3D Visualization of Hidden Paint Layers Using Stereographic Macro-XRF Technique

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Scientific investigation of paintings has been facilitated by the development of advanced non-destructive imaging methods. Characterization of painting stratigraphy traditionally requires extraction of small paint samples, thereby limiting its use to a few locations on a painting due to its destructive nature. Alternatively, non-destructive analysis of paint layer stratigraphy across an entire painting often requires highly specialized and costly equipment, and/or the transport of priceless artworks. While pump-probe microscopy has recently emerged as an option for nondestructive measurement of virtual paint cross-sections, it is non-portable, limiting its current utility [1].

We propose an alternative method for stereographic examination of paintings using a Bruker M6 Jetstream portable MA-XRF spectrometer with four 90 degree rotations of the specimen and reduced step sizes coupled with a novel data analysis method which will enable the study of topographical features of large areas of subsurface paint layers. As a prototype to test the feasibility of the method, we utilized a two-layer test sample consisting of pastose bone black pigment on pastose lead white, with an aluminum substrate. High resolution 3D optical microscopy was utilized to establish the ground truth for the thicknesses of both paint layers. Early results obtained by co-registering the four separate MA-XRF scans are promising in demonstrating the feasibility of inferring details of the painting stratigraphy from the combined signals of multiple off-axis x-ray detectors. Coupled with novel data fusion algorithms and visualization techniques, additional insight about painterly technique can thus be gained by utilizing existing MA-XRF scanners to scan a painting in multiple orientations.
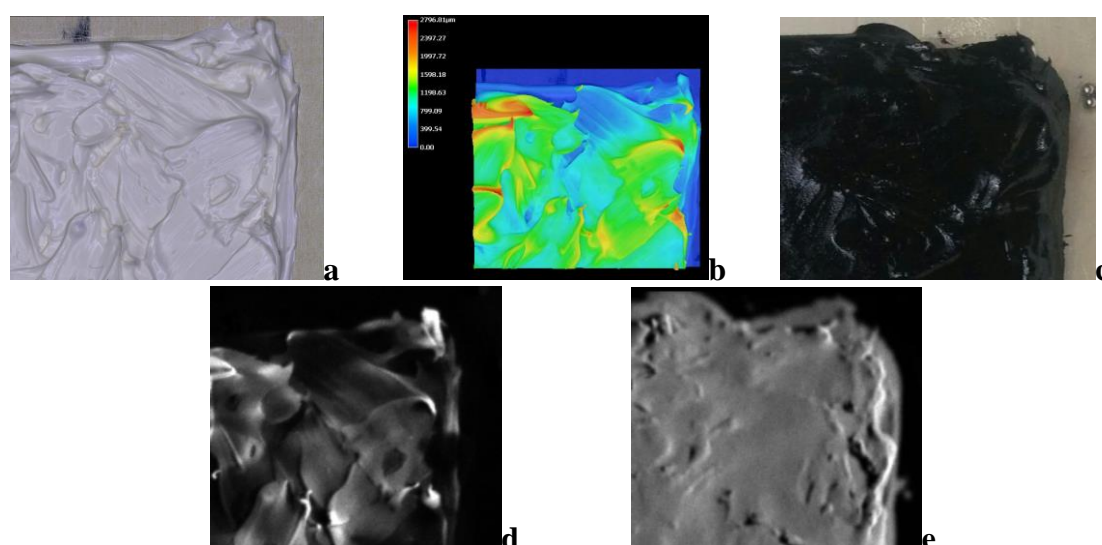
a. Optical microscope scan of lead white layer   **b**. 3D optical microscope scan of lead white layer
c. Bone black painted over lead white **d**. XRF Pb-Kβ distribution   **e**. XRF Ca-Kα distribution

[1] Villafana, T.E., Brown, W., Delaney, J.K., et al, PNAS 111(5), 2013, 1708-1713