# NEW TRENDS

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The use of synchrotron radiation induced X-ray fuorescence is well suited for pigment elemental analysis in art works since the analysis is very fast and non-destructive, micronsize beam spots and high fluences make possible to probe tiny regions to disentangle individual pigments and detect trace elements and the beam energy can be easily changed to probe different elements and/or vary the depth of analysis.

We present the results of a study of the pigments of the illumination on the opening page of a manuscript decorated around 1450 by the Fra Angelico workshop in Florence, using SR-XRF and a thick, fully-depleted CCD as X-ray detector. The study is aimed at clarifying the results of the stylistic analysis, which indicates that the illumination may be the work of two distinct artists, one responsible for the body of the initial and its foliate extensions, while a second hand paints the figure of the Saint, which inhabits the initial.

The use of a CCD sensor offers several advantages over a conventional Si(Li) bulk detector.

The active surface is large and the high pixellisation allows to operate with large fluxes, particularly important at a light source, without pile-up. For this study the average cluster density ranges from $10^{-3}$ to 50 clusters/mm$^2$, depending on the solid angle, primary beam intensity and pigment under analysis. Cluster shape analysis is performed to reject spurious background signals and scattered photons striking the detector at large angles and provides very high S/B ratio for X-ray lines. At the same time thick, fully depleted CCDs offer very high detection efficiency and excellent energy resolution, matching that of more conventional X-ray detectors.

The single pixel noise of the CCD used for this analysis is (4.2_1.0) $e^-$ENC and the energy resolution 155 eV FWHM at 5.9 keV.

The study is performed at the LBNL Advanced Light Source. The synchrotron radiation is produced in one of the main ring bending magnets, with a continuum spectrum up to ' 20 keV. A monochromator selects the beam energy, collimators collimator eliminate the white beam and define the monochromatic beam geometry and a shutter controls the time of irradiation, set to 0.5 s/event. For this study the beam energy is chosen to be 12 keV. The beam spot at the sample surface has a diameter of ' 0.7 mm. The sample is mounted on a computer-controlled XY stage, which allows to perform automated scans of the manuscript.

A total of twenty five points have been take on the decorated surface of the manuscript, corresponding to all the nine different colours present in the decoration. In particular, we compare the composition of the pigments in the foliate decoration and in the initial. We find that the composition of pigments corresponding to the same colours to be different. The red is mostly Pb, as in the minium on the extensions, while contains also Fe and traces of Zn and thus could be a ocra rossa, plus Cu, possibly from a preparation layer, in the book hold by the Saint in the initial. These results, though preliminary, support the conclusion from the stylistic analysis that there are two independent artists working on the miniature. We also study the pigments on the face of the Saint, where IR photography shows the

existence of areas of underpaint used by the artist for the rendering of deep shadows, on the gold leaf and the foliate extensions. Results of XRF pigment analysis prove helpful when aimed at the clarification of well-defined problems from the stylistic analysis and provide us with a more precise understanding of the techniques used in the workshop of one of the most in influential painters in early Renaissance Florence.

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