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# Using PSNR thresholds to modulate the degree of lossy compression in JPEG2000 files

Bill Comstock  
Head of Imaging Services, Harvard College Library

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# Disclaimer

I'm not an image scientist, a computer scientist, or a signal processing specialist.



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# A report from the field

- PSNR encoding JP2 files
- The benefits
- The failings
- Measuring and detecting difference
- Guarding against PSNR failings
- Statistics

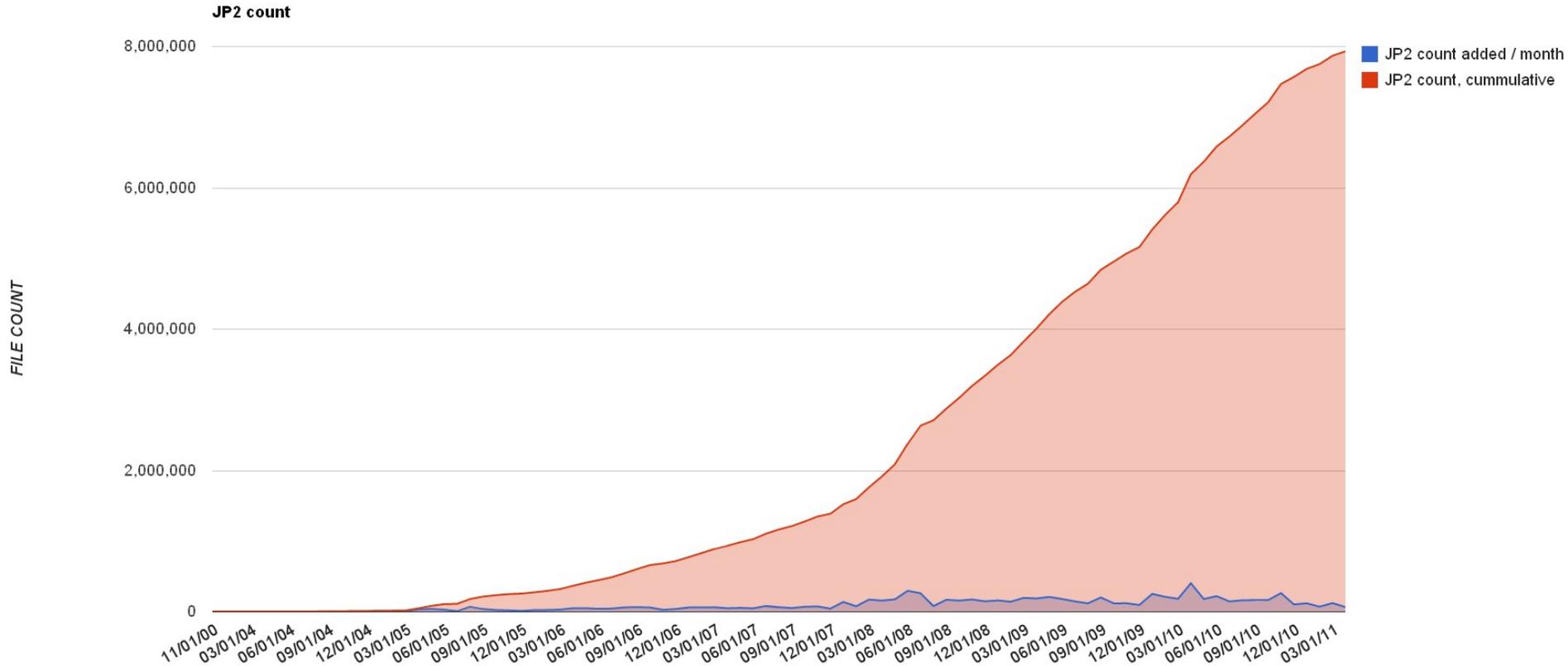
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# JPEG2000 @ the Harvard Library

November 28, 2000, the first JP2 deposited to the Library's Digital Repository Service (DRS).

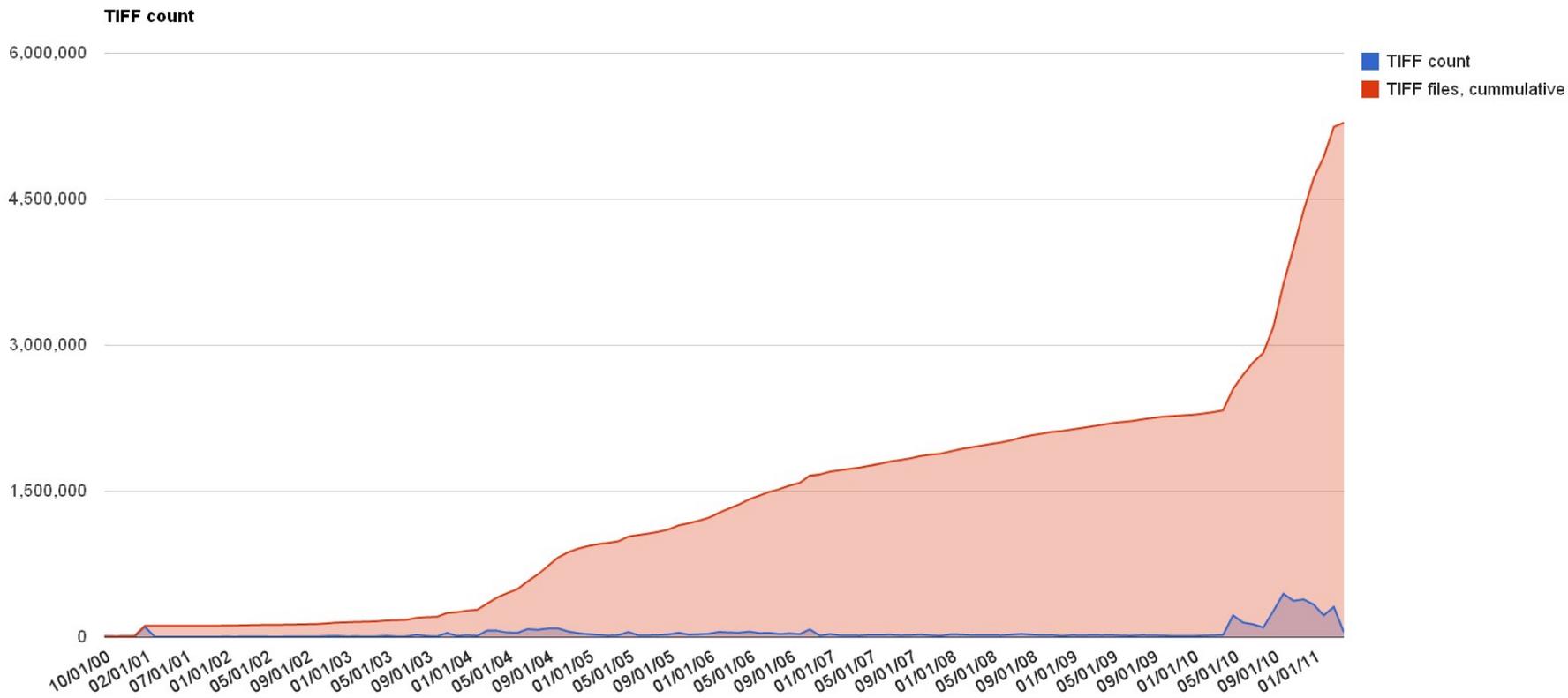
As of April 11, 2011, **7,925,443** JP2 files totaling **27.2 TB** are stored in DRS.

