From Jikji to Gutenberg
a research statement for the technical examination of East Asian and mid-European sheets of paper printed from inked moveable metal type 1300–1500 CE

draught of 21 May 2022

Contents

Aims

Collaboration between team members with their divergent expertises will strongly contribute to the success of the *From Jikji to Gutenberg* project, as stated repeatedly during our Kickoff meeting on Wednesday 11/Thursday 12 May 2022:
https://stream.lib.utah.edu/index.php?c=details&id=13497.

The following concept therefore proposes considerations for a smooth and efficient collaborative working manner, in order to agree upon a general protocol for the technical examination of the objects under research regarding material-technical aspects of metal type, paper, ink, printing, and conservation.

Other manners for acquiring information about the production of historical metal type, paper, printing inks, printing, and conservation can be:
- interpretation of contemporaneous documentation
- interpretation of comparable information from a different location
- interpretation of comparable information from a later period
- modern reconstruction research
- modern references regarding the materials and techniques of the objects under research

Observation

- appearance of *type design* and *type indentation*
- appearance of *paper*
- appearance and behaviour of *ink*
- characteristics of the *printing process*
- *interaction between paper and ink* during printing and after printing
- remains of *conservation*

Identification

- *type*: metal alloy, shape, design of typeface
- *paper*: fibre, mould texture, sizing, fillers, coating, surface treatment, dampening (or not)
- *ink*: colourant, binding medium, conditioners
- *printing*: type indentation, behaviour of ink and paper, interaction between paper and ink
- *conservation*: treatment, storage, provenance marks

Definitions

type: a cast metal object, its face keeping a character or letter that was inked and next printed on paper

paper: a thin, mould-made mat of vegetable fibres onto which inked type was printed
- in Korea, vegetable fibres produced from the rinds of different shrubs or trees, especially of mulberry
- in Europa, fibres usually produced from rags, especially linen cloth produced from flax fibres

ink: a paste-like substance that was applied to the surface of metal type to be printed on paper
- in Korea, a water-based substance, presumably a mixture of animal gelatine in water and a black pigment such as lampblack or boneblack
- in Europe, an oil-based substance, commonly heat-bodied (boiled and burned) vegetable oil (usually linseed oil) with a lead drier mixed and ground with a black pigment (always lampblack); for European blockbooks printed from woodblocks several kinds of recipes of water-based inks can also be observed

printing: offsetting ink applied to the surface of metal type onto a sheet of paper
- in Korea, ink was applied to the surface of metal type, a sheet of paper placed on top, the verso-side of the sheet rubbed with a special tool until ink was offset from all of the type onto the paper's surface
- in Europe, metal type was positioned in a common press (book printing press), ink was applied to the surface of the type, a sheet of paper positioned on top of it and a platen moved down semi-mechanically to press the paper against the inked type to offset the ink onto the paper; for blockbooks the block was inked and the verso-side of the paper positioned on top rubbed to make an impression

conservation: the life of the object from its production onward

Research questions

- What are the differences and similarities between *type casting* methodologies in the Korean and German theatres, and how significant are they?
- What are the characteristics of the *papers* selected for printing from metal type in the Korean and German theatres, and how significant are they?
- What are the differences and similarities between *ink formulations* for printing from metal type in the Korean and German theatres, and how significant are they?
- What are the differences and similarities between *printing processes* from metal type in the Korean and German theatres, and how significant are they?
- What are the differences and similarities between the *interactions between paper and ink* during and after printing in the Korean and German theatres, and how significant are they?
- How do printing *papers* for woodblocks and metal type in both locations compare?
- How do printing *ink formulations* for woodblocks and metal type in both locations compare?
- How do *printing processes* for woodblocks and metal type in both locations compare?
- Can *comparisons* be made between East Asian woodblock printing to early Korean and German typographic printing?

First selection of objects

The *From Jikji to Gutenberg Project* is a broad humanist enquiry seeking to make new discoveries regarding early moveable *metal type*, and its specific *printing papers*, *printing inks*, *printing processes*, and following *conservation* throughout the world. The printing of the *Jikji* (1377) with loose metal type precedes the printing of the *Latin Bible* (1452–55) by Johannes Gutenberg by more than 70 years, with the development of Korean printing from moveable metal type presumably going back to the 13th century CE. This gives rise to questions regarding differences and similarities about historic working methods and materials used for printing these artifacts in geographically separated parts of the world and in different periods. Included therefore are similar printings in Korea that surround the known date of the *Jikji* printing with additional printing in East Asia, and similar printings in Germany that surround the estimated date of the *Latin Bible* printing with additional printings by, for example, Gerard Leeu in the Netherlands, William Caxton in England, and Aldus Manutius in Italy.

From general to molecular

Examination of objects in plain light:
- images of recto-sides and verso-sides
- images of selected details

Examination of objects with raking plain light:
- images of recto-sides and verso-sides
- images of selected details

Examination of objects with transmitted plain light

Examination of objects in multispectral light:
- images of recto-sides
- images of verso-sides, depending on results of examination in normal light

Examination by digital microscopy:
- texture of papers, geography of ink layers, type indentations, conservation, aging, damages

Examination with XRF, SEM-EDX, and various spectroscopy techniques:
- identification of principle components
- format and shape of pigment and filler particles, and of paper fibres

Printing forme

- metal alloy constituents: see contemporaneous art technological sources and modern references to the examination of the oldest surviving pieces of metal type, possibly foreign metalic particle inclusions can be found during ink examination
- type production: see contemporaneous art technological sources, modern references to the examination of the oldest type, and by reconstruction research
- type handling: by reconstruction research
- shape of type used: see modern references, and by reconstruction research
- variety of type height (foot to image) of the same character/letter: due to manual production
- design of typeface: differences, or not, between, impressions of the same character/letter on the same page or different pages of the same volume
- type setting: differences, or not, between how type is set on the same page or different pages of the same volume

Printing support

- characterising the overall quality of the paper relative to other paper being made in the same region in the same period (other printing supports are not considered at the present stage)
- assessment of fiber selection and preparation
- mould surface construction and condition
- sheet forming
- couching and drying
- fillers, sizing, coating, colouring, bleaching, foreign inclusions
- dampening of sheets with water for printing, or not
- handling of paper during the printing process
- drying of the printed sheet
- identification of the printing process by means of observing paper behaviour

Printing medium

- ink constituents: colourant, binding medium, conditioners; see Ad Stijnman, *Literature on the technical examination of printing ink in incunabula, with some additional references, in chronological order* (2022)
- ink production
- ink application
- dullness/gloss of the ink surface
- opacity/transparency of the ink layer
- crispness of ink layer edges
- thickness of ink layer
- homogeneity/uniformity of the ink
- identification of the colourant/pigment
- average number (count) of pigment particles per cubic unit
- format and shape of pigment particles (extracted from printing ink samples)
- identification of the binding medium
- temperatures at which binding media were produced (presuming printing was carried out at 'room temperature')
- identification of conditioners, such as driers/siccatives
- identification of foreign inclusions, such as particles of the metal type printed from
- identification of the printing process by means of observing ink behaviour
- the former presence of now evaporised elements of the printing ink, such as water, volatile organic solvents, volatile fragrances

Printing process

Indentation, measuring surface geography and type impression depth by means of:
- digital microscopy

Printing ink layer, measuring thickness by means of:
- confocal microscopy
- Z-axis microscopy / focal stacking / Z-stacking
- interferometry
- Reflectance Transform Imaging (RTI)'

