MULTIBAND IMAGING GUIDE 2023

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Quick start

Visual imaging (VIS)

Light Source: Fillex lamps
Filter: XNite CC1

UV Luminescent Imaging (UVL)

Light source: Triple Bright 3s
Filter: CC1 on camera **AND**
Kodak 2E with **adaptor**

UV Reflected Imaging (UVR)

Light source: Triple Bright 3s
Filter: XNite 330 **AND** XNite BP1

IR Reflected Imaging (IRR)

Light source: Surveillance panels
Filter: XNite 830

Visible Induced Luminescence (VIL)

Light source: Disco lamps on red
Filter: XNite 830

Image Subtraction 660/735 bandpass (IS)

Light source: Fillex lamps on 3200K
Filter, first image: Midopt BP660

Filter, second image: Midopt BP735

NOTE: All filter cases should be labeled with their respective techniques!

RGB Channel movement

UVRFC: VIS Green -> Red

VIS Blue -> Green

UVR-> Blue

IRRFC: VIS Green-> Blue

VIS Red -> Green

IRR -> Red

Background

Multiband terminology & concepts

Band-pass—a filter that only lets through light in a certain "band" of wavelengths, lit. "band of passing through." Used for image subtraction (MidOpt BP660 and 735) for identifying indigo.

False-color imaging—A technique where RGB color channels from visual imaging are recombined with UVR or IRR imaging to gain more information about the materials.

For UVRFC: VIS green channel --> red channel

VIS blue channel --> green channel

UVR image (B&W) --> blue channel

For IRRFC: VIS red channel --> green channel

VIS green channel --> blue channel

IRR image (B&W) --> red channel

For these techniques to be successful all images must be correctly calibrated for exposure based on the Spectralon® standards.

NOTE: Terminology is not standardized, the AIC photo guide uses FCIR and FCUV instead of IRRFC and UVRFC respectively. UVL is also occasionally called UVF (**U**ltra **V**iolet **F**luorescence)

Flat-fielding—the process by which you compensate for inconsistent lighting. With good lighting and the quartz Janoptik lens this may not be necessary. A picture is taken of a piece of blue board (or other uniform reflector) under the lighting to be used and set as a LCC profile in Capture One. When applied to an image this will cancel out uneven lighting.

Gamma function/profile-- an adjustment applied by the camera to make images look more natural to our eyes, which do not perceive all wavelengths evenly. Can be removed and replaced with a linear response in Capture One if images are shot as RAW files.

Image subtraction—any technique that subtracts one image from another to visualize the difference between them. The IS 660/735 technique used in this imaging suite is used to detect indigo and other blue/black dyes, by visualizing the difference between the reflectance of the object at light of 660 nm and 735 nm in wavelength. For more details see Webb, 2014.

Luminescence/fluorescence imaging—these two are used interchangeably in the literature, there seems to be some regional variation. Light shining on a substance causes it to give off *different* light. Because of the law of conservation of energy, the light output must be lower energy (longer wavelength) than the input light.

UV illumination causes luminescence/fluorescence in the visual

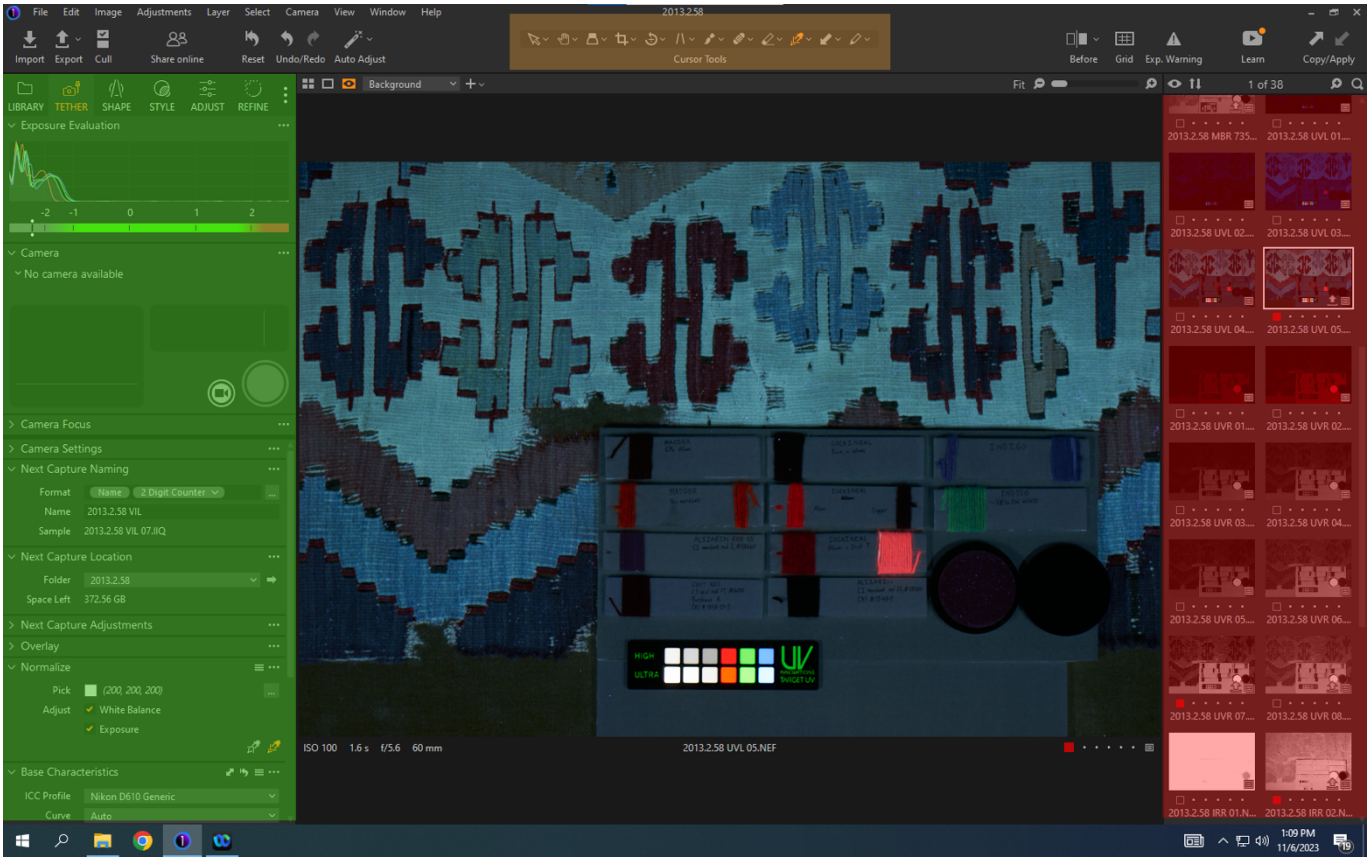
Blue light in the visual can create red luminescence (See Dyer 2017)

Red light in the visual causes IR luminescence/fluorescence

Reflectance imaging—the light that is reflected off the object is collected by the camera and makes the picture. "Normal" photography is visible reflected imaging

Important tools in Capture 1

Workspace



The Capture 1 workspace is divided into three major sections. On the left hand side are several tabs that correspond to different tasks—"Tether" for shooting with a tethered camera, "Library" for looking at file organization, and "Adjust" for adjusting Levels, Curve, Exposure, Saturation, etc. The "Shape" "Style" and "Refine" tabs will not be used in this workflow. This area is highlighted in green.

