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Use of X-Ray Mapping to Investigate Art Works Before Their Restoration

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Conservation involves the restoration and preservation of museum objects and historical monuments utilising compositional and structural information obtained from modern analytical techniques. The conservation of oil paintings requires an understanding of the individual structure of each work of art. This often involves the need for 1) correct identification of the pigments used by the artist, 2) a detailed knowledge of the chemical interactions between these pigments and 3) an understanding of the artist's method of mixing colours and laying paint on the canvas [1-3].

SEM/EDS analysis and X-ray mapping (XRM) are excellent tools for characterising the distribution of elements and phases in paint pigments as well as reacted paint pigments. The XRM analytical technique provides an image related to the distribution and relative abundance of elements within a given specimen and thus makes XRM particularly useful for i) identifying the location of individual elements, ii) mapping the spatial distribution of specific elements and iii) determining the reaction product (phases) within a sample [4-6]. SEM, X-ray microanalysis and XRM have been used for determination of the above points. With this information, conservation treatments can be specifically developed for particular oil paintings. A number of different art works have been investigated. The paintings used in this study were :

- Claude Monet "*Port-Goulphar, Belle-Île"* 1887, (oil on canvas, 81.0 x 65.0cm, Art Gallery of New South Wales, purchased 1949)
- John Russell *"Mon ami Polite"* 1900, (oil on canvas, 54.6 x 65.4cm, Art Gallery of New South Wales, purchased 1966)
- Phillips Fox *"Summer"* (1912), (oil on canvas, 205.7 x 88.9cm, Art Gallery of New South Wales, Gift of Mr Frank Grimley 1925)

Small paint chips were carefully excised from pre-existing damaged regions in each work of art and embedded in polyester resin (Struers Serifix), matching the hardness of an aged oil paint film. These samples were then carefully cross-sectioned with a microtome. The exposed sections were examined by optical microscopy under both incident visible and ultraviolet illumination.

Prior to imaging and analysis in the SEM, the microtomed resin blocks containing the cross-section of each paint chip were coated with 30nm of carbon to prevent localised charging under the electron beam, using a Balzers CEA010 carbon thread evaporation attachment connected to a Balzers SCD020 sputter coating unit. Each specimen was analysed using a JEOL 35CF SEM equipped with an Oxford energy dispersive spectrometry (EDS) X-ray detector with a Moran Scientific X-ray analysis and mapping system. SEI and BSE imaging were used to locate individual paint pigments for X-ray analysis. Pigments were then identified using a database of x-ray spectra collected from a broad range of 19th and 20th century pigments. Many of the pigments used in this era contained a signature element, which was utilised to map the distribution of each pigment within a given layer.

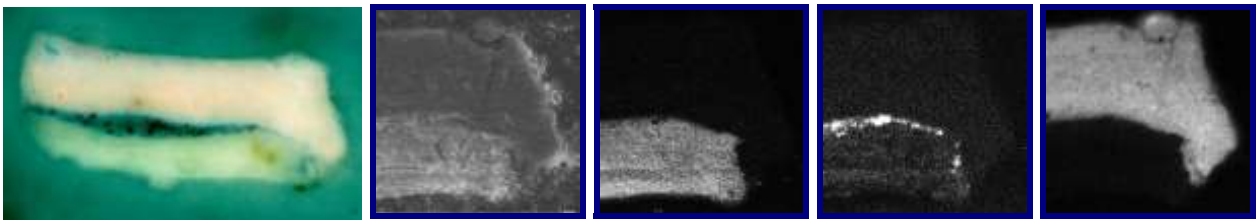
All X-ray maps were acquired at 25kV, 512×512 pixel resolution and a dwell time per pixel of 200 milliseconds to obtain good counting statistics.

Investigations of "*Port-Goulphar, Belle-Île"* gave an insight into the painting technique used by Claude Monet by examining the interface between successive paint layers in each specimen. The absence of a separation between adjacent paint layers signified that the artist laid paint wet on wet, mixing pigments directly on the canvas. The presence of a separation implied that the paint was applied wet on dry, indicating in this case that the artist worked on the painting over a extended period, as oil paints take some months to dry [1].

Investigations of John Russell's *"Mon ami Polite"* revealed this work was originally painted before 1900 and then repainted on the same canvas (FIG. 1). After 1900, Russell started using zinc white because he was worried that lead white could darken. Consequently, an insight into the painting technique of Russell and choice of pigments was investigated.

Investigations of Phillips Fox's painting *"Summer"* was performed to determine the cause of powdering and disintegration which had been observed within the yellow regions of the painting alongside dark discoloration at the interface of the yellow and the green. Results revealed the discoloration and cracking of the paint layers stem from a reaction between the cadmium yellow (CdS) and the emerald green (copper acetate arsenite) producing black sulphides of Cu which formed when the two pigments were used together.

This paper will demonstrate the use of SEM, EDS and XRM post processing techniques to obtain a better understanding of the paint pigment dispersion and determining the types of pigments used, with the overall aim of this research aiding the correct restoration method and maintenance of the paintings.



a. b. c. d. e.

FIG. 1: Paint Chip removed from John Russell's *"Mon ami Polite"* painting. a) Optical image, b) SEI Image, c) Pb X-ray map, d) Co X-ray map and e) Zn X-ray map.

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