Printing process, observing:
- rubbing the verso-side of paper sheets with a particular tool (Korea, European blockbooks)
- use of a common press (Europe)

Interaction between ink and paper, observing:
- ink penetration through the support in printing
- ink bleeding/feathering out lateraly and verticaly after printing
- pigment particles filtered out by the paper after printing, with binding medium bleeding out
- pigment particle migration immediately after printing
- powdering of the ink after drying, because too much binding medium did bleed into the paper

Conservation

Observation and documentation of the life of the object after printing, considering:
- long term behaviour of paper
- long term behaviour of ink
- long term interaction between paper and ink
- natural aging of the object and its materials
- microclimates between leaves of a book, causing local paper degradation
- transport of water through the bookblock hindered by ink, causing local paper degradation
- damage due to human beings (handling of the object), animals, insects, moulds
- water staining due to storage issues
- binding and re-binding processes
- restoration/conservation treatment of objects in general and leaves in particular

Goals

A broader survey from the outset will bear fruit later on. From the outcome of the first technical examinations in July 2022, experience will be gained to better understand the objects under research and how to examine them, in order to be able to focus more precisely for a second round of examinations. Then examinations can be narrowed down to what we want to look for and be able to negotiate the loan of valuable and rare materials.

Examples

The following slides show examples of earlier, comparable research projects, in order to consider what examination processes and techniques may be best suited for the present project:

- various examination techniques of a leaf of a German blockbook, *Apocalypse*, c.1460–1470, p. 9, Rev. 7:1–3 and 7:9–14; Amsterdam, Rijksmuseum, inv. RP-P-2009-24, by Arie Wallert, Rijksmuseum, Amsterdam
- textures of Asian and European papers photographed with transmitted light; by Ad Stijnman and by anonymous, London, British Library
- multi-spectral imaging of a page of a leaf of the Gutenberg Bible; by Mike Toth, R.B. Toth Associates, Oakton VA
- SEM-EDX analysis of a sample of Japanese paper: by anonymous
- XRF analysis and SEM images of black pigments; by Ineke Joosten, RCE, Amsterdam

Images in plain light
recto-side and verso-side in high resolution

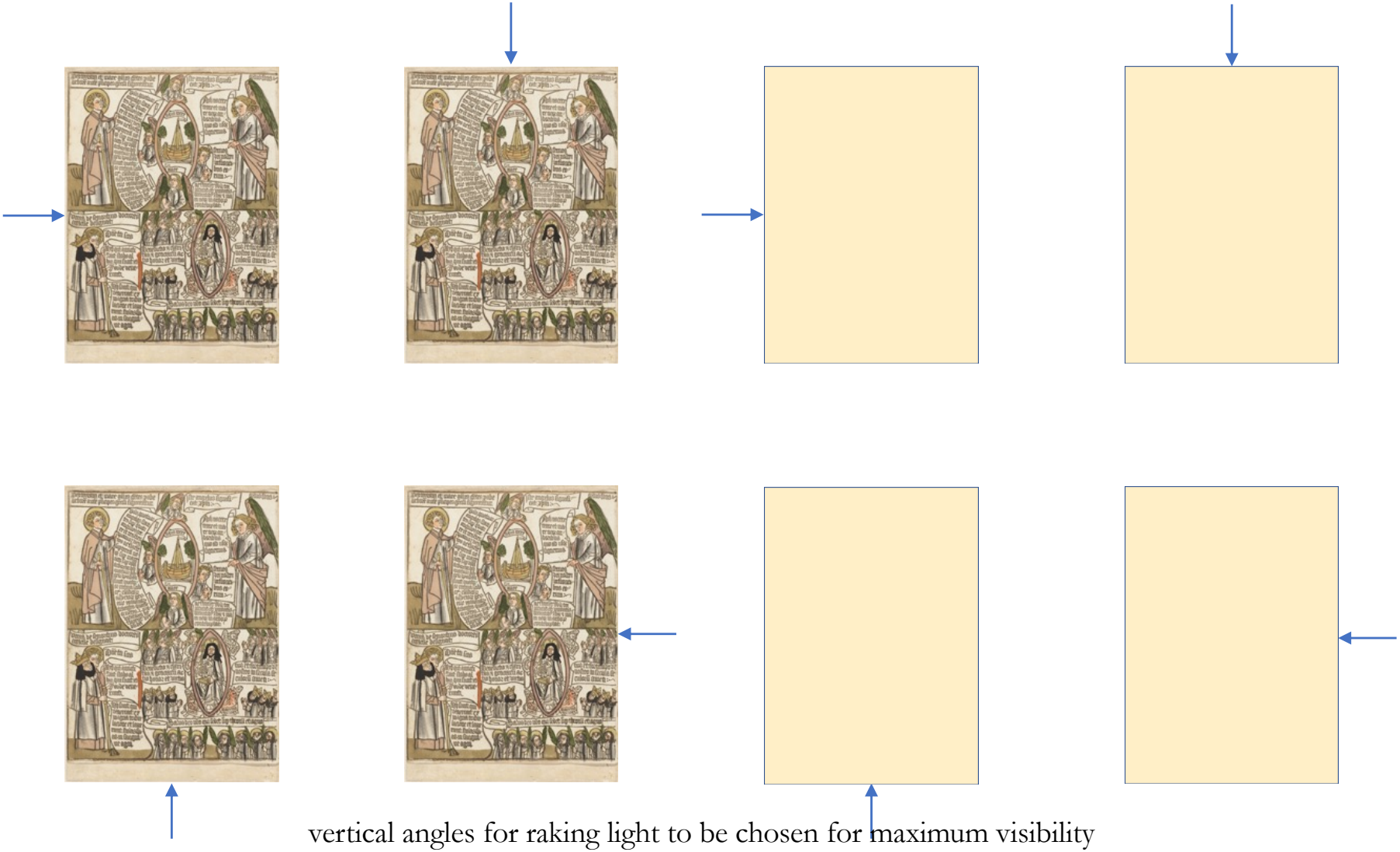
Image of recto-side allows selecting details for further examination

Image of verso-side (mock-up here) allows selecting details for further examination

Images in plain light
magnifications of selected details

observations: browned ink, mottled ink, squash/beaded edges, channeled squash, run ink (check for ink absorption on verso-side), stains, hand-colouring, various colourants, conservation treatments

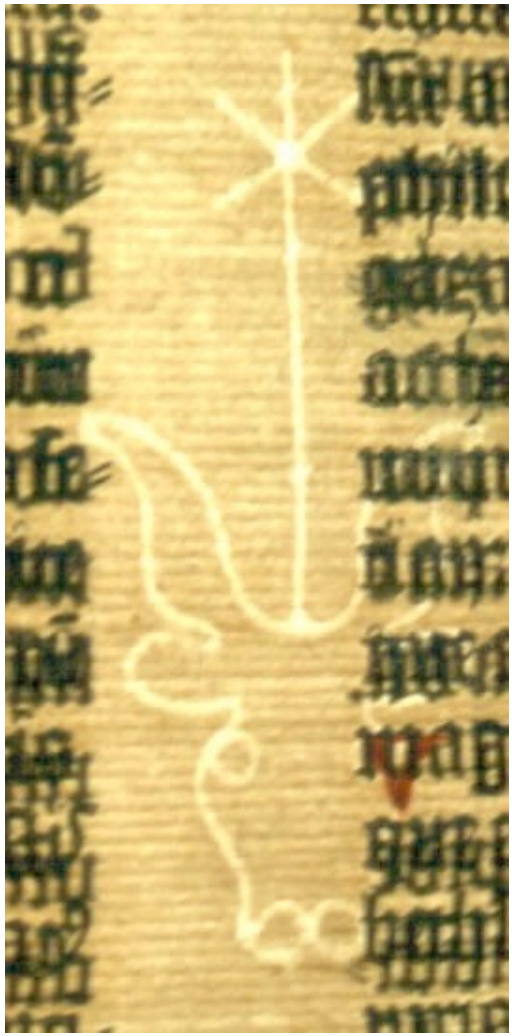
Images in raking light from the four edges recto-side and verso-side (mock-ups here) indentations, pasted-on materials, rubbed and erased parts



