

## **Note on Processed Spectral Images (2016)**

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*This document introduces, enumerates, and briefly defines the processed spectral image types produced by the two phases of the Livingstone Spectral Imaging Project (2010-13, 2013-17) and included in the spectral image archival packets.*

Introduction

Overview List of Spectral Images Types

Processed Spectral Image Descriptions

Notes on a Few Unusual Imaging Cases

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### **Introduction**

Our work on the critical editions of Livingstone's 1870 and 1871 Field Diaries and the Letter from Bambarre has resulted in a range of processed spectral images. Below, we introduce, enumerate, and briefly define the processed spectral image types developed by our scientists (Roger Easton, Keith Knox, and Caroline Houston) in close collaboration with our scholars (Adrian S. Wisnicki, Megan Ward, Debbie Harrison, and Kate Simpson) to address our research goals.

For the second phase of the Livingstone Spectral Imaging Project (2013-17), we have repurposed a handful of processed images from the first phase (2010-13), as review showed that some images previously developed to recover faded text could also illuminate material history. These repurposed images are marked with two asterisks (\*\*) in the list below. The other images from the first project phase are marked with a single asterisk (\*). Images and other items not marked with any symbol are a direct result of the second project phase.

For each item, we provide 1) the short name by which we refer to the image type, animation, or presentation throughout our critical materials, 2) the original image name suffix (if available), which can contain unique processing information related to image creation, 3) a short description (provided by our scientists) of the underlying processing technique, 4) a list of material manuscript features for which the given image type proves particularly suited (images related to 1870 Field Diary only), and 5) the name of the scientist(s) who led the relevant spectral image processing.

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## I. Overview list of processed spectral image types

color\*\*

color\_raking

IC1\_(liv\_000204\_0001\_trans)

IC2\_(liv\_000204\_0001\_trans)

IC3\_(liv\_000204\_0001\_trans)

IC4\_(liv\_000204\_0001\_trans)

IC5\_(liv\_000204\_0001\_trans)

ICA\_pseudo\_(liv\_000204\_0001\_trans)

ICA\_pseudo\_(liv\_000205\_0032\_trans)

intercept\*

PCA\_pseudo\_(liv\_000205\_0032\_stats)

PCA\_pseudo\_(liv\_000205\_0034\_stats)

pca###r\*

pca###r\_adapThresh\*

pca###r\_adapThresh\_multiply\*

pca###r\_pcolor\*

pseudo\_0505-0780\*\*

pseudo\_0780\*

pseudo\_0780\_by\_0940\*

pseudo\_0940\_by\_0592

pseudoBY\_0940\_by\_0592

pseudoratio\_0505-0780\*

RAIPratio\*

raking\_irdiff\*\*

raking\_irdiff\_mockup

RAPRatio\*

RARR\*

ratio\_by\_940\*\*

red\_green

RIRL\*

sharpie\_0505-0780\*\*

sharpieratio\_0505-0780\*

\* = developed for the first phase of the Livingstone Spectral Imaging Project (2010-13), which included the development of critical editions of Livingstone's Letter from Bambarre and 1871 Field Diary.

\*\* = developed for the first phase of the Livingstone Spectral Imaging Project (2010-13) and repurposed for the second phase (2013-17), which includes the development of critical editions of Livingstone's 1870 Field Diary and select 1871 letters.

## **II. Notes on a Few Unusual Imaging Cases**

liv\_000200\_0006\_PCA\_pseudo\_(liv\_000205\_0034\_stats)

liv\_000202\_0004

liv\_000202\_0004\_color

liv\_000204\_0001 and liv\_000204\_0002

liv\_000204\_0001\_PCA\_pseudo\_(liv\_000205\_0034\_stats)

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## **I. Processed Spectral Images**

### **color\*\***

*Original file name suffix:* color

*Processing description:* This image approximates a natural light image and is created using registered, 16-bit flattened TIFF images captured under five visible illuminant bands: royal blue (450 nm), cyan (505 nm), green (535 nm), amber (592 nm), and red (638 nm). A set of linear formulae is used to calculate calibrated color values from the five bands at each pixel position, and each image is output using a CIE L\*a\*b color space. The white swatch of the ColorChecker24 placed in each of the 5 input image files is used to establish the white point.