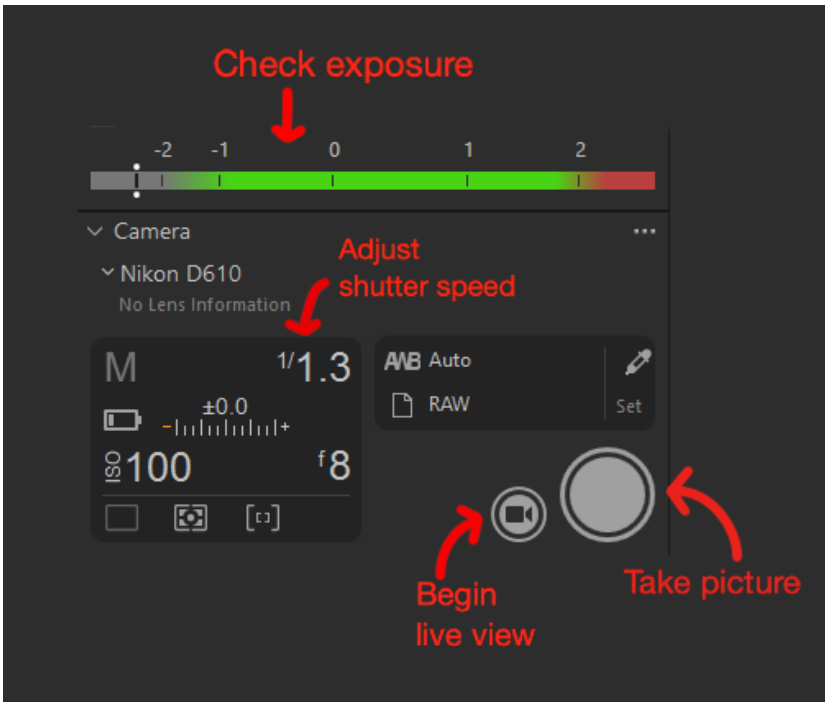
On the right side are thumbnails of the images that have been taken so far. These can be color-coded, rated, and deleted. Right-clicking on an image brings up a large menu of options. This section is highlighted in red

The central plane shows the image (or images) currently being viewed or edited.

At the center top are cursor tools, many of which have drop-down menus that may be useful. The White Balance, Normalize, Add Color Readout, Delete Color Readout, and Hand tools can be found here. This is highlighted in yellow.

Camera

When a camera is plugged in and turned on for capturing tethered images, information about the camera settings will be shown here. Shutter speed, aperture, and ISO can all be adjusted using this tool.



It is recommended to shoot at ISO 100 and f8, with the shutter speed adjusted as necessary to achieve an appropriate exposure. The following are good starting places for the various techniques:

VIS—1/1.3

IS 660—3s

IS 735—6s

UVL—30s

UVR—5s

IRR—1/1.3

VIL—**4-12 minutes** using the bulb setting, remote release cord, and **f4** (6 minutes is a good starting point, although keep in mind that some synthetics fluoresce very strongly in the IR and may require a shorter exposure)

Because the quartz Janoptik lens used for this system is manual focus only, the focus must be physically modified on the lens and cannot be changed in Capture 1.

File naming protocols

The standard file name for multiband images is as follows:

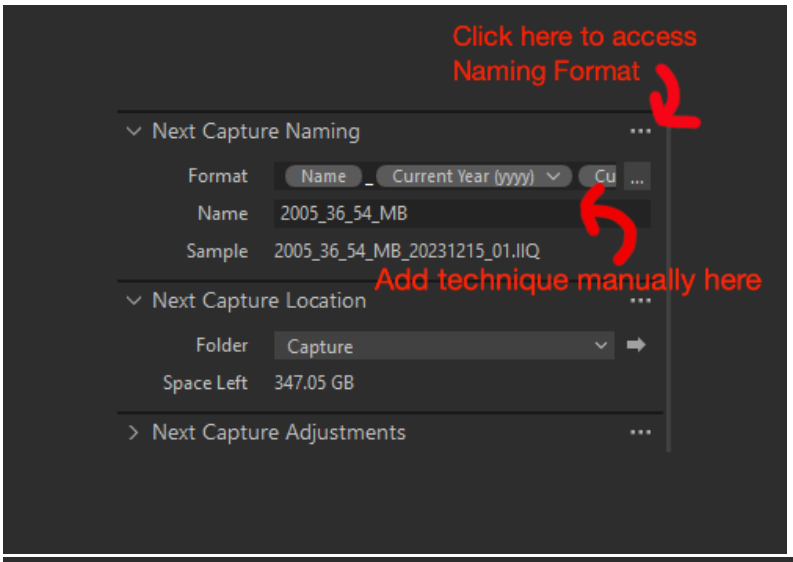
ACCESSION_NUM_MB_TECHNIQUE_YEARMONDAY

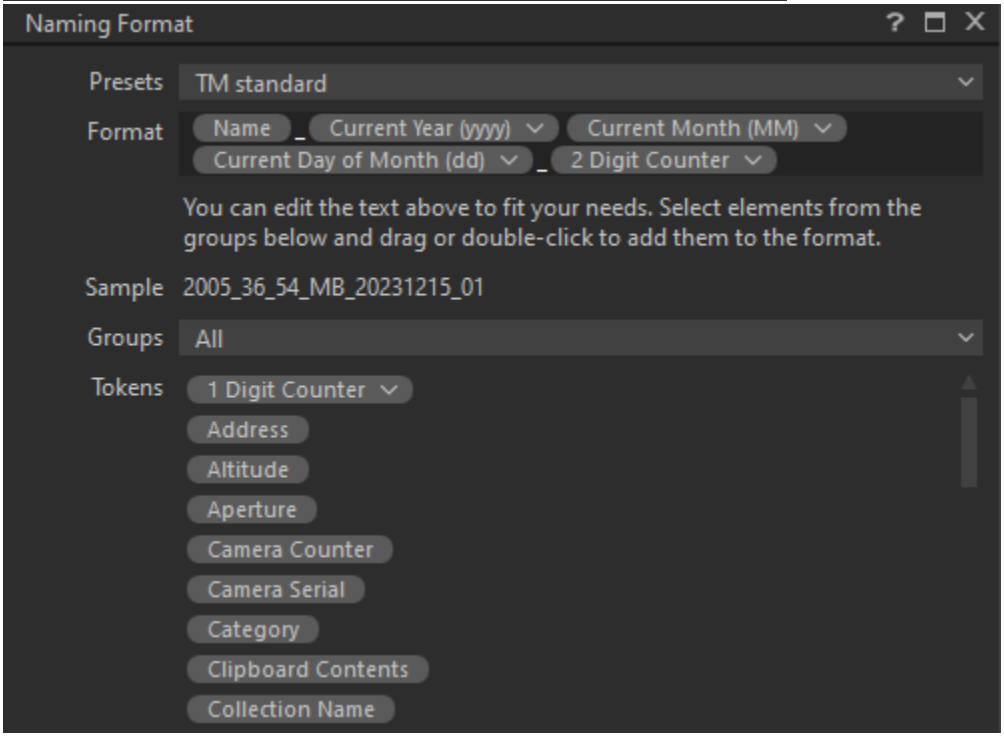
For example, if 1950.1.2 was shot on January 1, 2021, the images would be labeled:

1950_1_2_MB_XYZ_202111

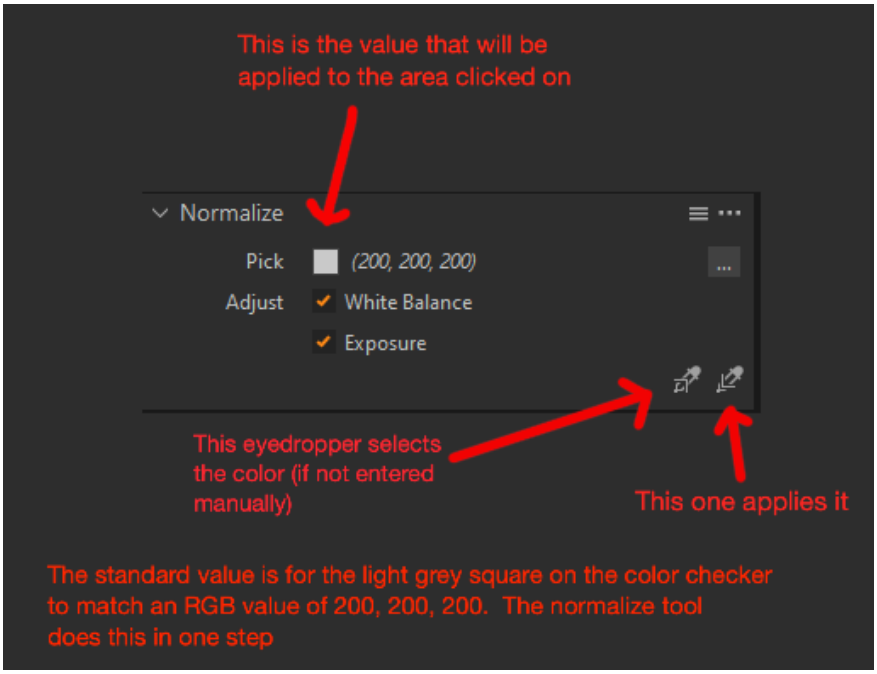
where XYZ is the applicable imaging technique.

When opening a Capture One session, the session is named ACCESSION_NUM_MB, and the rest of the file name format is saved in Capture One as <TM standard>. The technique portion of the name must be modified manually as the session progresses.



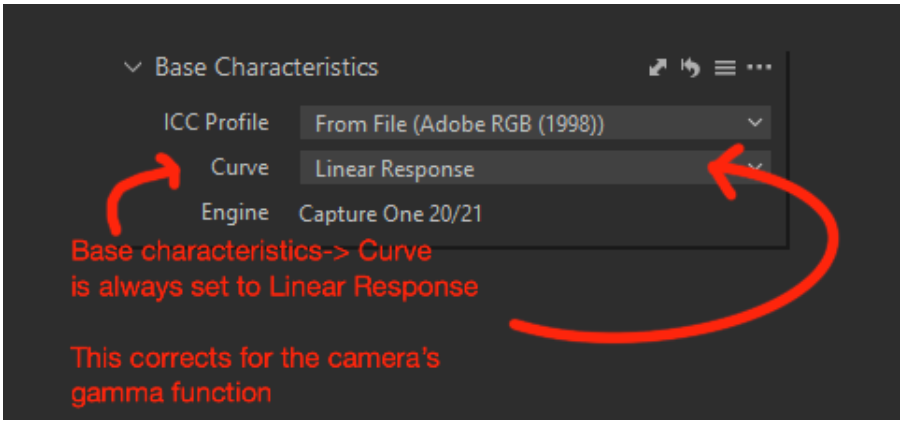


Normalize



The normalize tool is used in VIS imaging to simultaneously adjust white balance and exposure. The lightest grey square on the Color checker mini is adjusted to RGB (200, 200, 200)

Base characteristics



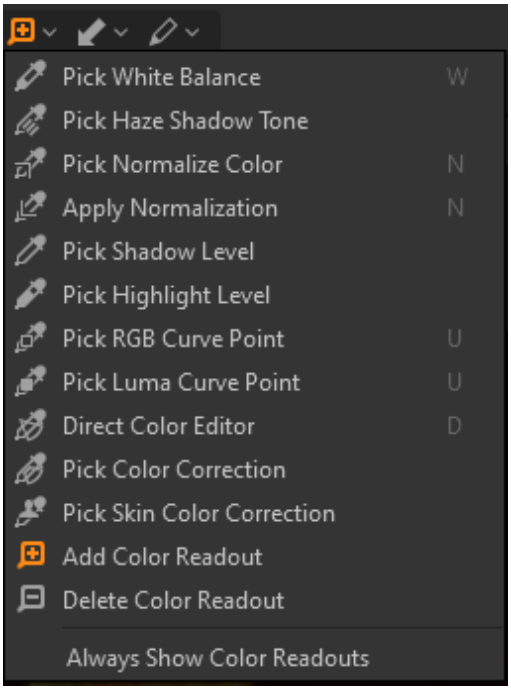
All images must have their Curve set to Linear Response to account for the camera's gamma function and provide accurate images.

White Balance

The white balance tool is similar to the normalize tool but adjusts white balance only. Clicking on a known neutral grey value with white balance engaged will correct the entire image. This tool is used in UVL to white balance to the UV reference greyscale.

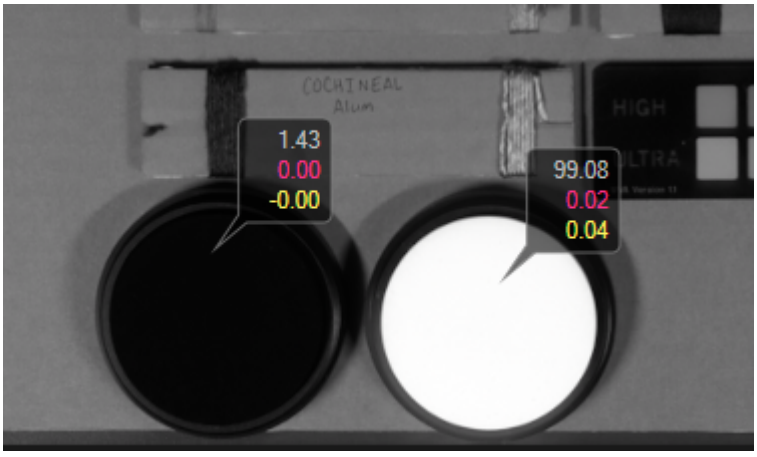
Color readout tool

The color readout tool can be accessed from the cursor tools bar (yellow in the Capture 1 workspace image) in a drop-down menu that also includes Normalize and White Balance.



For the tool to work properly, Lab readout must be turned on (under View-> Lab readout-> generic)

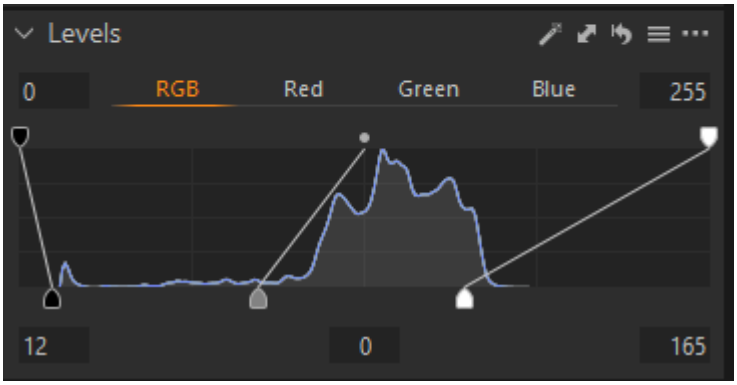
Clicking on a location in the image shows a readout of the L*a*b* measurements for that spot.