vertical angles for raking light to be chosen for maximum visibility

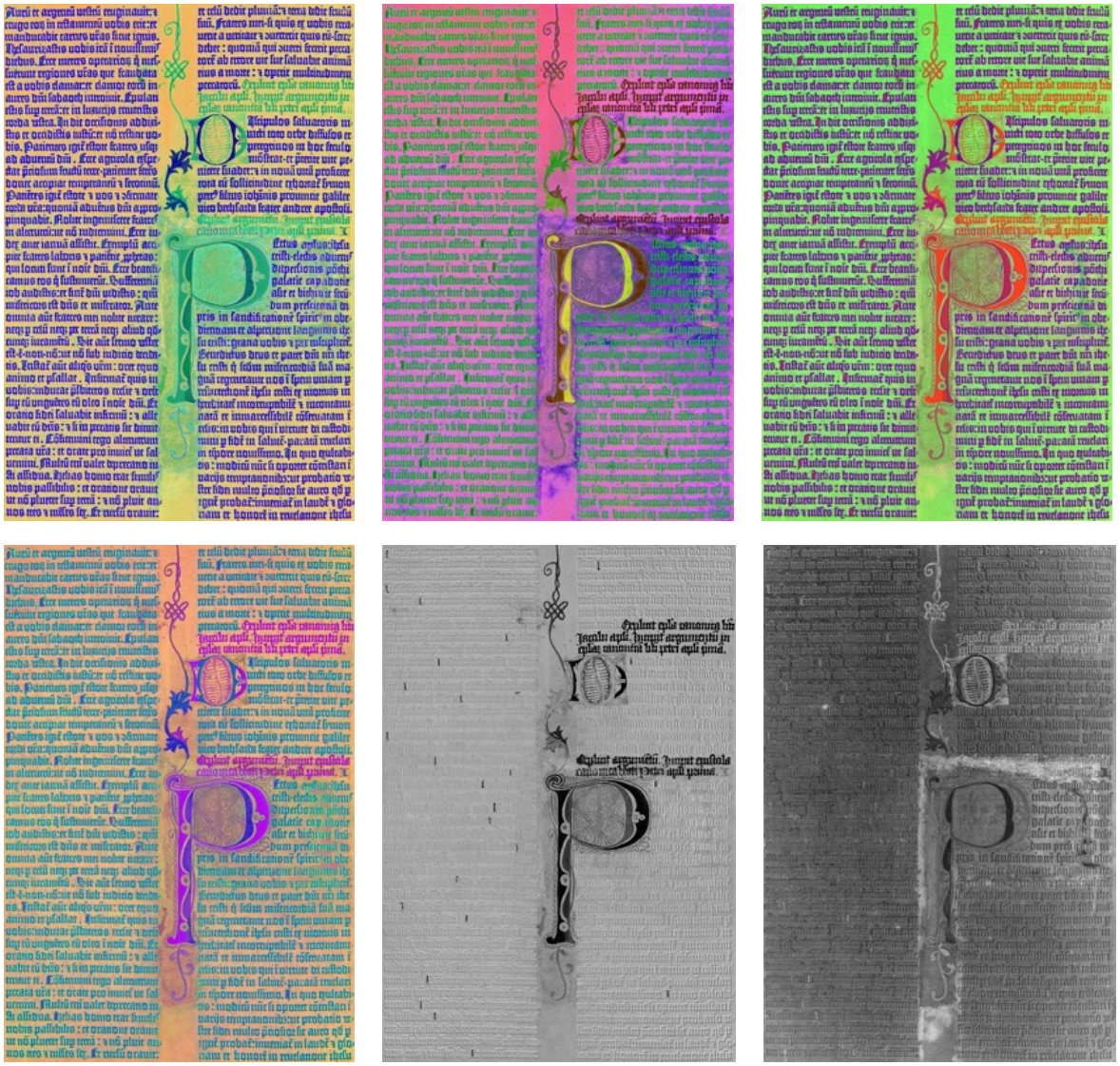
Images in transmitted light
paper density, pasted-on materials, erased ink, damages, mould surface construction, watermarks, paper condition

Japanese paper, 18th century; private collection, by Ad Stijnman



watermark from Gutenberg's Latin Bible;
London, British Library, their paper copy

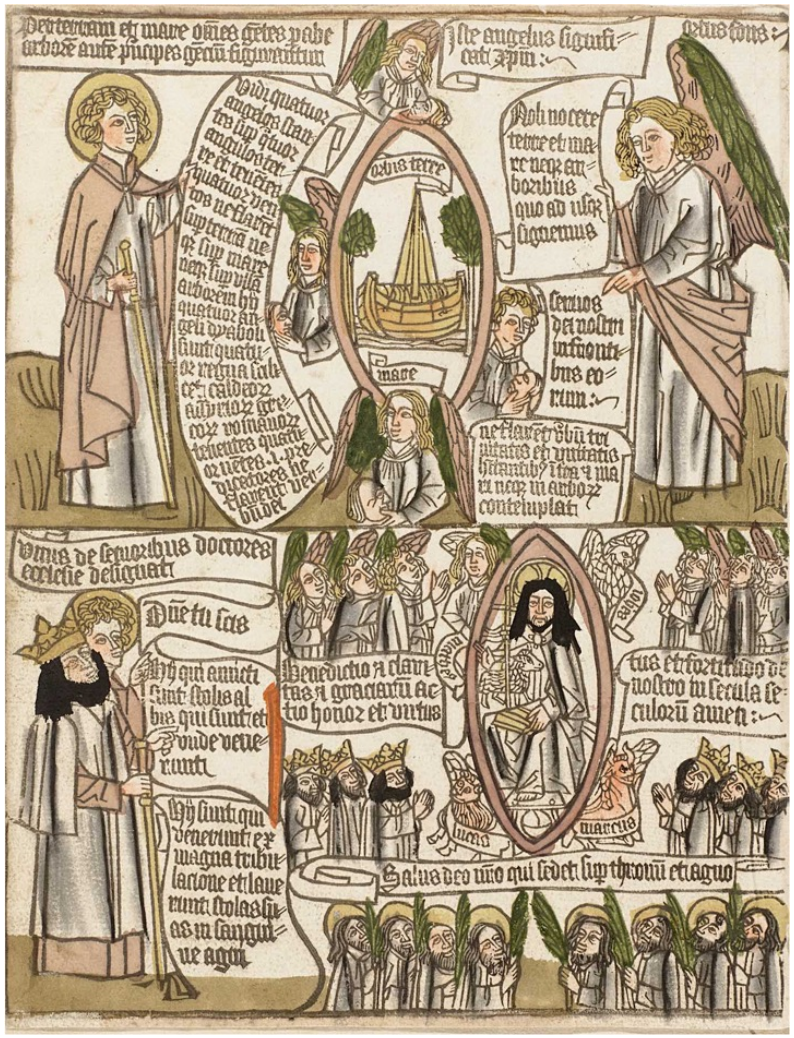
Images by multi-spectral imaging (MSI)
wavelengths: 3 in UV, 10 in visible light, 3 in IR + filters



The short wavelength ultraviolet (UV) and some blue light may offer better resolution. They may reveal paper and ink components and residues. They may also reveal paper damage.
The visible light wavelengths (reds, greens and blues) replicate what the human eye sees in natural light.
The longer red and infrared (IR) wavelengths will penetrate some surfaces and reveal more information about the paper. They may also reveal the presence or absence of carbon in inks.