*Aspects of manuscript enhanced:* Preliminary composition and additions, reinking and revision, impressions, torn pages, brown stains, red stains, other material features

*Lead Scientist:* Knox

## **color\_raking**

*Original file name suffix:* color\_raking

*Processing description:* Blending of a full-color, natural light image with a raking light image that shows page topography. The raking light image is the difference of the two infrared (940 nm) raking images, divided by the regular reflectance infrared (940 nm) image. By blending the two images together, the condition of the handwriting can be related to the topography of the page.

*Aspects of manuscript enhanced:* Folds, impressions, holes

*Lead Scientist:* Knox

## **IC1\_(liv\_000204\_0001\_trans)**

*Original file name suffix:* cal\_trans\_DLC297d\_20-17-18-19\_001r\_0\_cube\_12bands\_text\_IC1

*Processing description:* First band generated from the 12 independent components evaluated using the transformation determined from the spectral images of liv\_000204\_0001 (originally called: DLC297d\_20-17-18-19\_001r).

*Aspects of manuscript enhanced:* Primary printed texts, pre-composition

*Lead Scientist:* Easton

## **IC2\_(liv\_000204\_0001\_trans)**

*Original file name suffix:* cal\_trans\_DLC297d\_20-17-18-19\_001r\_0\_cube\_12bands\_text\_IC2

*Processing description:* Second band generated from the 12 independent components evaluated using the transformation determined from the spectral images of liv\_000204\_0001 (originally called: DLC297d\_20-17-18-19\_001r).

*Aspects of manuscript enhanced:* Handwritten additions

*Lead Scientist:* Easton

## **IC3\_(liv\_000204\_0001\_trans)**

*Original file name suffix:* cal\_trans\_DLC297d\_20-17-18-19\_001r\_0\_cube\_12bands\_text\_IC3

*Processing description:* Third band generated from the 12 independent components evaluated using the transformation determined from the spectral images of liv\_000204\_0001 (originally called: DLC297d\_20-17-18-19\_001r).

*Aspects of manuscript enhanced:* Primary printed texts, handwritten additions, pre-composition, folds, impressions, torn pages, holes, red stains

*Lead Scientist:* Easton

**IC4\_(liv\_000204\_0001\_trans)**

*Original file name suffix:* cal\_trans\_DLC297d\_20-17-18-19\_001r\_0\_cube\_12bands\_text\_IC4

*Processing description:* Fourth band generated from the 12 independent components evaluated using the transformation determined from the spectral images of liv\_000204\_0001 (originally called: DLC297d\_20-17-18-19\_001r).

*Aspects of manuscript enhanced:* Primary handwritten texts, pre-composition, reinking and revision, page discolor, red stains, miscellaneous singular stains, invisible stains

*Lead Scientist:* Easton

**IC5\_(liv\_000204\_0001\_trans)**

*Original file name suffix:* cal\_trans\_DLC297d\_20-17-18-19\_001r\_0\_cube\_12bands\_text\_IC5

*Processing description:* Fifth band generated from the 12 independent components evaluated using the transformation determined from the spectral images of liv\_000204\_0001 (originally called: DLC297d\_20-17-18-19\_001r).

*Aspects of manuscript enhanced:* Primary handwritten texts, pre-composition, reinking and revision, invisible stains

*Lead Scientist:* Easton

**ICA\_pseudo\_(liv\_000204\_0001\_trans)**

*Original file name suffix:* cal\_trans\_DLC297d\_20-17-18-19\_001r\_0\_cube\_12bands\_text\_ICA\_R1G2B4

*Processing description:* Pseudocolor image created from three bands evaluated by independent component analysis using the transformation determined for liv\_000204\_0001 (originally called: DLC297d\_20-17-18-19\_001r). IC band 1 was placed in the red channel, IC band 2 in the green, and IC band 4 in the blue.