Because the Spectralon® reflectance samples have known reflection percentages of 2% and 98% across all wavelengths of light, the L values should be 2 and 98. Images that are close can be adjusted using the levels tool.

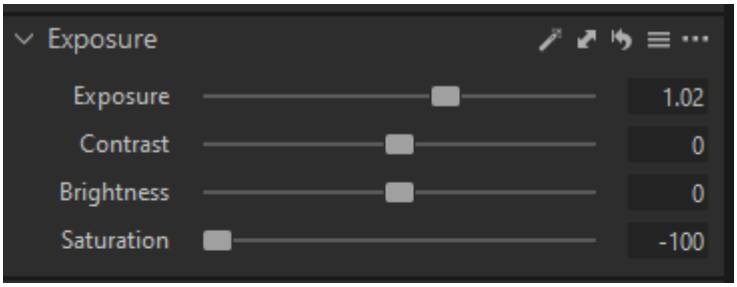
Color readouts can be deleted by clicking on them while the Delete Color Readout tool is active.

Levels



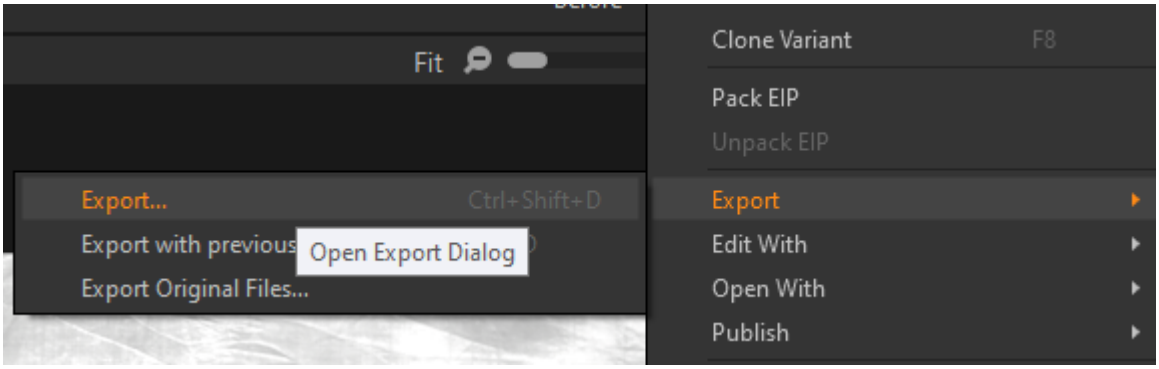
To adjust the L values of the white and black Spectralon® samples, the white and black points on the levels tool are adjusted by grabbing and sliding. Generally, both the white and black points will need to be moved in to achieve appropriate L values. Adjusting one modifies the other, so some back and forth will be necessary.

Exposure and saturation



The Exposure tool contains four sliders, only two of which are utilized in this imaging protocol. Exposure is used to adjust the color readout in UVL to an L value of ~50, while saturation is used to change single-channel images (UVR, IRR, IS 660, IS 735, and VIL) to greyscale. This is preferred to using the Black and White tool in Capture 1, which is designed to modify artistic B&W images.

Export



Right-clicking on an image thumbnail will bring up a long list of options, including Export. Images should be exported to the default folder (session output) and saved as 16-bit .tif files.

Materials used

The Multi Bond Car(t) should contain the following:

- 1 Nikon 610 modified for MBI
    - This should be equipped with a quartz Janoptik UV-VIS-IR 60 mm 1:4 APO Macro lens and quick-release plate for the Manfrotto tripod head
    - The camera bag should also contain a spare battery, battery charger, hotshoe level, and a remote release cord for long exposures
- 1 Desktop computer equipped with Capture One and Adobe Photoshop
- 2 folding lamp stands
- 1 lamp stand weight
- 2 Fiilex P360S Portable LED Light (2800-6500K) lamps for VIS and IS 660/735, associated cables, and diffusers
- 2 Triplebright UV sources for UVL and UVR, mounted to Kupo superknuckles for attachment to a lamp stand
- 2 IR surveillance panels for IRR, mounted to Kupo superknuckles, and assorted cables
- 2 American DJ 64B LED color lamps for VIL
- 4 Manfrotto magic arms (use optional)
- 2 Multi-outlet extension cords
- Nikon tethering cable
- Color standards including
    - Xrite calibrite classic mini
    - ISA UV target (luminescence standard)
    - Spectralon® reflectance standards at 98% and 2% reflectance
- Filters (see quick-start guide)
- Black lab coats
- Safety glasses
- Multiband back-up drive
- All documentation for light sources, filters, etc. (with color standards)

Image capture

Imaging space

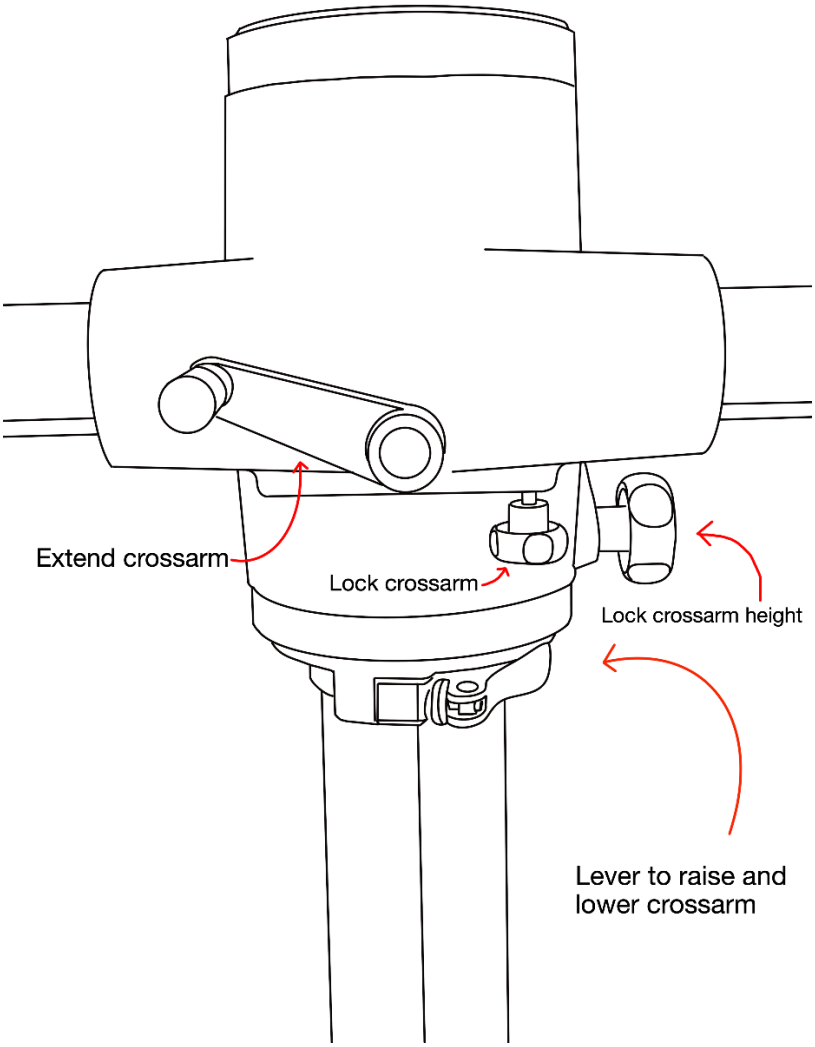
The goal of the imaging set-up is to evenly illuminate the object, as well as have it consistently in-focus. With the flexible material in The Textile Museum collection, this is most easily achieved with the camera pointed downwards and the object flat on a table. Because the Janoptik lens has a narrow field of view, it is best to lower the tables to have as much of the object in the frame as possible.

