SCANNING X-RAY POWDER DIFFRACTION MAPPING OF PAINTED WORKS OF ART USING CU AND AG LAB SOURCES: ADVANTAGES AND LIMITATIONS

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A transportable laboratory-X-ray powder diffraction (XRPD) set-up consisting of a microfocus X-ray source (100x100 µm²) and a two-dimensional single-photon counting XRD detector was constructed. This was augmented with a motorized sample/artefact stage and appropriate software to create a macroscopic XRPD scanner, capable of delivering large scale maps reflecting the distribution of crystal phases on/near the surface of quasi-flat artistic artefacts. By changing the geometry of the different components, imaging analyses can be performed both in transmission- and reflection-geometry. Simultaneous switching between a Ag-anode and a Cu-anode X-ray tube allows to collect either superficial or depth-averaged information.

Recently, several painted works of art from the 16-19th century have been investigated with this device in musea such as the Royal Museum of Fine Arts, Antwerp and the Musea Brugge (Belgium) and in the Rijksmuseum and Van Gogh Museum, Amsterdam, as well as in the Mauritshuis museum, The Hague (Netherlands).

When comparing the results produced by the MA-XRPD instrument with those obtained by means of other non-invasive methods such as macroscopic X-ray fluorescence analysis (MA-XRF) and various types of hyperspectral imaging, it is possible to pinpoint a number of strong and weak points of this method. Advantages include the high specificity with which mapping of crystalline paint components can be performed. Next to providing information on the distribution of the pigments employed by the artist, a marked advantage is that also information on degradation products can be obtained. The latter are formed *in situ* as a result of spontaneously occurring chemical reactions inside the paint, often induced by light. Limitations of MA-XRPD stem from the fact that the measurement time per scanning point is quite extensive (typically in the 1-10 s range) while in reflection geometry also a fairly large primary X-ray footprint (of the order of 0.1x1 mm^2) must be used. Both of these drawbacks cause the final image resolution to be limited. However, when MA-XRPD is combined with a less specific but faster imaging method such as MA-XRF, a number of the disadvantages can be compensated for.

The (dis)advantages of MA-XRPD will be illustrated with case studies involving non-invasive MA-XRF and MA-XRPD mapping of works of art by the 17th century painters Jan Davidsz. de Heem, Abraham Mignon and Johannes Vermeer and by 19th century artist Vincent van Gogh.