*Aspects of manuscript enhanced:* Primary handwritten texts, handwritten additions, page discolor, brown stains, red stains

*Lead Scientist:* Easton

**ICA\_pseudo\_(liv\_000205\_0032\_trans)**

*Original file name suffix:*

cal\_trans\_NLS10703\_052\_018v\_bands01+03+05+07+09+11\_cal\_text\_ICA\_R1G5B6

*Processing description:* Pseudocolor image created from three bands evaluated by independent component analysis of six original bands using the ICA transformation

determined for liv\_000205\_0032 (originally called: NLS10703\_052\_018v). IC band 1 was placed in the red channel, IC band 5 in the green, and IC band 6 in the blue.

*Aspects of manuscript enhanced:* Preliminary composition and additions, page discolor, the big stain, miscellaneous singular stains

*Lead Scientist:* Easton

### **Intercept\***

*Processing description:* Infrared images (700 nm - 940 nm) are fit to a best straight line on a pixelwise basis. This generates "slope" and "intercept" images.

*Lead Scientist:* Knox

### **PCA\_pseudo\_(liv\_000205\_0032\_stats)**

*Original file name suffix:* cal\_stats\_NLS10703\_052\_018v\_bands01-12\_text\_PCA\_R-1G-1B3

*Processing description:* Pseudocolor image created from first and third bands evaluated by principal component analysis using the statistics determined from 12 reflectance bands of liv\_000205\_0032 (originally called: NLS10703\_052\_018v). The files were rendered using a linear mapping that discarded the values for the top 2% and bottom 2% of the pixels for the entire image.

*Aspects of manuscript enhanced:* Page discolor, the big stain

*Lead Scientist:* Easton

### **PCA\_pseudo\_(liv\_000205\_0034\_stats)**

*Original file name suffix:* cal\_stats\_NLS10703\_054\_019v\_bands01-12\_text\_PCA\_R1G5B6

*Processing description:* Pseudocolor image created from three bands evaluated by principal component analysis using the statistics determined from 12 reflectance bands of liv\_000205\_0034 (originally called: NLS10703\_054\_019v). The files were rendered using a linear mapping that discarded the values for the top 2% and bottom 2% of the pixels for the entire image.

*Aspects of manuscript enhanced:* Page discolor, the big stain

*Lead Scientist:* Easton

### **pca###r\***

*Variants of file name suffix:* pca321r, pca321r\_1, pca321r\_2, pca421r, pca621r, pca721r

*Processing description:* Grayscale image that is extracted from a single channel of the corresponding pca###r\_pcolor image. Note: the ### indicates the principal component bands used.

*Lead Scientist:* Easton/Houston

### **pca###r\_adapThresh\***

*Variant of file name suffix:* pca321r\_adapThresh

*Processing description:* Adaptive threshold. A bitonal image (black, white) is calculated from a gray-scale image where the gray value used to threshold is based on the local statistics, i.e., it "adapts" to the local situation. Note: the ### indicates the principal component bands used.

*Lead Scientist:* Easton/Houston

### **pca###r\_adapThresh\_multiply\***

*Variants of file name suffix:* pca321r\_adapThresh\_multiply,  
pca321r\_1\_adapThresh\_multiply, pca321r\_2\_adapThresh\_multiply,  
pca421r\_adapThresh\_multiply, pca621r\_adapThresh\_multiply,  
pca721r\_adapThresh\_multiply

*Processing description:* Grayscale image that is the result of the multiplication of the thresholded grayscale image and the corresponding pca###r image. Note: the ### indicates the principal component bands used.