Object set-up

Ensure the object is as flat as possible, as wrinkles and creases will cause shadows in the final images that make interpretation difficult. The Colorchecker Mini, UV Luminescence standard, and Spectralon® reflectance standards must also be in the frame, ideally in the same plane as the object. ***Due to the common nature of pesticide contamination in the TM collection, place a barrier between the object and the standards***. This can be any material that does not fluoresce under UV—blue board works well, muslin is an option (although not ideal) and archival Mylar® is yet to be tested.

Stand set-up

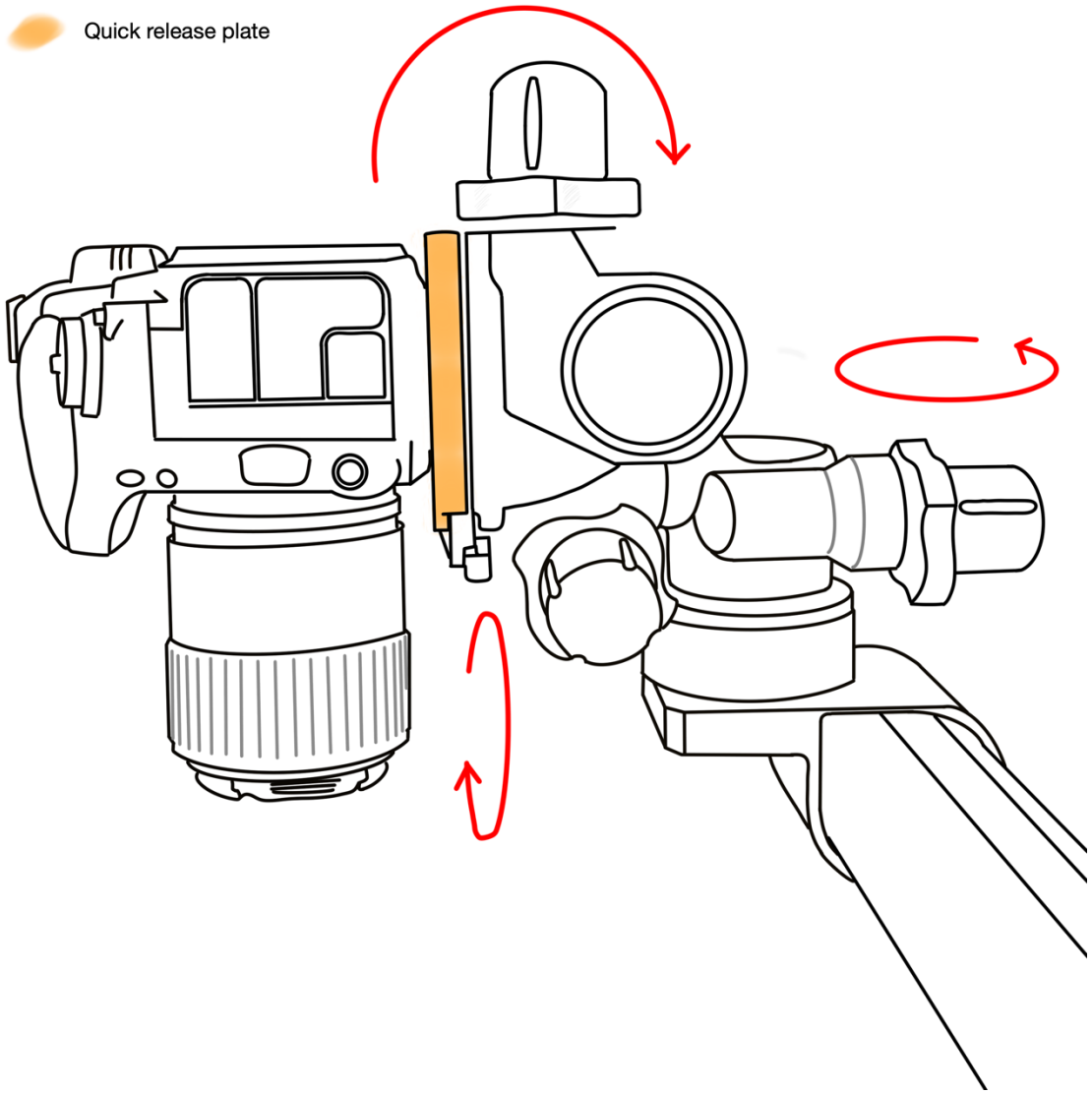
It is critical to use an extremely steady camera support for multiband imaging, as some exposures are very long. It is also essential to ensure that the VIS, IRR, and UVR images align properly to generate false-color images



As of 2023, The Textile Museum uses a CAMBO stand with counterweighted cross-arm. The arm controls are shown above.

The modified Nikon 610 is mounted to a quick-release plate that is attached to a Manfrotto tripod head with three-axis rotation. The camera is attached to the tripod head by pressing the lever all the way across and slotting the quick release plate into the adaptor notch. The lever will click and swing back when the plate is in place. Release the camera by doing the reverse.

The hotshoe level can be used to check that the camera body is flat—often the 90° marker on the tripod head is not exactly flat. A larger level can also be used to check that the bottom of the lens is horizontal. Be sure to check this every time, even if the head has not been adjusted—often there is a small amount of drift.



Tether the camera to the computer and turn it on. Open Capture 1, begin a new session, and use live view to adjust the stand and crossarm so that the appropriate field of view is seen and focus the camera. Once the camera is in place, lock the arm and raise the casters until the stand touches the floor. Double-check that this has not influenced the image focus.

Image capturing

Each object should have its own Capture 1 session. Start by opening Capture 1 and selecting File -> New Session, and name the session ACCESSION_NUM_MB.

Set the Base Characteristics curve to Linear

Under Next Capturing Naming click the three dots to bring up Naming Format and select <TM standard>

Use live view to check the image focus, double clicking with the hand tool to zoom in on particular areas.

