

The secret of black marker pens: Identification workflow with non-invasive hyperspectral and macro X-ray fluorescence imaging techniques

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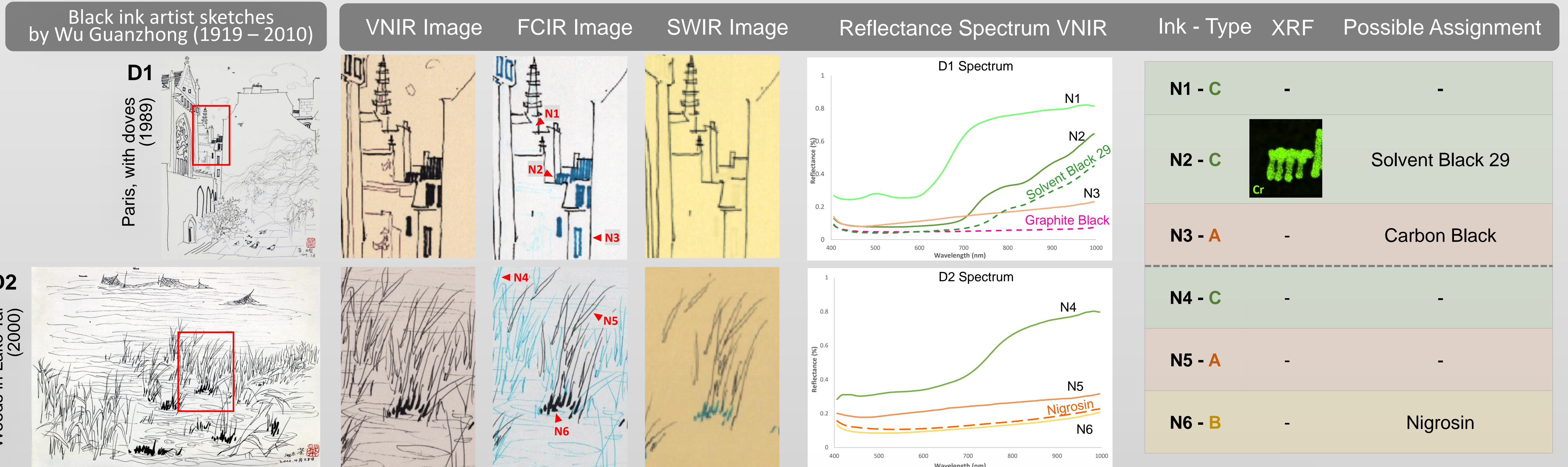
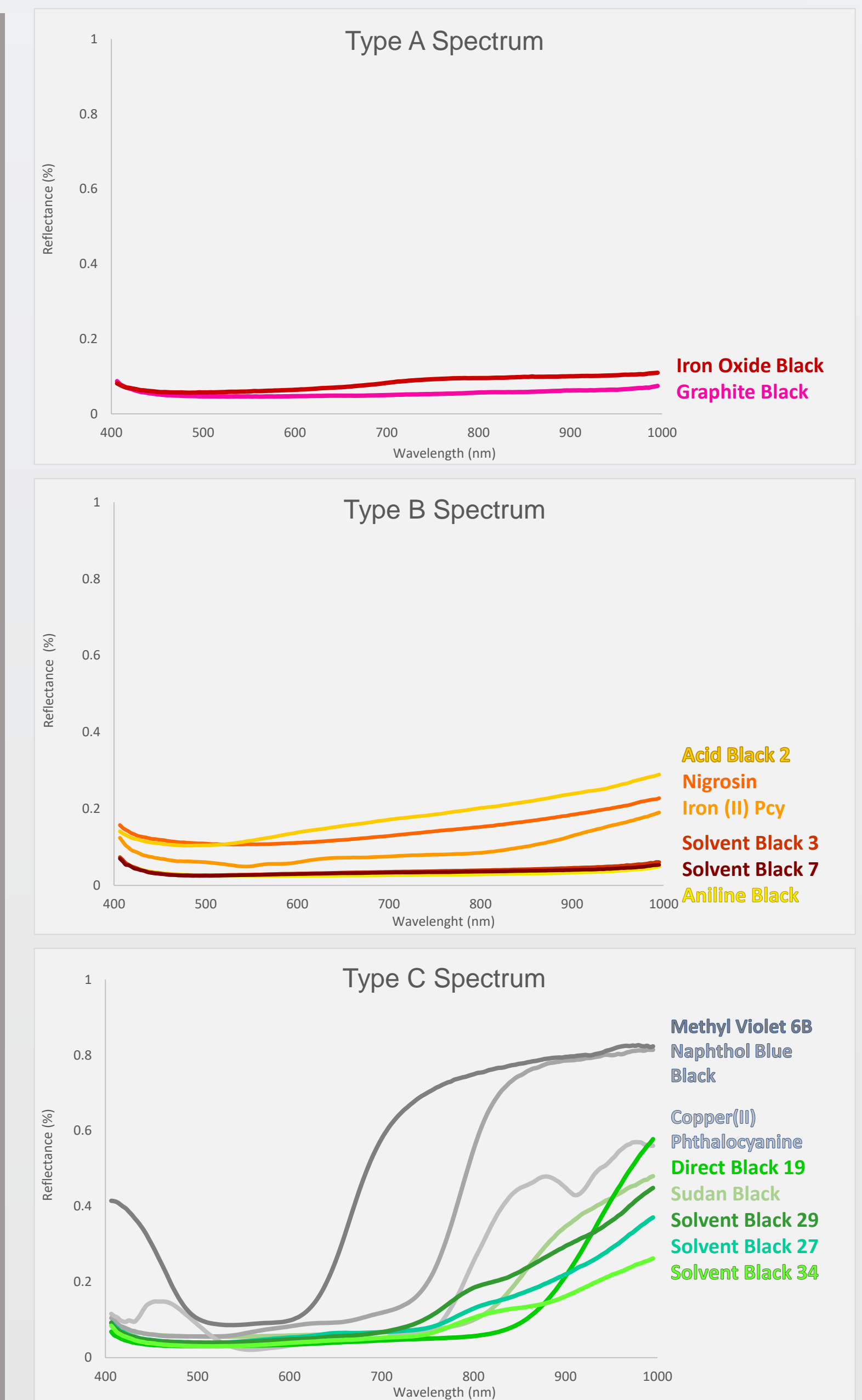
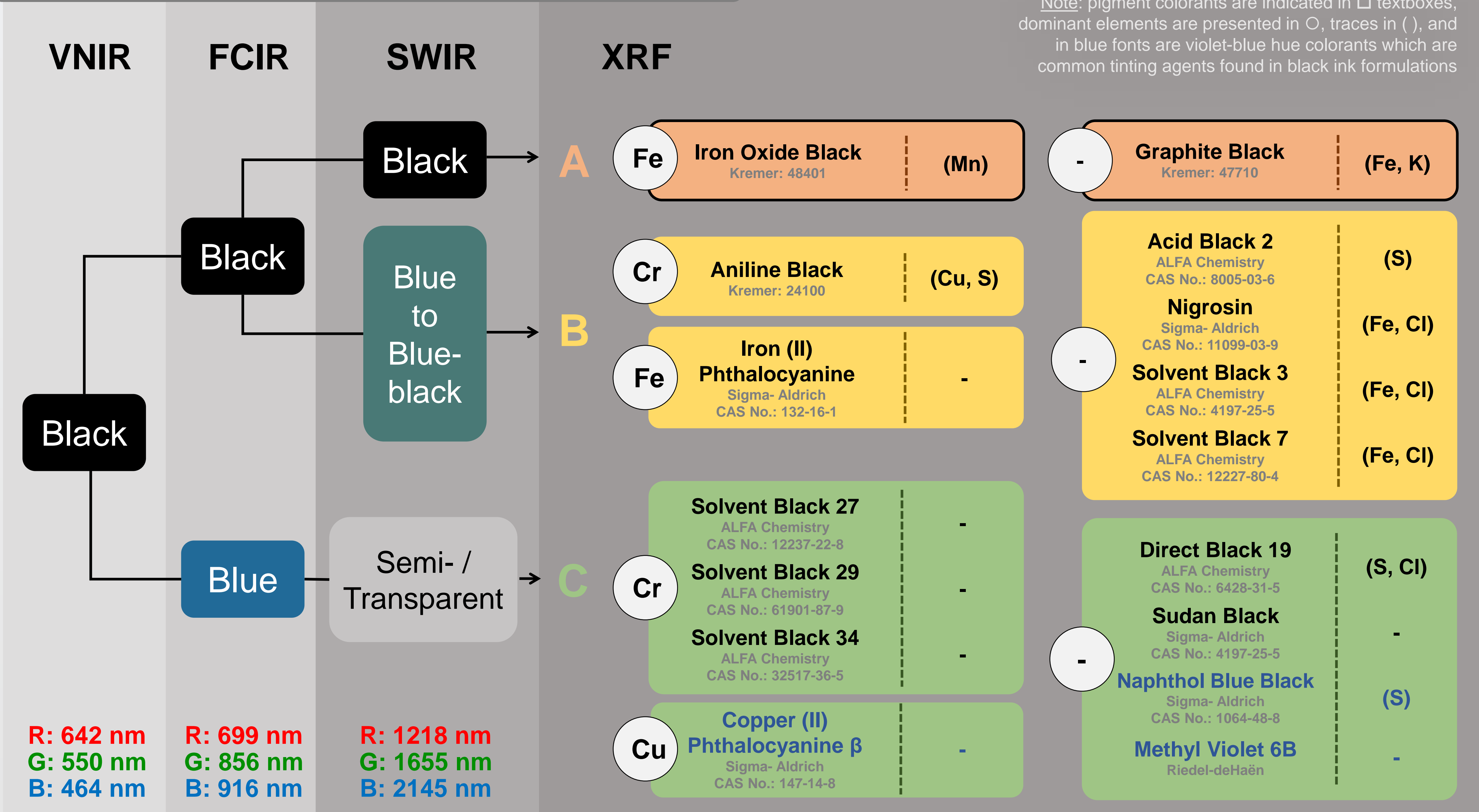
Background and Objectives