# JPEG2000 @ the Harvard Library

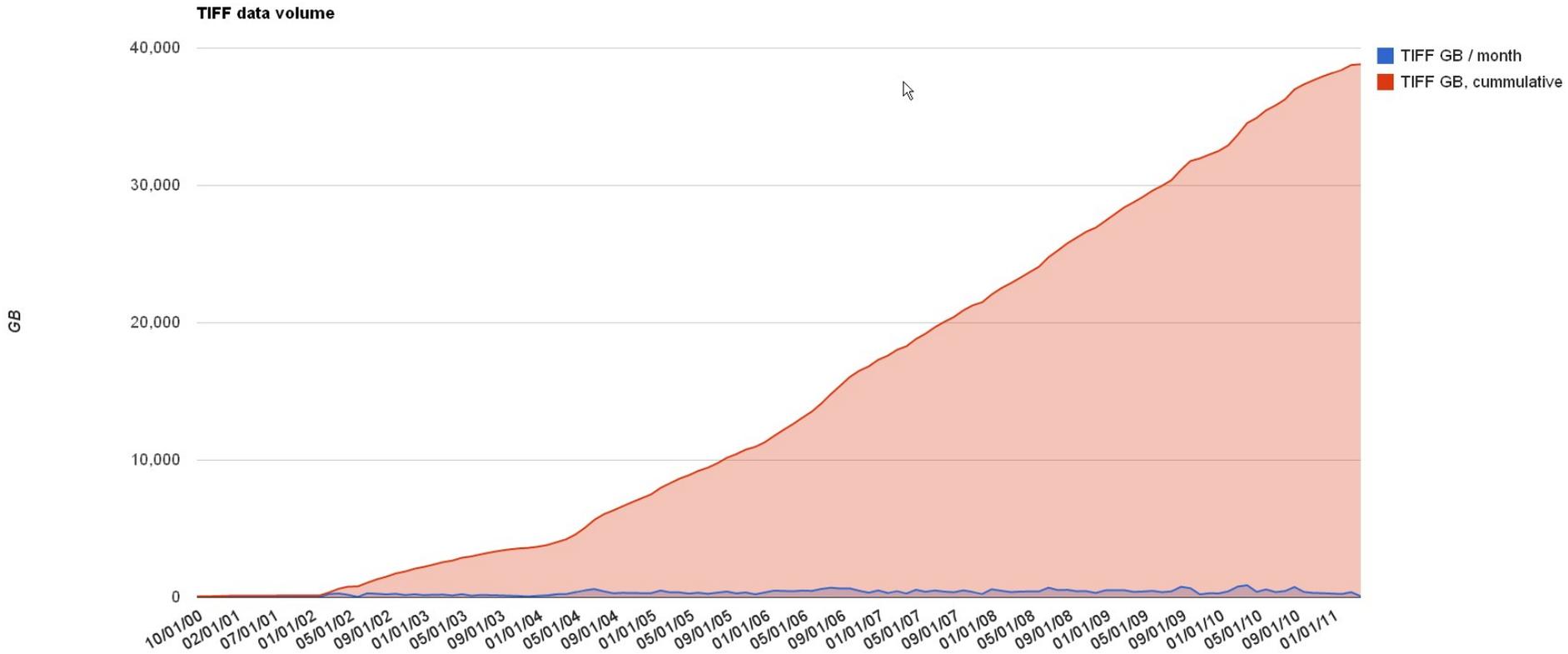


# JPEG2000 @ the Harvard Library

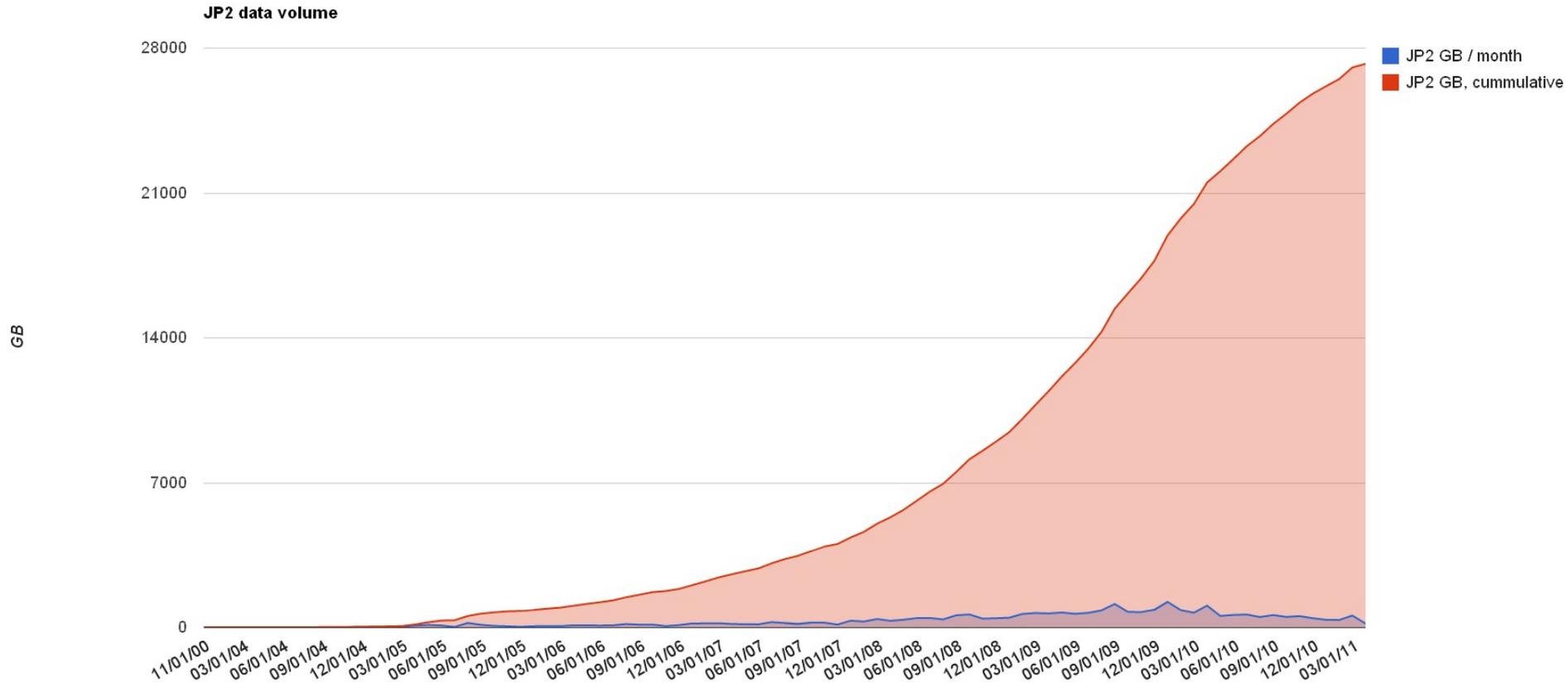
FILE COUNT



# JPEG2000 @ the Harvard Library



# JPEG2000 @ the Harvard Library





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# Peak Signal to Noise Ratio

The phrase peak signal-to-noise ratio, often abbreviated PSNR, is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale.

*[Wikipedia entry](#)*

# Peak Signal to Noise Ratio

The PSNR is most commonly used as a measure of quality of reconstruction in image compression etc. It is most easily defined via the mean squared error (MSE) which for two  $m \times n$  monochrome images  $I$  and  $K$  where one of the images is considered a noisy approximation of the other is defined as:

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} \|I(i, j) - K(i, j)\|_2^2$$

The PSNR is defined as:

$$PSNR = 10 \cdot \log_{10} \left( \frac{MAX_I^2}{MSE} \right) = 20 \cdot \log_{10} \left( \frac{MAX_I}{\sqrt{MSE}} \right)$$

[Wikipedia entry](#)



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# Peak Signal to Noise Ratio

In expressing PSNR as an image encoding parameter, you make explicit the difference you are willing to accept between the source image and the lossy compressed copy you are creating.



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# Other options?

- Fixed file size
- Fixed compression ratio (encoded file to source file)



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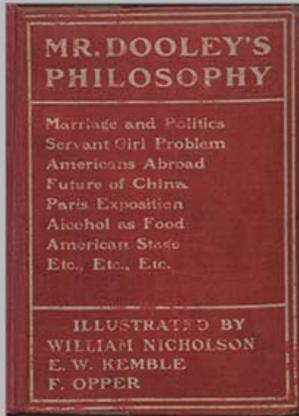
# Why did we elect to control compression using PSNR?

- PSNR is a smart control.
- It adjusts compression based on the content of the image.
- Image content: The arrangement and distribution of pixel-to-pixel differences within the source image.
- PSNR is a smart control, but it isn't perfect.