In general, the image capturing process proceeds as follows:

1. Place the appropriate light sources on both stands and place them on opposite sides of the object. The light sources should be angled down at ~45º
    a. For the UV sources, plug in the YELLOW cord at least 20 seconds before plugging on the plain one
2. Attach the appropriate filters to the lens
3. Double-check that Base Characteristics is set to Linear Response
4. Change the capture name in Capture 1 to the next technique and restart the capture counter
5. Turn off the overhead lights!
6. Take several images, adjusting the shutter speed until an appropriate exposure is reached. Generally a color readout of the Spectralon® reference standards of ~70 for the 98% and ~15% for the 2% are sufficient

Notes

- Protective eyewear is required when UV lights are on! If you wear glasses, this is sufficient, but the Multi Bond Car(t) also has safety glasses. Put a sign up on the door to warn others to knock before entering when using UV/IR sources.
- While eyewear is not necessary for working with IR, it is still not a good idea to look directly at the panels
- There are different ways of marking selected images. All the others can be deleted by selecting their thumbnails and hitting the "Delete" key on your keyboard. This does not delete them permanently it instead moves them to the session trash. There are also rating systems built into the thumbnail panel of Capture 1 that can be utilized.
- Remember to turn the camera off when image capture is done to save battery

Adjustments and processing in Capture 1

Visible Reflected Imaging (VIS)

1. Normalize the light grey square of the color checker to RGB (200, 200, 200)
2. Place a Color Readout reference on both the white and black Spectralon® references
3. Adjust the white and black points in the Levels tool until the L values are 98 and 2 respectively for the 98% and 2% Spectralon® references

660/735 bandpass subtraction (IS)

1. Convert image to greyscale by adjusting saturation to -100
2. Adjust the white and black points in the Levels tool until the L values are 98 and 2 respectively for the white and black references

Ultra-violet Luminescent Imaging (UVL)

1. White balance the selected image using any of the greyscale squares on the UV reference
2. Turn on Lab readouts under View-> Lab readout-> Generic
3. Select the reference square with a similar value to any fluorescence of the object and place a Color Readout reference on that square
4. Adjust the exposure until the L value of the color readout is ~50

Ultra-violet Reflectance Imaging (UVR)

1. Convert image to greyscale by adjusting saturation to -100
2. Place a Color Readout reference on both the white and black Spectralon® references
3. Adjust the white and black points in the Levels tool until the L values are 98 and 2 respectively for the white and black references

Infra-red Reflectance Imaging (IRR)

1. Convert image to greyscale by adjusting saturation to -100
2. Place a Color Readout reference on both the white and black Spectralon® references
3. Adjust the white and black points in the Levels tool until the L values are 98 and 2 respectively for the white and black references

Visible-induced IR Luminescence Imaging (VIL)

1. Convert image to greyscale by adjusting saturation to -100
1. Place a Color Readout reference on both the white and black Spectralon® references
2. Adjust the white and black points in the Levels tool until the L values are 98 and 2 respectively for the white and black references

Export all processed and selected images to the output folder!

False-color and image subtraction in Photoshop

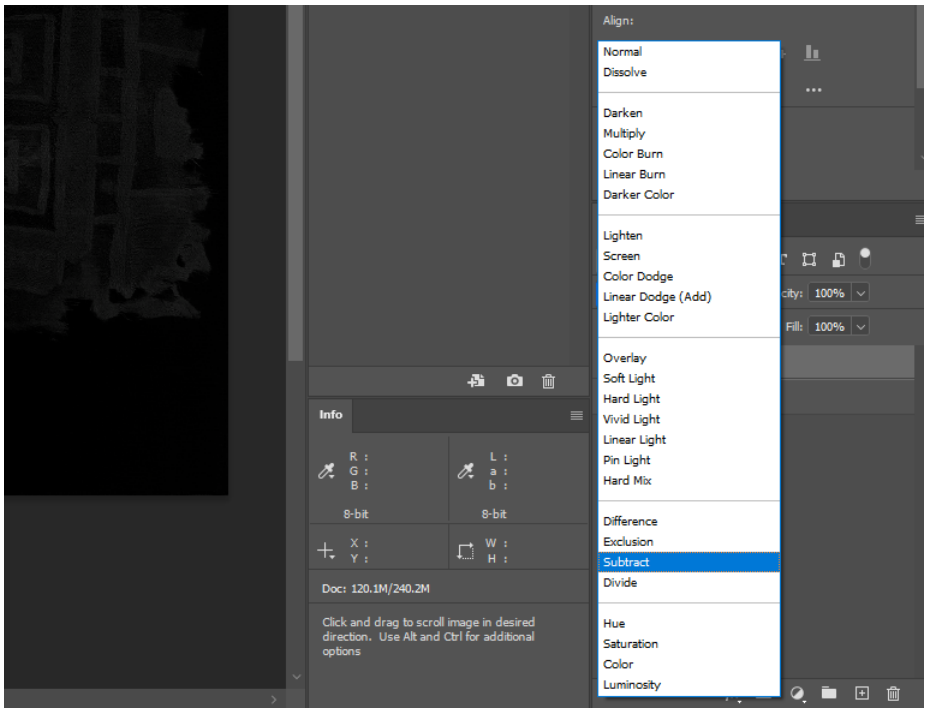
Some post-processing needs to be done in Photoshop instead of Capture One. This is also a good time to convert the images to .jpg format to upload to Museum Plus.

Start by opening all session images in Photoshop. UVL and VIL images are not needed for post-processing, so they can be exported as .jpgs (File-> Export-> Export As) and closed.

Image subtraction

1. Select the entirety of IS 660 by using CNTL+A and copy with CNTL+C
2. Switch to the IS 735 window and paste (CNTL+V)

3. IS 660 should now be a second layer in IS 735. Select it, and change the layer interaction to Subtract

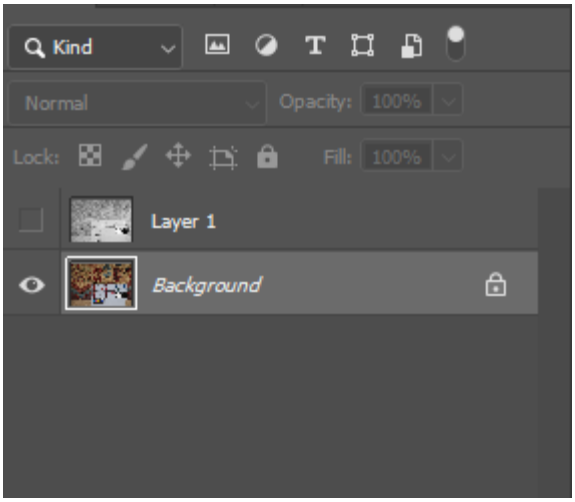


4. The resulting image should be dark overall, with some lighter areas usually corresponding to blue, green, purple, or black portions of the textile.
5. Flatten the image and save it as ACCESSION_NUM_MB_IS_DATE.tif, and export it as a .jpg.

Generating false-color images

Color images taken in RGB mode are made of three channels, each corresponding to a color. False-color imaging takes single-channel (greyscale) images taken in IR reflectance and UV reflectance and integrates them into the color channels of a visible image to simultaneously provide information about the visible color of a region and its UV or IR behavior.

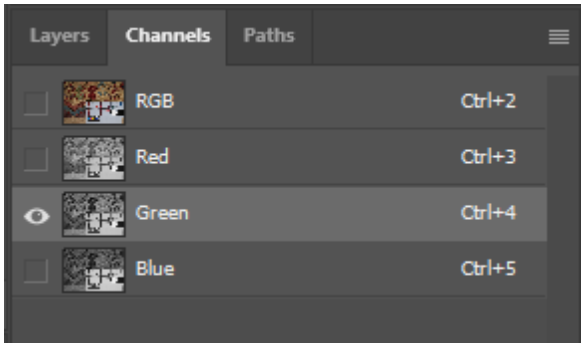
To understand how these images are generated, it is important to understand how layer and channel selection works in Photoshop. The select all (CNTL+A) tool will be used frequently, but this tool does not necessarily select everything *present* in an image.



For example, in the screenshot above the Background layer is both *visible* (eye symbol) and *selected* (highlighted compared to other layers). Using CNTL+A in this context will select all of Background, but none of Layer 1.