*Lead Scientist:* Easton/Houston

### **pca###r\_pcolor\***

*Variants of file name suffix:* pca321r\_pcolor, pca421r\_pcolor, pca621r\_pcolor,  
pca721r\_pcolor

*Processing description:* Psuedocolor image made up of principal component bands with the hue angle rotated. Note: the ### indicates the principal component bands used.

*Lead Scientist:* Easton/Houston

### **pseudo\_0505-0780\*\***

*Original file name suffix:* pseudo\_0505-0780

*Processing description:* 505 nm and 780 nm wavelengths are combined in a no-veil pseudocolor image with the 780 in the red separation and the 505 in the blue and green separations.

*Aspects of manuscript enhanced:* Primary handwritten texts, preliminary composition and additions, reinking and revision, red stains

*Lead Scientist:* Knox

### **pseudo\_0780\***

*Processing description:* 505 nm and 780 nm wavelengths from one side of a page are put into the red and green separations, respectively. The 505 nm wavelength image of the reverse side is reversed and aligned with the front side, then placed in the blue separation.

*Lead Scientist:* Knox

### **pseudo\_0780\_by\_0940\***

*Processing description:* 505 nm and 780 nm wavelengths from one side of a page are divided by the 940 nm wavelength and put into the red and green separations, respectively. The 505 nm wavelength image of the reverse side is divided by the 940 nm wavelength, reversed and aligned with the front side, then placed in the blue separation.

*Lead Scientist:* Knox

### **pseudo\_0940\_by\_0592**

*Original file name suffix:* pseudo\_0940\_by\_0592

*Processing description:* Pseudocolor image that combines images from the front and back sides of the given page. The image on each side is the ratio of an infrared image (940 nm) with a red image (592 nm). The ratio sharpens the smeared handwriting. The pseudocolor combination of the two sides separates the handwriting from the smearing from the other side, by rendering the two sides in different colors (red and green).

*Aspects of manuscript enhanced:* Blotting and bleed through

*Lead scientist:* Knox

### **pseudoBY\_0940\_by\_0592**

*Original file name suffix:* pseudoBY\_0940\_by\_0592

*Processing description:* Pseudocolor image that combines images from the front and back sides of the given page. The image on each side is the ratio of an infrared image (940 nm) with a red image (592 nm). The ratio sharpens the smeared handwriting. The pseudocolor combination of the two sides separates the handwriting from the smearing from the other side, by rendering the two sides in different colors (blue and yellow).

*Aspects of manuscript enhanced:* Blotting and bleed through

*Lead Scientist:* Knox



**pseudoratio\_0505-0780\***

*Processing description:* 505 nm and 780 nm wavelengths are divided by the 940 nm wavelength and then combined in a standard pseudocolor image.

*Lead Scientist:* Knox

**RAIPratio\***

*Processing description:* Left and right raking infrared images are divided by the non-raking 940 nm image and used in a standard pseudocolor image.

*Lead Scientist:* Knox

**raking\_irdiff\*\***

*Original file name suffix:* raking\_irdiff

*Processing description:* Left and right raking images in infrared are differenced, divided by the non-raking 940 nm wavelength, then linearly stretched to fit 6 standard deviations from white to black.

*Aspects of manuscript enhanced:* folds, impressions, torn pages, holes

*Lead Scientist:* Knox

**raking\_irdiff\_mockup**

*Original file name suffix:* pseudo\_raking\_irdiff

*Processing description:* Independent components analysis image, derived from 12 wavelength bands, which gives a similar appearance to raking\_irdiff images (created by differencing left and right raking images). These images are created instead of raking\_irdiff images in those instances where raking images were not captured during original imaging.

*Aspects of manuscript enhanced:* folds, impressions, torn pages, holes

*Lead Scientist:* Knox

**RAPRatio\***

*Processing description:* Right raking blue and infrared images are divided by the non-raking 940 nm image and used in a standard pseudocolor image.