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IT WORKS

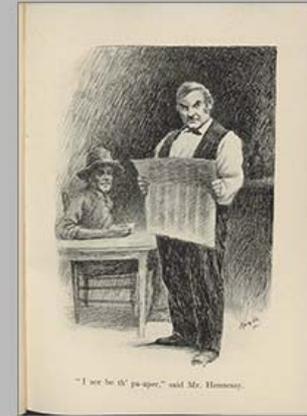
# 5 least compressed page images



0001.jp2  
Today, 6:47:42 PM



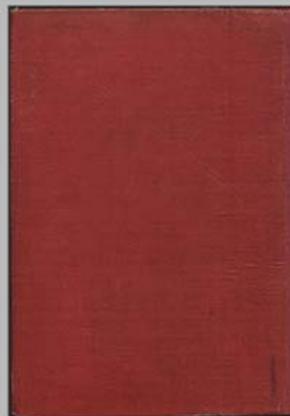
0073.jp2  
Today, 6:47:46 PM



0095.jp2  
Today, 6:47:49 PM

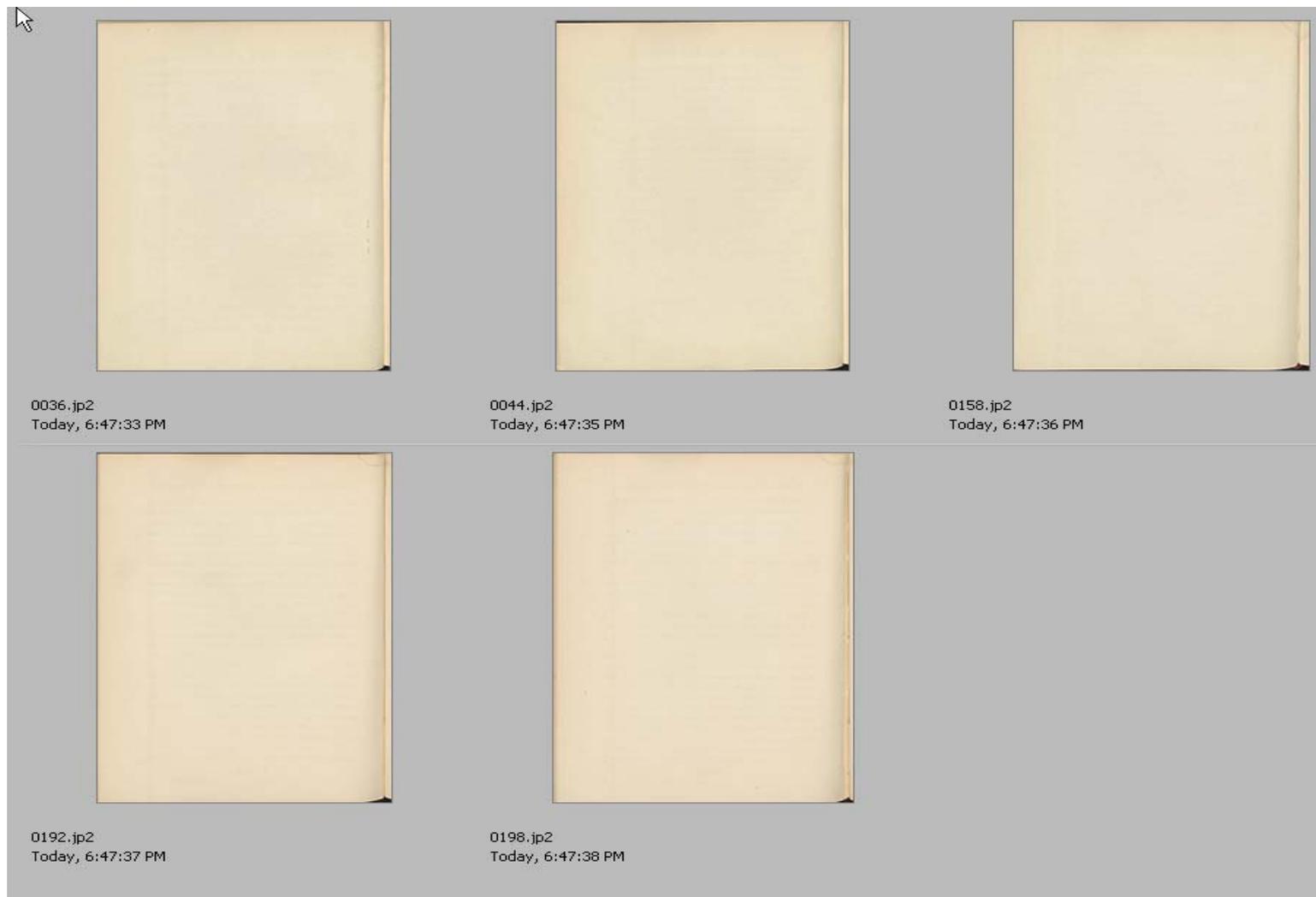


0217.jp2  
Today, 6:47:52 PM

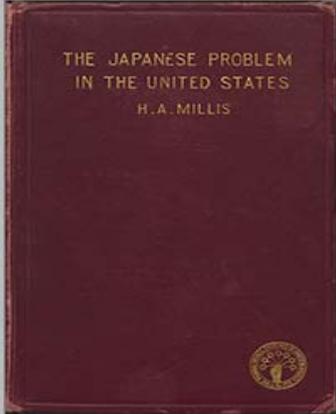
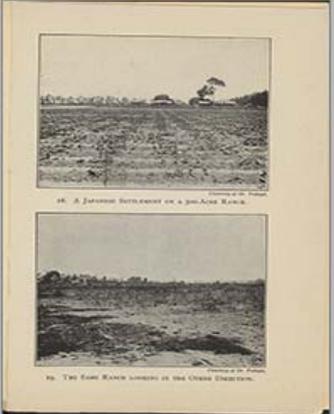
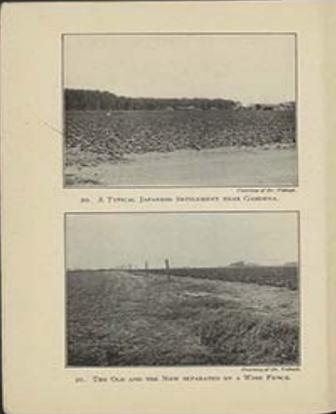
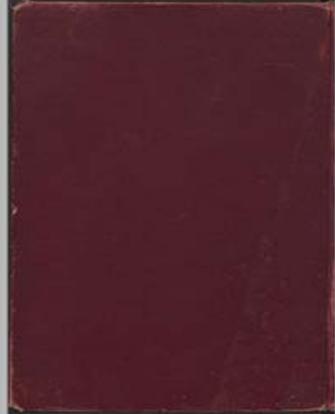