This can be utilized to help generate false-color images.

1. Copy the UVR image and paste into VIS (CNTL+A , CNTL+C in the UVL window, CNTL+V in the VIS window)
2. Ensure that the VIS image (now Background) is visible and selected, while UVR (now Layer 1) is not selected and invisible.
3. Click on the Channels tab next to Layers



4. Once again, it is going to be important to ensure that only one of the color channels is selected and visible at once! For UVR, select the Green channel (as shown above) and use CNTL+A, CNTL+C to copy it. Click on the Red channel (which should now be selected) and using CNTL+V to paste.
5. Repeat to move the Blue channel to Green.
6. Return to Layers and deselect and hide Background. Ensure Layer 1 (the UVL image) is selected and visible. CNTL+A, CNTL+C to select the UVR image and copy it.
7. Deselect and hide Layer 1. Ensure Background is visible and selected. Navigate back to Channels, click on Blue, and use CNTL+V to paste the UVR image into the blue channel. Because UVR is a greyscale image, it is equivalent to the single-channel of a RGB image.
8. Flatten image, save as ACCESSION_NUM_MB_UVRFC_DATE.tif and export as a .jpg

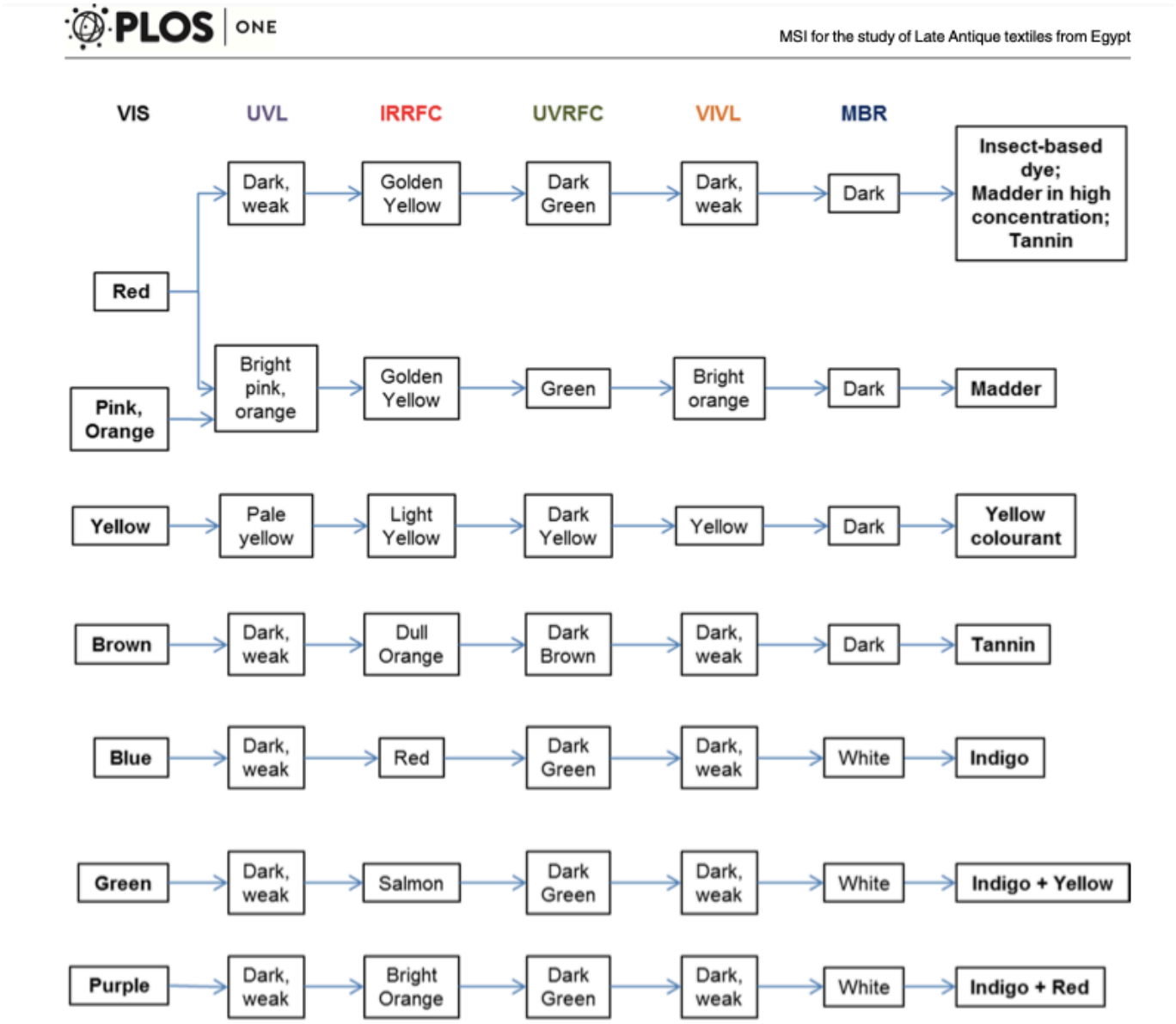
A completed UVRFC image is shown below.

This is repeated with IRR, only in this case Background's Green is moved to Blue, Red is moved to Green, and the IRR image is inserted as the Red channel.

Remember to flatten the image, rename it, and export as a jpg!

Options for Analysis

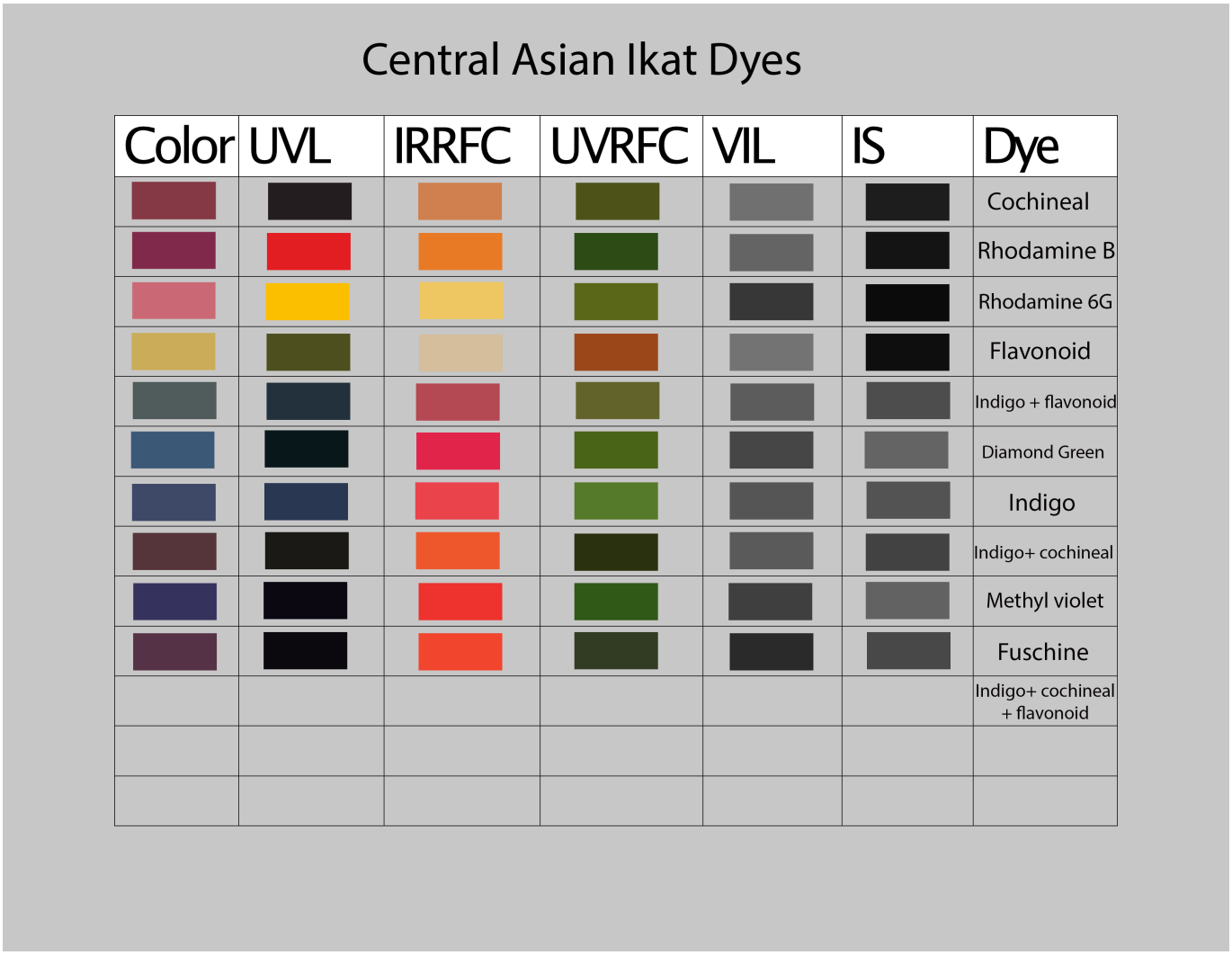
Once multiband images have been gathered, the results can be compared against standards with known dyestuffs to draw conclusions about which dyes have been used. There are different ways of doing this, including flow charts (such as the following from Dyer et al, 2018).