*Lead Scientist:* Knox

**RARR\***

*Processing description:* Right raking blue image is divided by the right raking infrared image and then linearly contrast stretched.

*Lead Scientist:* Knox

**ratio\_by\_940\*\***

*Original file name suffix:* ratio\_by\_940

*Processing description:* 450 nm, 592 nm and 850 nm wavelengths are divided by the 940 nm wavelength, stretched to fit 6 standard deviations from white to black and put into the red, green and blue separations respectively.

*Aspects of manuscript enhanced:* Preliminary composition and additions

*Lead Scientist:* Knox

**red\_green**

*Original file name suffix:* [...]\_Red\_[...]\_Green\_color

*Processing description:* Pseudocolor image that combines the color images of both sides of the given page. The reverse side is aligned with the front side and the two color images are blended together, emphasizing the red separation of the front and the green separation of the reverse side.

*Aspects of manuscript enhanced:* Blotting and bleed through, red stains

*Lead Scientist:* Knox

**RIRL\***

*Processing description:* Left and right raking infrared images are differenced and linearly contrast stretched.

*Lead Scientist:* Knox

**sharpie\*\***

*Original file name suffix:* sharpie\_0505-0780

*Processing description:* 505 nm and 780 nm wavelengths are combined in a no-veil pseudocolor image with the 780 in the red separation and the 505 in the blue and green separations. The sharpie image is made by linearly stretching the difference of the red and blue separations of the pseudocolor image.

*Aspects of manuscript enhanced:* Primary handwritten texts, handwritten additions, miscellaneous singular stains

*Lead Scientist:* Knox

### **sharpieratio\_0505-0780\***

*Processing description:* 505 nm and 780 nm wavelengths are divided by the 940 nm wavelength and then combined in a standard pseudocolor image. The sharpie image is made by linearly stretching the difference of the red and blue separations of the pseudocolor image.

*Lead Scientist:* Knox

## **II. Notes on a Few Unusual Imaging Cases**

### **liv\_000200\_0006\_PCA\_pseudo\_(liv\_000205\_0034\_stats)**

The original version of this image differed considerably from the other processed images of this type. The gray values of the image were therefore rescaled. In other words, the initial rendering of the brightest and darkest pixels for the image relied on statistical metrics that set "white" at the 98th percentile and "black" at the 2nd percentile of the numerical values of the pixels over the entire scene. In creating the rescaled version (the one used in this edition), therefore, we relied on the same calculations, but as applied over pixels only on the actual page of text, where the range of brightness values of pixels is smaller.

### **liv\_000202\_0004**

Unfortunately, the original spectral imaging of this page failed to produce one of the required raw spectral images (535nm, i.e., the fifth band). As a result, during the present project we recreated this band by approximating it from the other available bands and, in turn, used this "synthetic" band in order to produce the other processed spectral images of this page.

### **liv\_000202\_0004\_color**

Due to a missing spectral band (see previous entry), the original version of this image differed considerably from the other processed images of this type. We thus modified the original image in Adobe Photoshop CC 2015.5 by using Auto Tone and adjustments to the Brightness/Contrast, Hue/Saturation, and Color Balance in order to produce the version of the image used in this critical edition.

**liv\_000204\_0001 and liv\_000204\_0002**

The leaf that constitutes liv\_000204 is unusually large. During the original imaging, the project team divided the leaf into quadrants and photographed each individually. We, therefore, turned Photoshop's Photomerge feature to create the images available in the present edition.

**liv\_000204\_0001\_PCA\_pseudo\_(liv\_000205\_0034\_stats)**

Photomerge (see previous entry) produced unsatisfactory results in rendering the background of liv\_000204\_0001\_PCA\_pseudo\_(liv\_000205\_0034\_stats). The PCA pseudocolor images were thus rerendered for the present critical edition using a different scaling (linear 2% on a smaller section instead of over the full image) prior to stitching.