USE OF VISIBLE AND INFRARED REFLECTANCE AND LUMINESCENCE IMAGING SPECTROSCOPY TO STUDY MEDIEVAL ILLUMINATED MANUSCRIPTS

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Site specific, *in situ* techniques such as X-ray fluorescence (XRF) and Raman spectroscopy are commonly used to identify pigments on illuminated manuscripts. While such methods are analytically powerful, they cannot be used to survey the entire surface of a miniature. With both techniques, spectra are usually acquired on visually identified sites thought to be representative of the pigments and mixtures used for the illumination. Such visual inspection may not always ensure an adequate representation of the pigment diversity. Here we present some results regarding the application of multispectral visible/infrared reflectance and luminescence imaging spectroscopy, along with fiber optics reflectance spectroscopy (FORS) to help determine and map the primary pigments on medieval illuminated leaves, and to help visualize preparatory sketches and changes ("*pentimenti*"). The use of imaging spectroscopy for the study of light sensitive materials such as illuminated manuscripts can be problematic because of the need for higher light levels as the spectral bands are narrowed. Many of the existing multi-spectral imaging camera systems having high spatial fidelity require high light levels. Recently an optimized low noise, high sensitivity 4 mega pixel 12 band visible/near-infrared multi-spectral imaging camera with enhanced blue lights, was developed for the study of works of art on paper and vellum requiring low illumination, comparable to gallery light levels. This camera system was also used to collect luminescence images in the visible to near infrared, while illuminating the objects with blue light. Reflectance images in the 1000 to 2500 nm infrared spectral region were acquired using another highly sensitive camera that allowed observation of preparatory sketches and compositional changes at the same low light level. Additionally, higher resolution reflectance spectra were collected using a FORS spectrometer (350 to 2500 nm). Several works in the NGA collection were imaged using this methodology, some of which will be used as case studies to illustrate the application of these techniques to the study of illuminated manuscripts. XRF and visible/infrared FORS analyses of visually selected sites on the manuscripts showed the presence of several pigments typically used for illuminations in the Middle Ages, e.g. azurite, ultramarine, vermillion, lead white, "mosaic gold", organic dyes and yellow earth pigments. Additionally, the spectral analysis of the multispectral reflectance images yielded distribution maps for these pigments (i.e., regions of azurite, ultramarine, vermillion) along with some indication of pigment layering not identified visually. The luminescence image gave a probable map of the organic dye(s). The reflectance and luminescence multispectral images therefore allowed completing the characterization of the pigment distribution and layering on the illuminated leaves in a totally non-invasive and relatively fast way, not requiring a time-consuming detailed observation under the microscope. This approach of combining high fidelity site-specific methods (FORS and XRF) with the mapping capability of multispectral reflectance and luminescence imaging spectroscopy appears thus to be a useful tool, providing improved *in situ* mapping and identification of pigments in illuminated manuscripts.