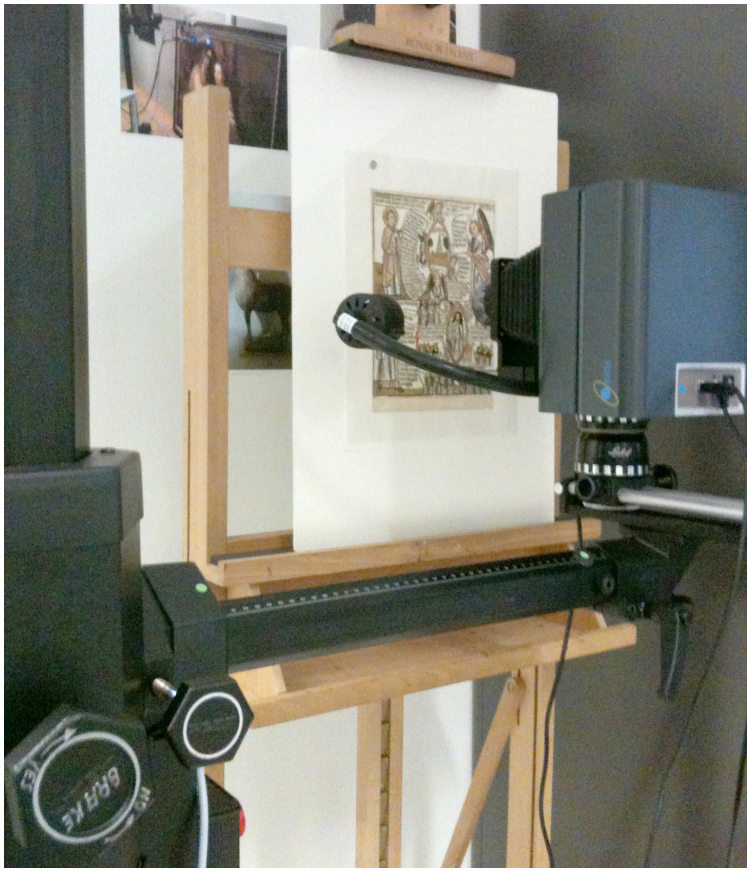
page of leaf from Gutenberg Bible; by Mike Toth, R.B. Toth Associates, Oakton VA

Examinations of leaf of German blockbook (c.1460–1467)

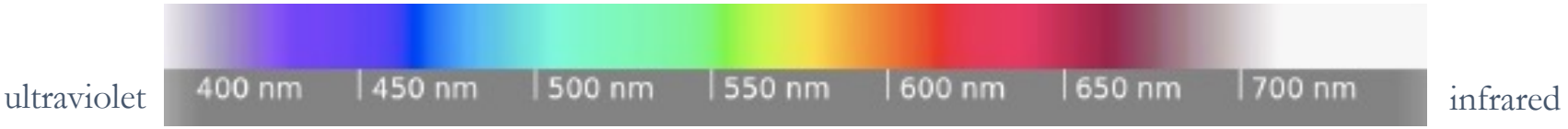


Apocalypse, p. [9], Rev. 7:1–3 and 7:9–14; Amsterdam, Rijksmuseum, inv. RP-P-2009-24, technical examination and all related images by Arie Wallert, Rijksmuseum, Amsterdam

Infrared reflectography (IRR)

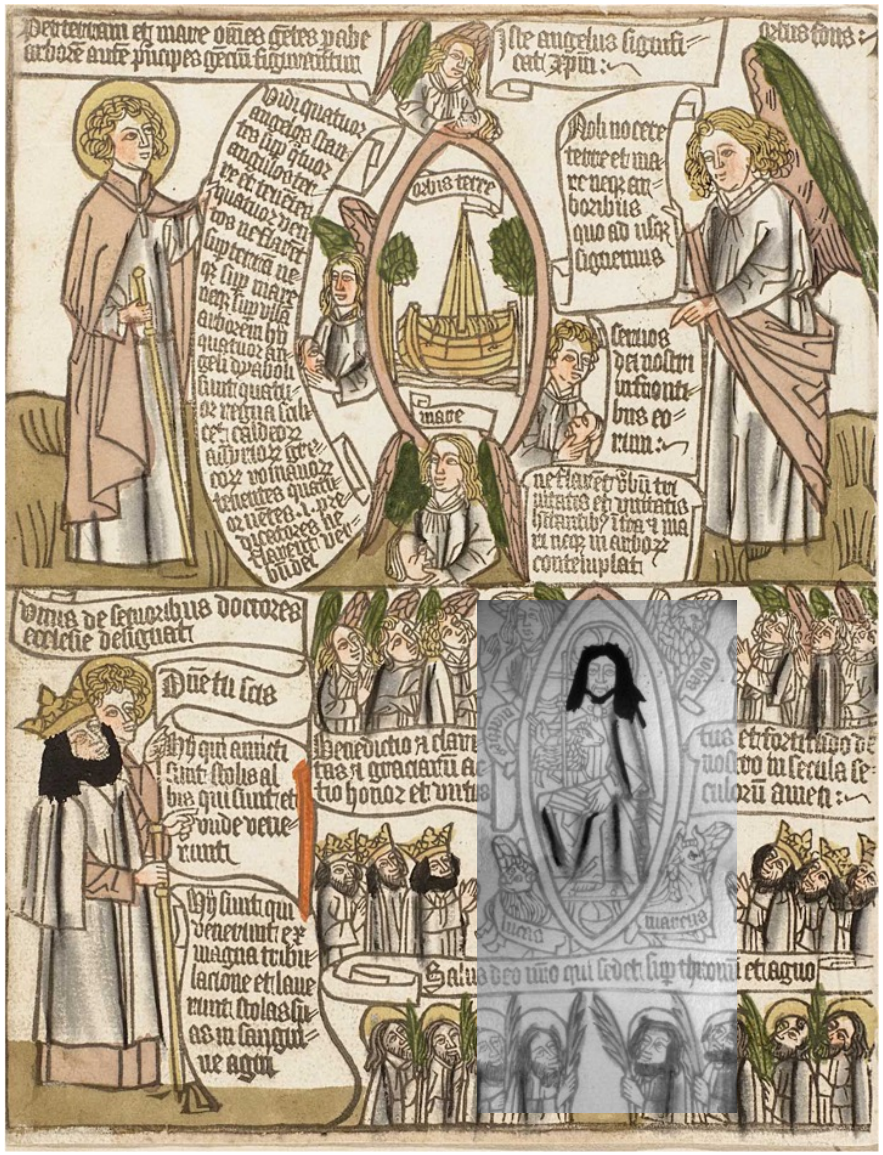


Osiris 512 × 512 infrared camera, equipped with a Hamamatsu (G11135-512DE), InGaAs linear image sensor with 25 × 25 μm pixel size.
Sensitivity in the NIR (near infrared) region to approximately 1700 nm, visible light filtered off at 875 nm