0274.jp2  
Today, 6:47:55 PM

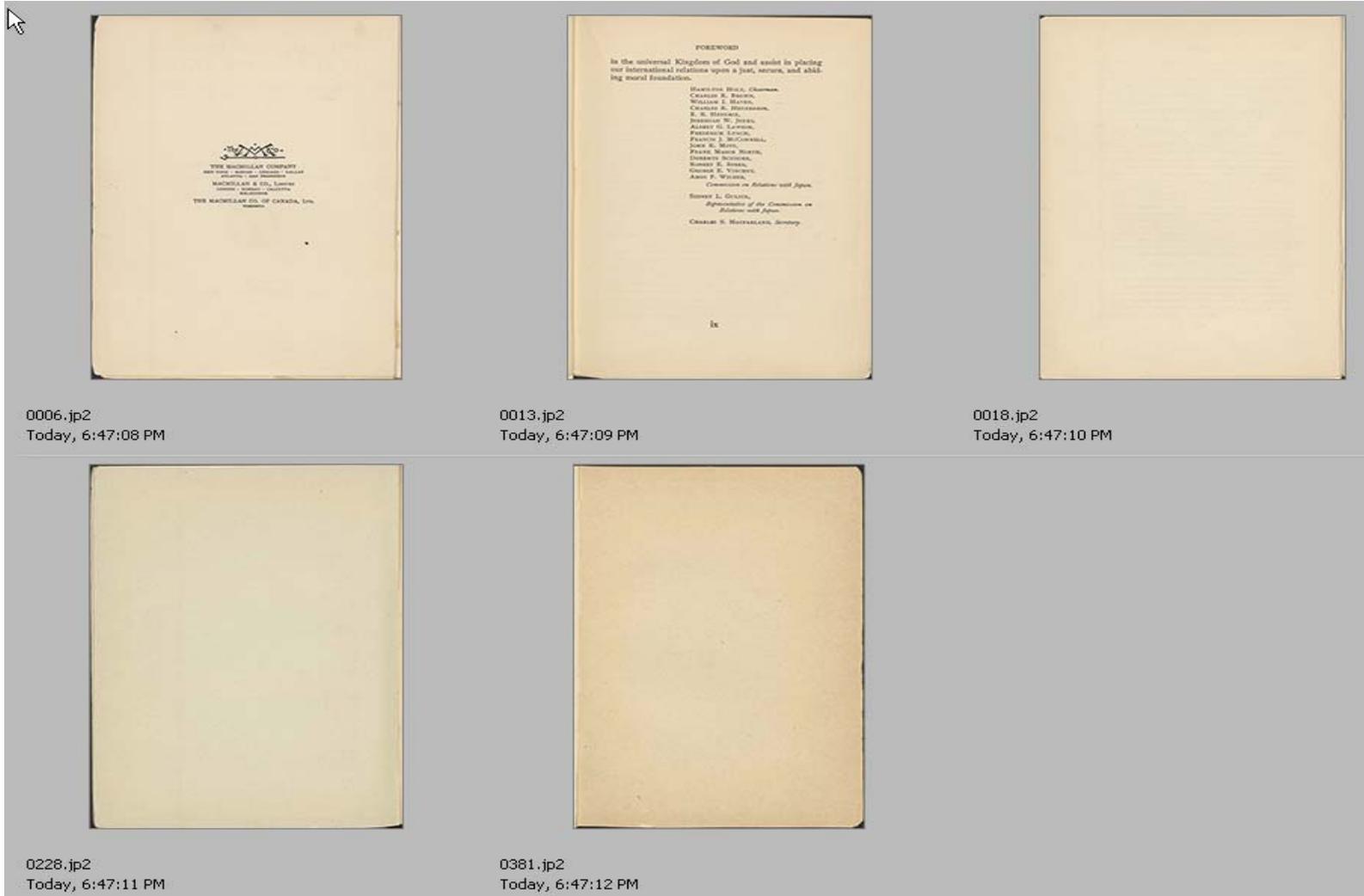
# *5 most compressed page images*



# 5 least compressed page images

 <p>0001.jp2 Today, 6:47:16 PM</p>	 <p>0198.jp2 Today, 6:47:19 PM</p>	 <p>0223.jp2 Today, 6:47:23 PM</p>
 <p>0224.jp2 Today, 6:47:27 PM</p>	 <p>0384.jp2 Today, 6:47:31 PM</p>	

# 5 most compressed page images



The image displays five pages from a document, arranged in two rows. The top row contains three pages, and the bottom row contains two. Each page is accompanied by a filename and a timestamp.

0006.jp2  
Today, 6:47:08 PM

0013.jp2  
Today, 6:47:09 PM

0018.jp2  
Today, 6:47:10 PM

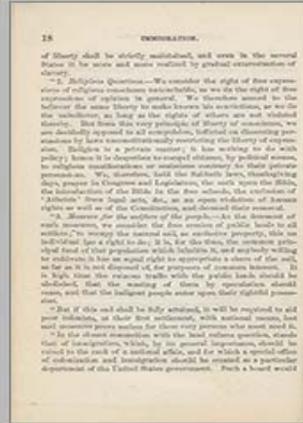
0228.jp2  
Today, 6:47:11 PM

0381.jp2  
Today, 6:47:12 PM

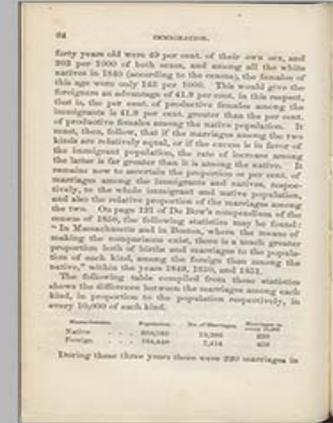
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0026.jp2  
Today, 6:46:58 PM



0092.jp2  
Today, 6:47:00 PM

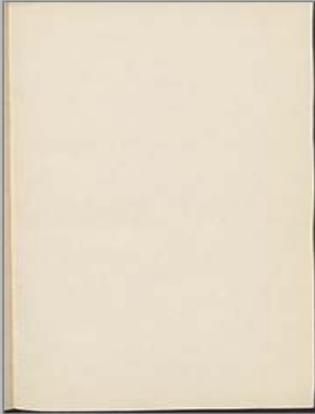


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0176.jp2  
Today, 6:47:06 PM