Note—Dyer et al refer to the 660/735 bandpass subtraction technique as MBR, not IS.

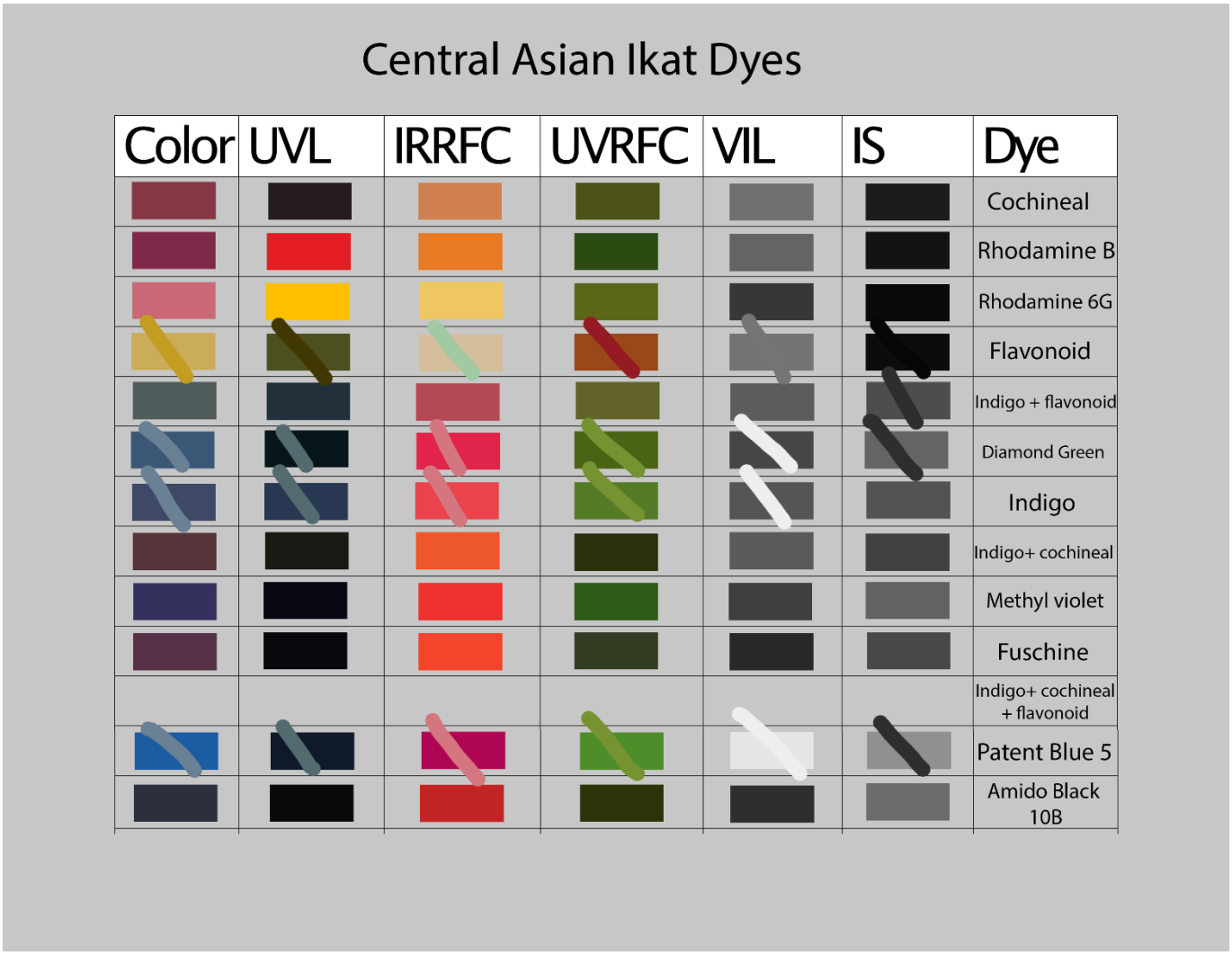
However, it can be difficult to accurately compare colors to written descriptions. Although this chart makes sense for publication, where figures that are legible when printed in greyscale are ideal, we are prototyping a different method.

Central Asian Ikat Dyes



This chart contains all reference dyes known to be found in Central Asian Ikats (see Tamburini 2020). All have been imaged using this multiband system, and representative color blocks generated using the eyedropper tool in Photoshop.

Objects can then be compared to this chart, for ex:



This ikat contains three colors—undyed silk, yellow, and blue. The yellow regions are compared to flavonoid dyes, while the blue is compared to Indigo, Diamond Green (CI #42000), and Patent Blue 5 (CI #42051). The IRRFC and UVRFC responses of the yellow dye do not match the flavonoid dye used in Central Asian Ikats, so the yellow cannot be identified. The blue also does not match with the response expected for indigo, so it appears that the dye used is a synthetic, possibly Patent Blue 5.

Image archiving

Capture One sessions should be backed up on the Multiband Back-Up external drive.

All output images (.tif and .jpg) are uploaded to Box in (Group) GWM-TM-Conservation-> IMAGES-> Analytical Imaging->Multiband in a folder labeled with the object accession number.

.jpg files are added to an Analysis Report in Museum Plus under the Conservation module. Use the following details for the report:

Analysis type—Multiband Imaging

Type details-- Visible, UV luminescent, UV reflected (false-color), IR reflected (false-color), visible-induced IR luminescence and 660/735 bandpass subtraction

Method-- For details, see Multiband guide 2023

Results/conclusions—any conclusions that you drew from the images.