the spectrum visible to human beings

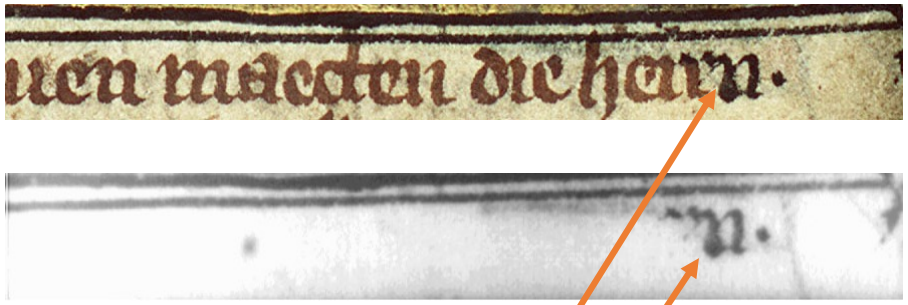
Surface area scanned



Black paint is 100% opaque, because it contains lampblack browned ink should be completely transparent, which here it is not due to the presence of lampblack

The IR-filter absorbs all wavelengths that reflect on reddish colours (= near infrared), leaving infrared showing as dark areas. Notice that red, yellow and brown colours are invisible. Browned iron gall ink does not contain materials that reflect infrared light and consequently is transparent for it. Addition of lampblack makes it opaque.

Example from manuscript text in iron gall ink



correction to the text made with a different iron gall ink containing additional lampblack

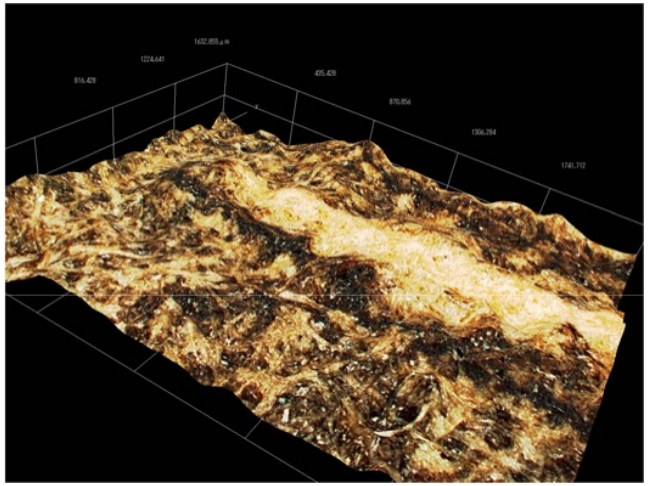
image in plain light

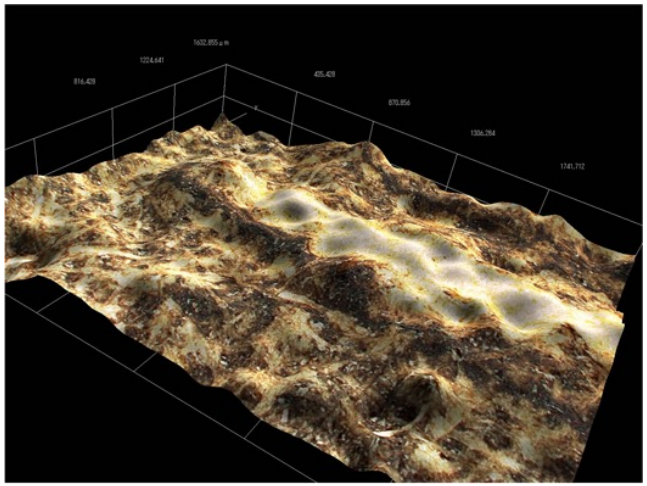
image in infrared light showing browned ink contains lampblack

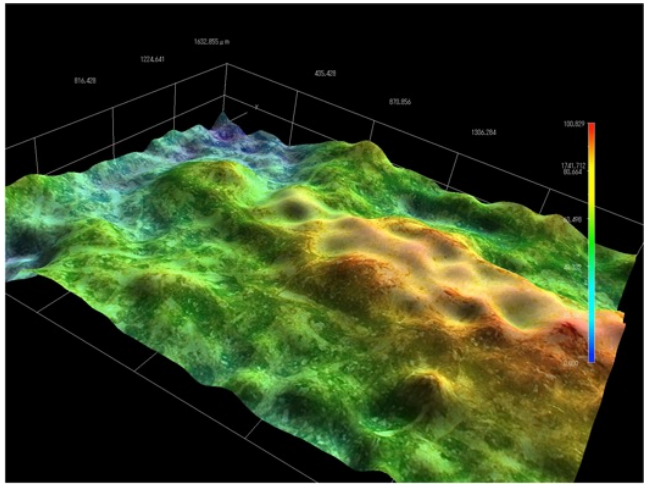
Digital enlargement

light microscopy carried out with HIROX KH-7700 digital microscope with 2.11 megapixel CCD sensor, res. max. 10.000 × 10.000 pixel, magnifications 35× – 2000×

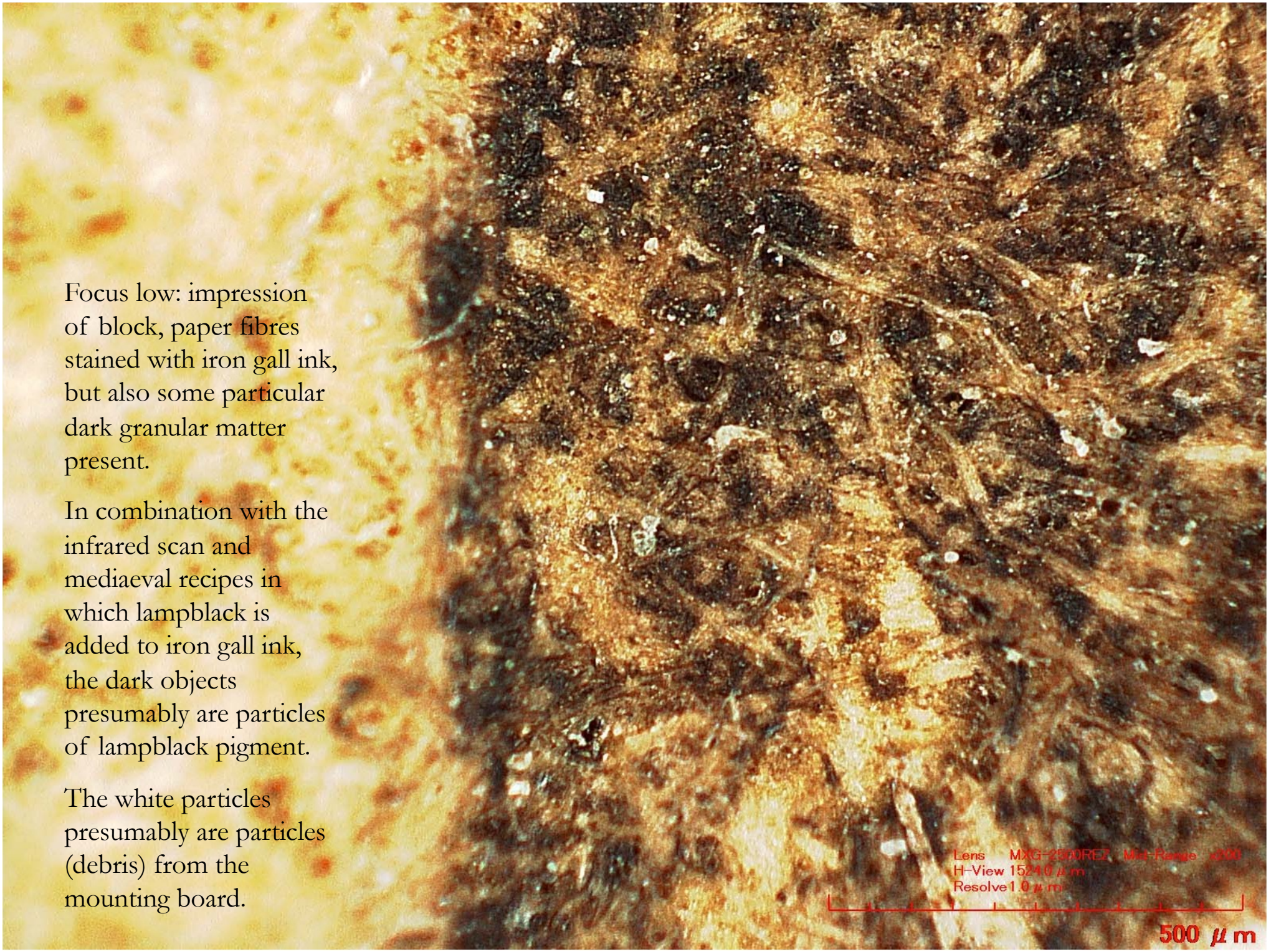
Indentation
image processing shows a bas-relief where the raised parts of the block are embossed into the paper sheet