- Marker pens were popularized in the 1950s, a common and convenient writing stationery, widely used in artist drawings, illustrations, architectural plans and archival documents
- Blue and black inks are well-studied in the field of forensic science but the analytical methods usually involve sampling which is not always applicable to cultural heritage objects
- Media identification is fundamental in the development of preservation plans
- This study aims to establish a workflow by a combination of the non-invasive techniques - **hyperspectral imaging (HSI)** and **macro X-ray fluorescence (MA-XRF)** analysis to characterize and attempt to identify some of the commonly found **black colorants in marker pens and modern drawing inks**

Method

- **13 commonly occurring black colorants** in modern black inks were studied
- Dry pigments were mixed with gum arabic, dyes were dissolved in ethanol or water, then applied on off-white 130 gsm drawing paper
- HSI data was collected with **HySpex VNIR-1800** for the **visible to near infrared range 400-1000 nm** and **HySpex SWIR-384 short-wave infrared** from **930-2500 nm**
- **False Colour (FC) images** were created with the VNIR images by adjusting the wavelength display channels (nm) : **R → 699, G → 856 and B → 916**
- XRF scan of the colorants was performed with the M6 Bruker Jetstream (Rh anode, 50 kV, 600 μA, air-path)
- A **flowchart** was developed based on the FCIR, SWIR images and elemental results of the colorants which could be **summarized into 3 categories**

Flowchart for the categorization of black colorants



Application and Results

- 2 black ink artist sketches (D1-2) from the Wu Guanzhong collection of the Hong Kong Museum of Art were scanned with HSI and XRF
- 3 distinctive inks are observed in each of the drawings, evidently in their FC images: inks N1-3 in D1 and inks N4-6 in D2
- Results would suggest **Category A – pigment based inks, Categories B and C – dye based inks**
- Following the flowchart, reflectance spectrum of each ink is compared with reference materials, and possible assignments are determined for **N2 – Solvent Black 29 (dye), N3 – carbon (graphite) black and N6 – Nigrosin (dye)**
- N3 is in fact a dark blue ink, this is replicated by a peak at around 500 nm and shoulder above 600 nm in its reflectance spectrum

Discussion and Future Work

- Imaging result provides **insight to the artistic creative process** of the artwork
- Analysis of a **combination of FCIR and SWIR images** has proved to be effective to **differentiate between the various black inks** present in an artwork
- The flowchart categorization of inks may help to evaluate the vulnerability of an artwork, **to distinguish between black pigment and dye based inks**, as the latter are more moisture sensitive and prone to fading and/or discoloration
- Some **black dye colorants exhibit distinctive spectral features and/or elemental component** which show potential for media identification
- Building a media reference library on colorants in their chemical forms, as well as commercial drawing inks and pens will aid material studies of the contemporary museum and archival collection
- **Ink deterioration and fading, mixtures and concentrations** are all factors which complicate ink identification, **further study** is required to investigate and verify their impacts on the categorization and identification flowchart

Selected References

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