Applications of environmental scanning electron microscopy, X-ray energy dispersive spectrometry and focussed ion beam techniques to cultural heritage research

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The last decade has seen a concerted effort to apply microscopic and microanalytical techniques to the field of cultural heritage research. For example, in the USA a 2009 workshop co-sponsored by the National Science Foundation (NSF) and the Andrew W. Mellon Foundation concluded that the field of cultural heritage science could greatly benefit from collaboration between conservation scientists, located in US museums, and chemists and materials scientists in academic institutions [1]. NSF initiated a program to facilitate collaborations between conversation scientists and materials scientists to address challenges in the field of science of cultural heritage [2]. In Europe, the “Cultural Heritage Advanced Research Infrastructures: Synergy for a Multidisciplinary Approach to Conservation/Restoration” program is a European Union funded project carried out within the Seventh Framework Programme "Research Infrastructures". The project promotes access to advanced scientific instruments and fosters collaboration between scientists, conservators/restorers and curators. The University of Michigan Electron Microbeam Analysis Laboratory has a number of active projects with cultural heritage investigators. Three of these are summarized below.

The Detroit Institute of Arts (DIA), in its endeavor ensure the attributions of a number of donated works to the museum, has been analyzing the morphology and chemistry of the paint layers of those works. A work entitled “Three Figures Resting Under a Tree” bears the apparent signature of Claude Monet and scanning electron microscopy (SEM) and X-ray energy dispersive spectroscopy (XEDS) of small (~200µm) particles of paint extracted from the canvas reveal layers and pigments consistent with the time period. However, in his archive research, DIA Associate Curator of European Paintings Salvador Salort-Pons, found a photograph of the painting, taken when it was exhibited at the Carnegie Museum of Art in Pittsburgh, bearing the signature of British artist Sir Alfred East, a contemporary of Monet’s. The painting is actually entitled “The Tewkesbury Road.” This identification serves to emphasize the necessity of applying multiple techniques in the analysis of historical materials.

In a project to determine the production sequence of a set of silver coins, from the reign of King Eadberht of Northumbria, 737-758AD, XEDS was employed to measure the bulk chemistry of the coins. Each coin is coated in a patina, removal of which devalues the coins considerably. Small cracks in the patina were widened and the coin surface lightly polished to allow XEDS analysis of the silver rich α and copper rich β alloy mixture (Figure 2). Results of the XEDS analyses have been compared with bulk X-ray fluorescence studies to determine the most effective, accurate and minimally invasive technique for determining the chemical composition of the coins.

At The Henry Ford Museum, a 1907 Model G White Steam Touring car [3][4], is of particular interest to the museum’s conservators, as it is believed to have its original paint. The museum’s founder, Henry Ford, frequently restored damaged components and had resources available to repaint and re-make parts. That this specimen was not heavily restored is important, since the car is from an era where the early automobile paint processes were being derived from the coach builders’ craft. The sequence and composition of paint layers is important if the conservation of the car is to proceed without seriously changing the original materials. Analysis of cross-sections of paint flakes from the car has revealed the presence of six distinct layers, all but one of which (layer 5) were comprised of fine grain particles (Figure 3). XEDS analysis of the layers (Figure 4), and subsequent
scanning transmission electron microscope (STEM) microscope analysis of focused ion beam (FIB) extracted thin sections, has shown that the 3rd and 4th layers contain pigments contemporary to 1907. The final 6th layer, however, which is about 8µm thick, is comprised of fine grain paint pigments suggesting an overpainting in the 1940s.

References