light microscopy carried out with HIROX KH-7700 digital microscope with 2.11 megapixel CCD sensor, resolution maximum 10.000 × 10.000 pixel, magnifications 35× – 2000×

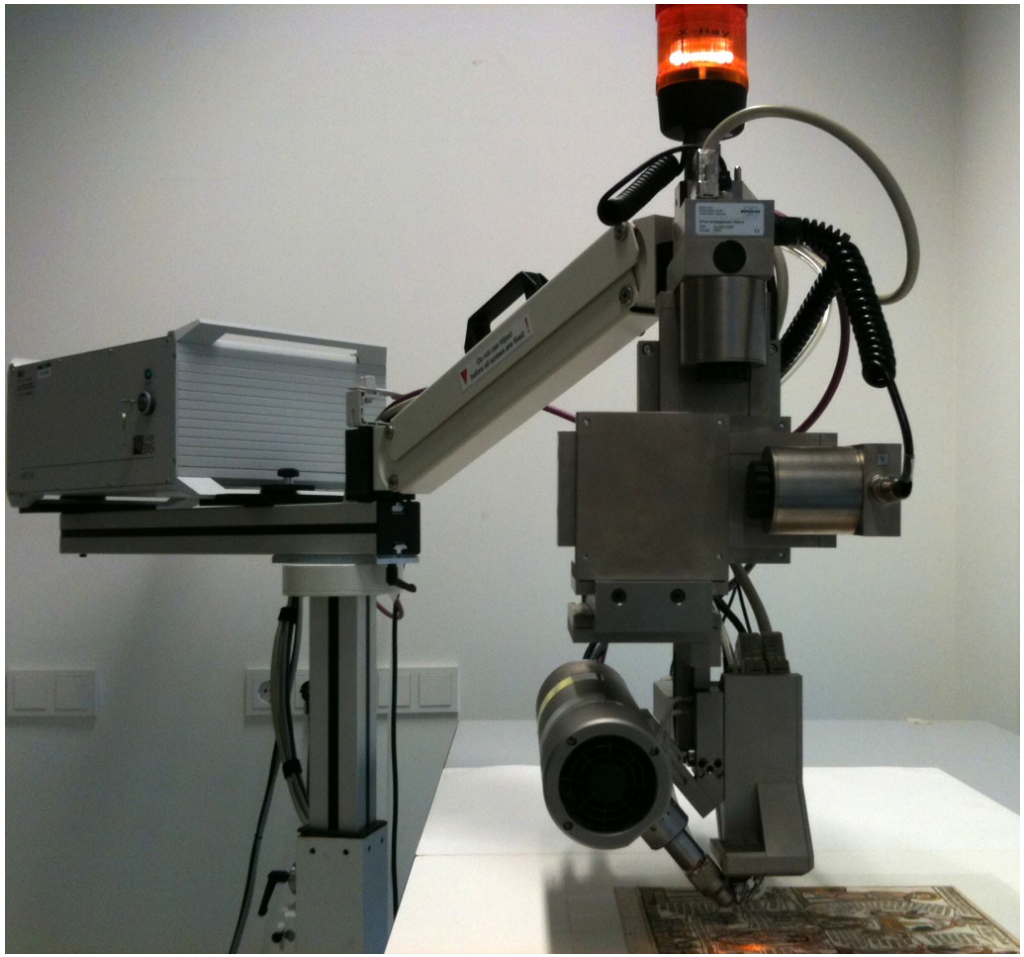


Focus low: impression of block, paper fibres stained with iron gall ink, but also some particular dark granular matter present.

In combination with the infrared scan and mediaeval recipes in which lampblack is added to iron gall ink, the dark objects presumably are particles of lampblack pigment.

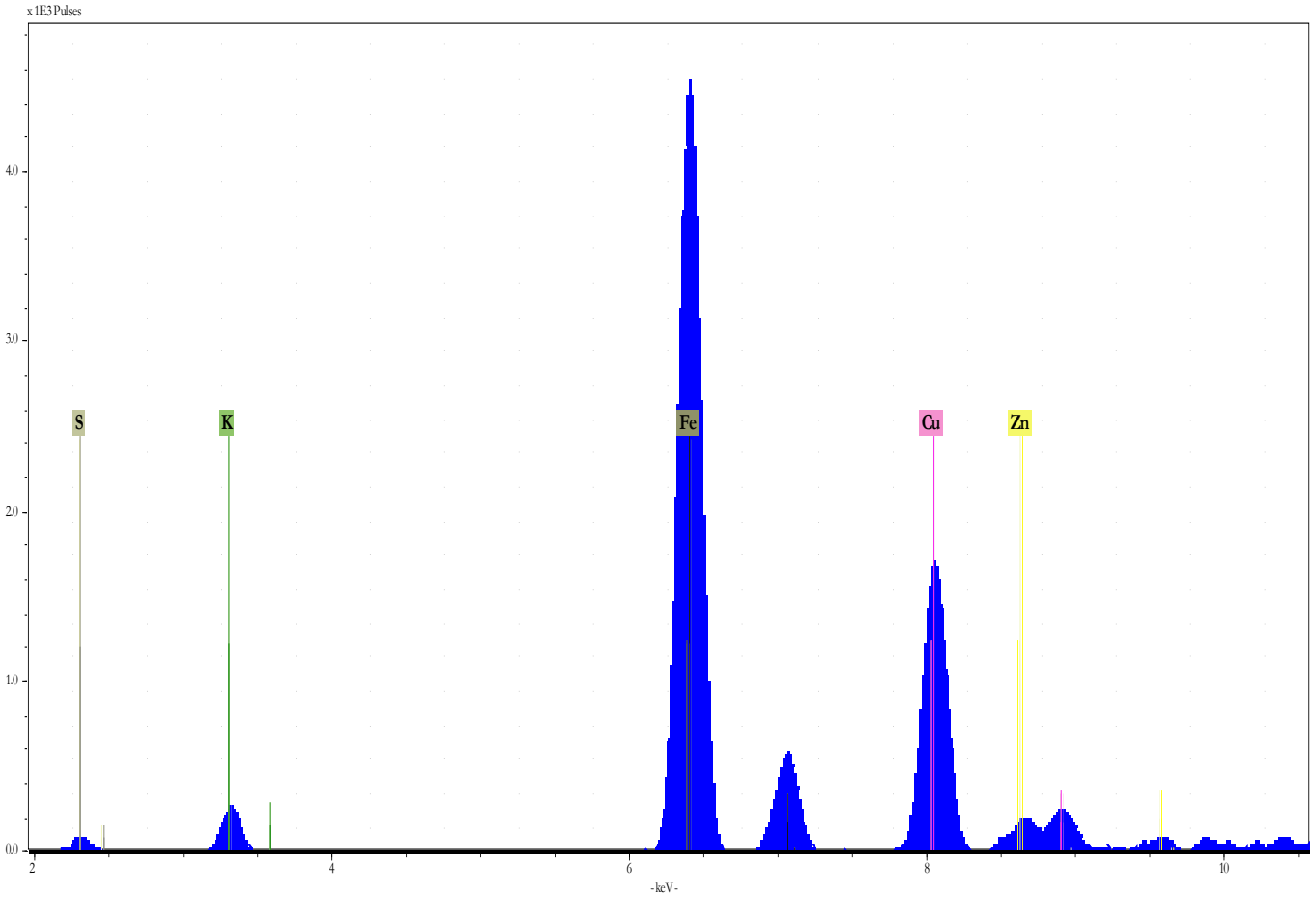
The white particles presumably are particles (debris) from the mounting board.