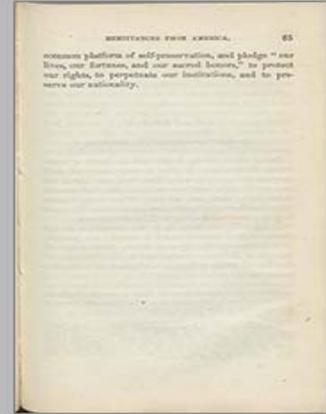
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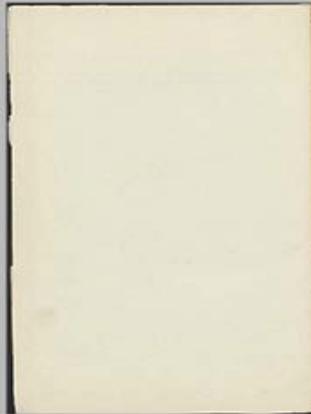
0008.jp2  
Today, 6:46:49 PM



0073.jp2  
Today, 6:46:51 PM

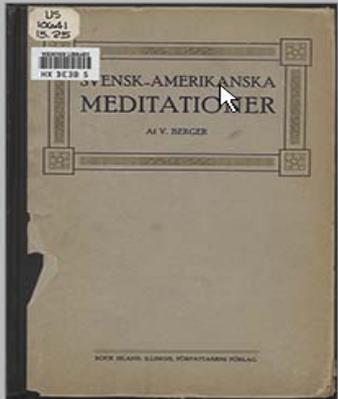


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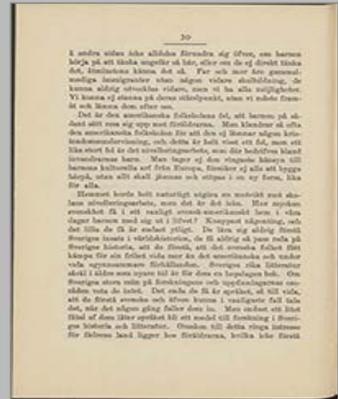


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# 5 least compressed page images



0001.jp2  
Today, 6:46:35 PM



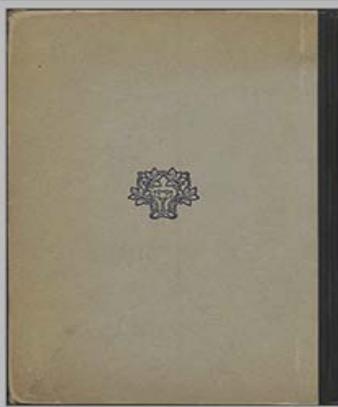
0034.jp2  
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Today, 6:46:41 PM



0108.jp2  
Today, 6:46:43 PM



0160.jp2  
Today, 6:46:47 PM

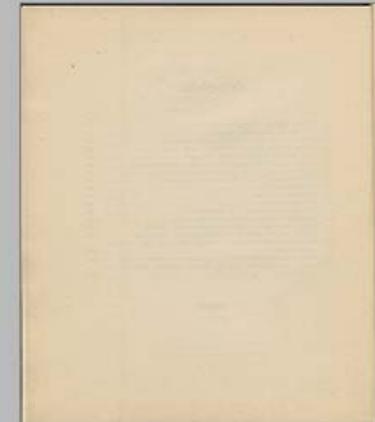
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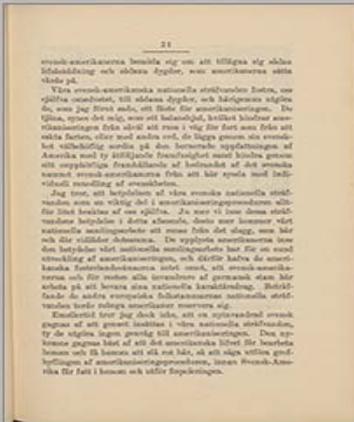
0005.jp2  
Today, 6:46:22 PM



0006.jp2  
Today, 6:46:24 PM



0008.jp2  
Today, 6:46:25 PM



0025.jp2  
Today, 6:46:28 PM

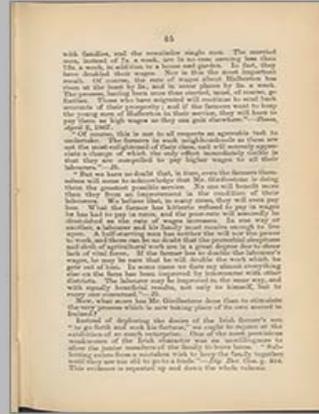


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Today, 6:46:31 PM

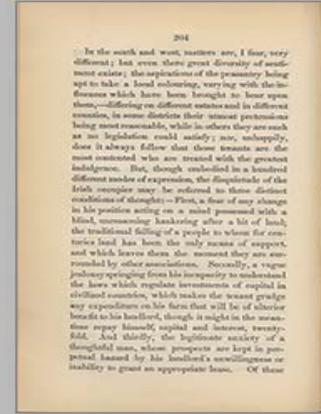
# 5 least compressed page images



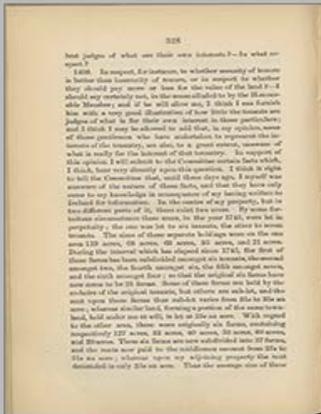
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Today, 6:46:09 PM



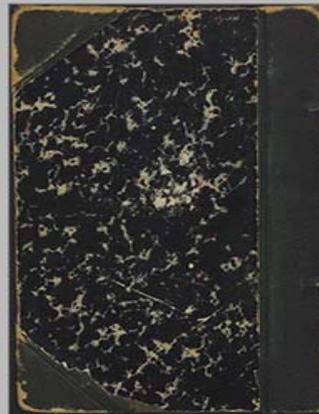
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Today, 6:46:12 PM



