In *Lichtenstein, Sculpture and Drawings: The Corcoran Gallery of Art, Washington, D.C.,* ed. Jack Cowart, 9–26. Washington, D.C.: Corcoran Gallery of Art.

Crook, J. and Learner, T. 2000. *The Impact of Modern Paints*. London: Tate Gallery Publishing.

Herbst, W. & Hunger, K. 2004. *Industrial Organic Pigments*. Weinheim: Wiley-VCH.

Kirby, D.P., Khandekar, N., Sutherland, K. and Price, B.A. 2009. "Applications of laser desorption mass spectrometry for the study of synthetic organic pigments in works of art". *International Journal of Mass Spectrometry* , 284: 115–122

Kuhn, H. & Curran, M. 1986. "Chrome yellow and other chromate pigments," in *Artists' Pigments*, Vol. 1, ed. R.L. Feller. Cambridge: Cambridge University Press. 187-218.

Learner, T. 2004. *Analysis of Modern Paints*. Research in Conservation. Los Angeles: Getty Conservation Institute.

Plage, B., Berg, A-D., and Luhn, S. 2008. "The discrimination of automotive clear coats by pyrolysis-gas chromatography and comparison of samples by a chromatogram library software", *Forensic Science International*, 177: 146-152.

Rivenc, R, Learner, T., Phenix, A. and Wolfe, J. 2009. "The identification of paints used on modern and contemporary outdoor sculpture". In *Art d'aujourd'hui, patrimoine de demain: conservation et restauration des œuvres contemporaines*, proceedings of 13th SFIIC Colloquium Paris, 24-26 June 2009. Champs-sur-Marne: SFIIC. 284-291.

Wicks, Z.W., Jones, F.N., and Pappas, S.P. 2007. *Organic Coatings: Science and Technology.* 3rd Edition. Hoboken, N.J.: Wiley-Interscience.

Wampler T.P. 1997. "Recent changes in automotive paint formulation using pyrolysis gas chromatography/mass spectrometry for identification", *Journal of Analytical and Applied Pyrolysis,* 40-41: 79-89.

Zieba-Palus, J., Zadora, G., Milczarek, J., 2008. "Differentiation and evaluation of evidence value of styrene acrylic urethane topcoat car paints analysed by pyrolysis-gas chromatography", *Journal of Chromatography A*, 1179: 47-58.

Acknowledgements

The Getty project team would like to thank the Roy Lichtenstein Foundation and the Roy Lichtenstein Estate, especially Jack Cowart, Dorothy Lichtenstein, and James DePasquale.

June 2011

For more information on the GCI Science program, visit
www.getty.edu/conservation/