ARTAX μ-XRF spectrometer, 50kV, 300μA, Mo-anode, 0.060μm capillary lens, He-flush 1.7L/m, 120 sec.



the instrument allows non-invasive measurements to be taken on very small areas (0.060μm)

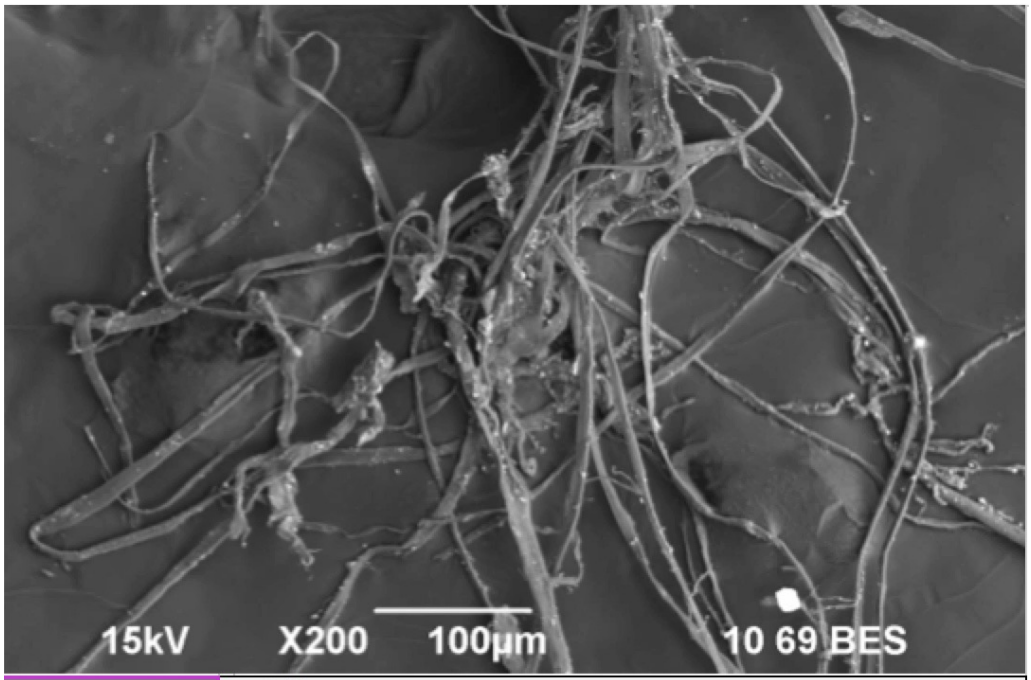
Principal components (elements) in the printing ink



signal for Fe, Cu and Zn + S: elements consistent with *iron gall ink* prepared with impure *vitriol*, which is used for printing the woodblock

vitriol = iron(2) sulphate (FeSO4) + possible contamination with other sulphates, such as from copper (Cu), manganese (Ma) and zinc (Zn)