0239.jp2  
Today, 6:46:14 PM



0363.jp2  
Today, 6:46:17 PM



0443.jp2  
Today, 6:46:20 PM

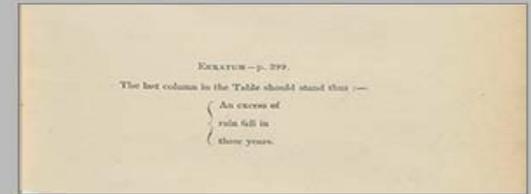
# 5 most compressed page images



0005.jp2  
Today, 6:46:01 PM



0006.jp2  
Today, 6:46:02 PM



0009.jp2  
Today, 6:46:03 PM

249

Table showing the Number of Male Cultivators employed in Belgium and Flanders. (see p. 142)

	Belgium	and Flanders
Population agricultural, et forestière, vigneronne, et de pisciculture de culture	230,470	112,828
Reposés, horticulteurs, pépiniéristes	4,811	736
Agriculteurs et cultivateurs agricoles, forestiers, vigneronnes, etc.	235,281	113,564
Total	240,092	114,300

Length of Belgian Levees

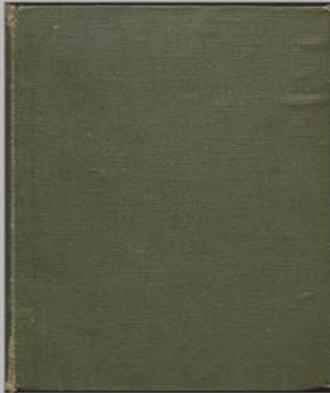
"Les levées ont été considérablement améliorées par une série de grands travaux, et les brèches ont été entièrement réparées de manière à être prêts pour être, etc. de tout etc." - *Report of Belgian Census, 1846.*

0244.jp2  
Today, 6:46:04 PM



0441.jp2  
Today, 6:46:05 PM

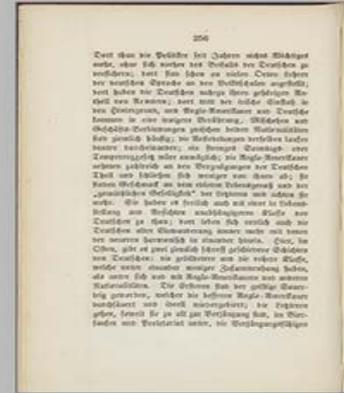
# 5 least compressed page images



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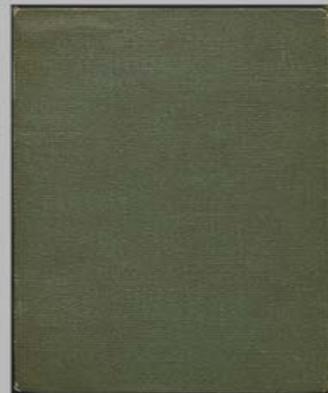
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Today, 6:45:50 PM



0276.jp2  
Today, 6:45:52 PM

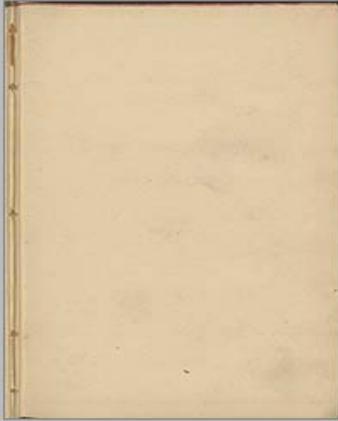


0288.jp2  
Today, 6:45:55 PM

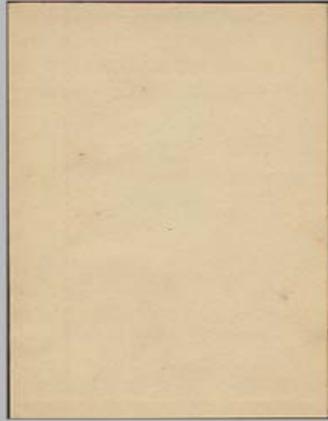


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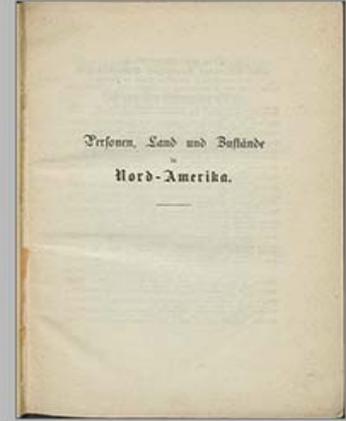
# *5 most compressed page images*



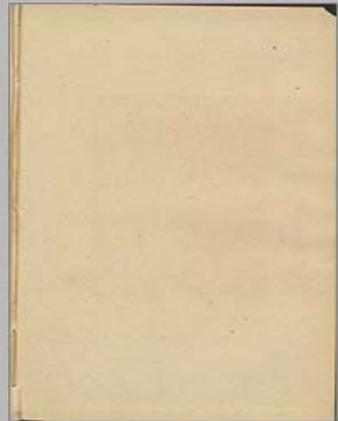
0003.jp2  
Today, 6:45:37 PM



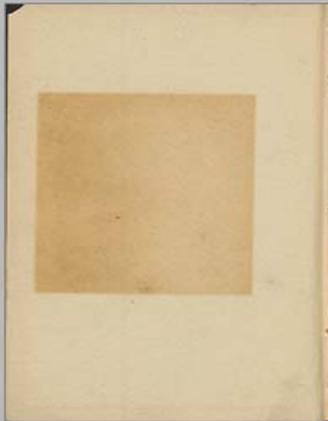
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Today, 6:45:39 PM