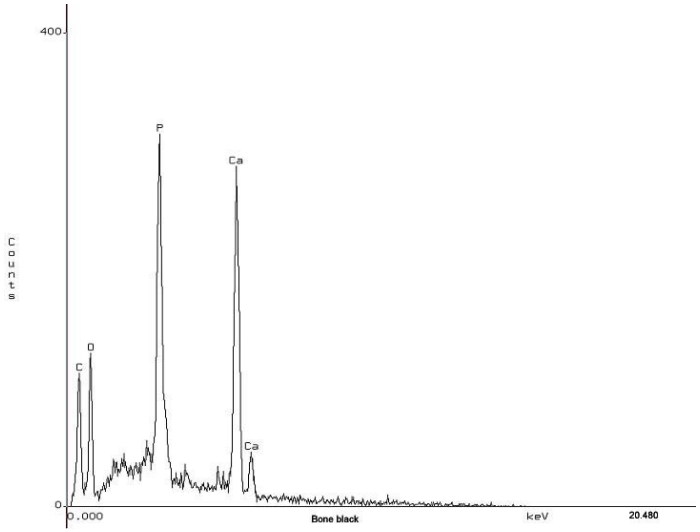
Example of a filler in Japanese paper

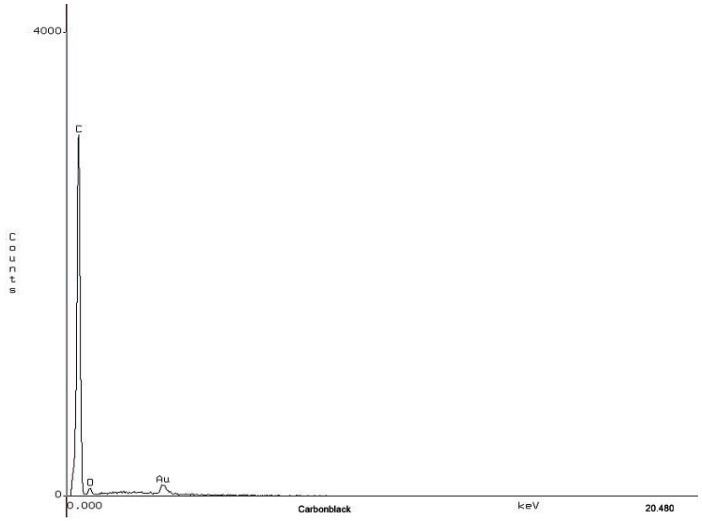


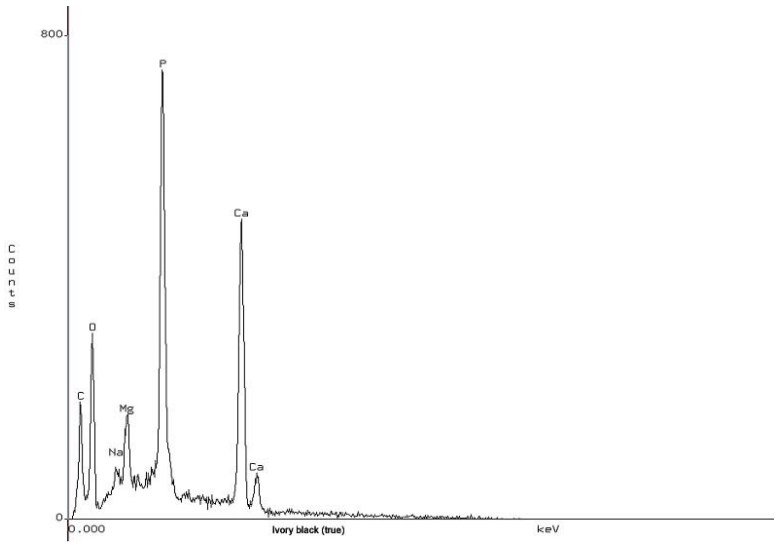
RP-P-1962-53	
	Main fiber
	Gampi (violet)
	Accessory substances
	Unknown
	Detected elements on fiber
	Si (66.7) , Al (17.5) , Ca (6.9) , Fe (2.4) , Cl (1.8) S (1.4) , Na (1.3) , K (1.1)
	Detected elements on inorganic mixture
	Si (75.9) , Al (13.2) , K (9.9)
	Estimated inorganic mixture
	Feldspar ($KAlSi_3O_8$) or Other Clay minerals etc.

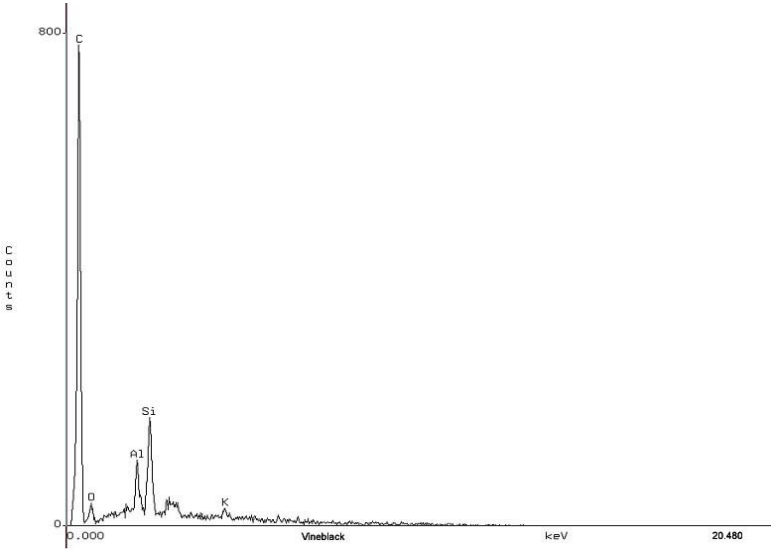
SEM-EDX examination of filler particles in sample of Japanese *gampi* paper; Amsterdam, Rijksmuseum, RP-P-1962-53, by anonymous

Examples of XRF examination of dry black pigments



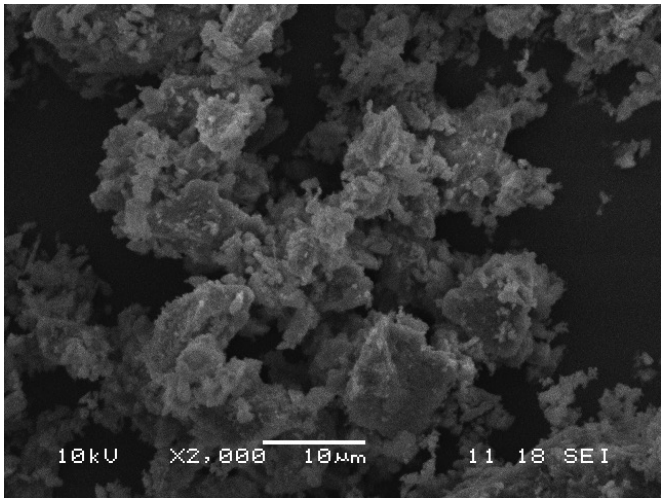




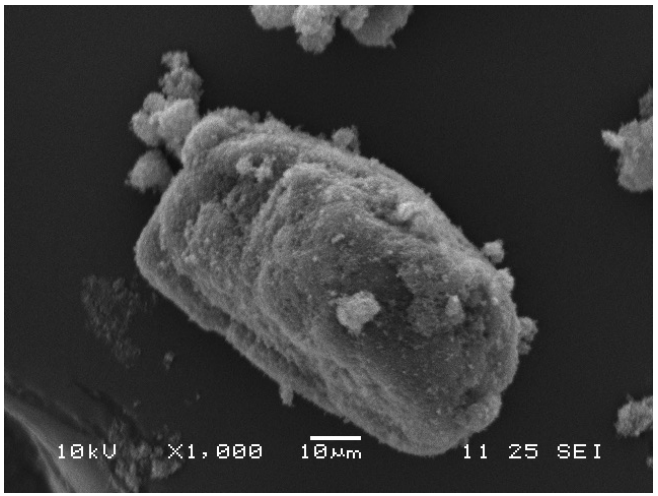


by Ineke Joosten, RCE, Amsterdam

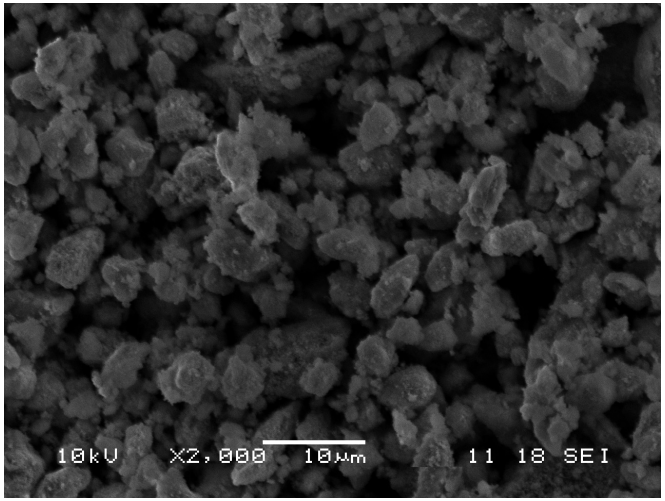
Examples of SEM examination of dry black pigments



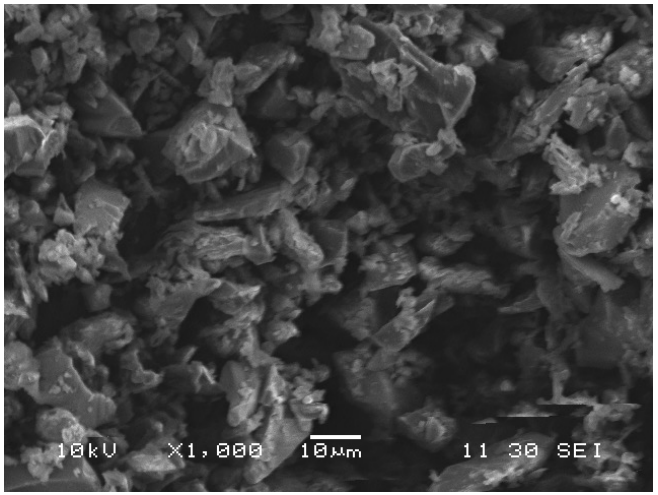
boneblack



carbonblack



ivory black (true)



vine black

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