0005.jp2  
Today, 6:45:40 PM



0373.jp2  
Today, 6:45:41 PM



0374.jp2  
Today, 6:45:42 PM

# *5 least compressed page images*



W362726\_1.jp2  
Today, 10:33:17 PM



W362729\_1.jp2  
Today, 10:34:10 PM



W362740\_1.jp2  
Today, 10:36:30 PM



W362753\_1.jp2  
Today, 10:45:34 PM



W362874\_1.jp2  
Today, 11:41:50 PM

# 5 most compressed page images



W362843\_1.jp2  
Today, 11:36:44 PM

W362860\_1.jp2  
Today, 11:39:16 PM

W362871\_1.jp2  
Today, 11:41:13 PM

W362875\_1.jp2  
Today, 11:42:10 PM

W362882\_1.jp2  
Today, 11:43:18 PM



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# IT FAILS



<http://flic.kr/p/8VVWY>

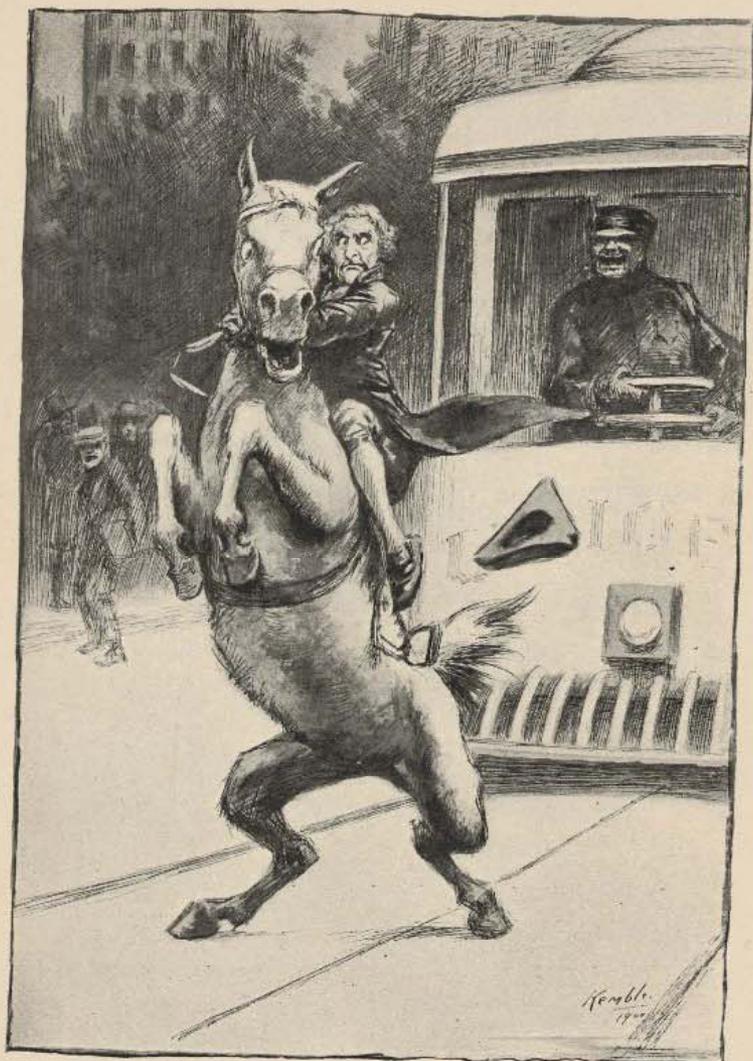


*Cypripedium Haynaldianum*, Rehb. f.

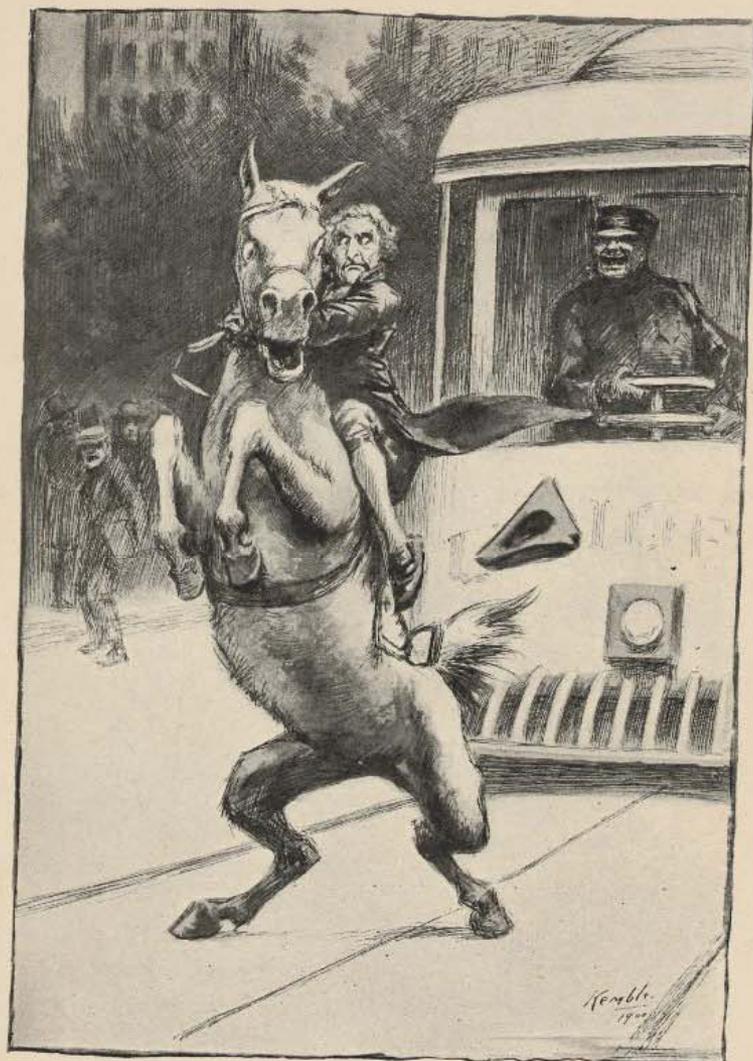






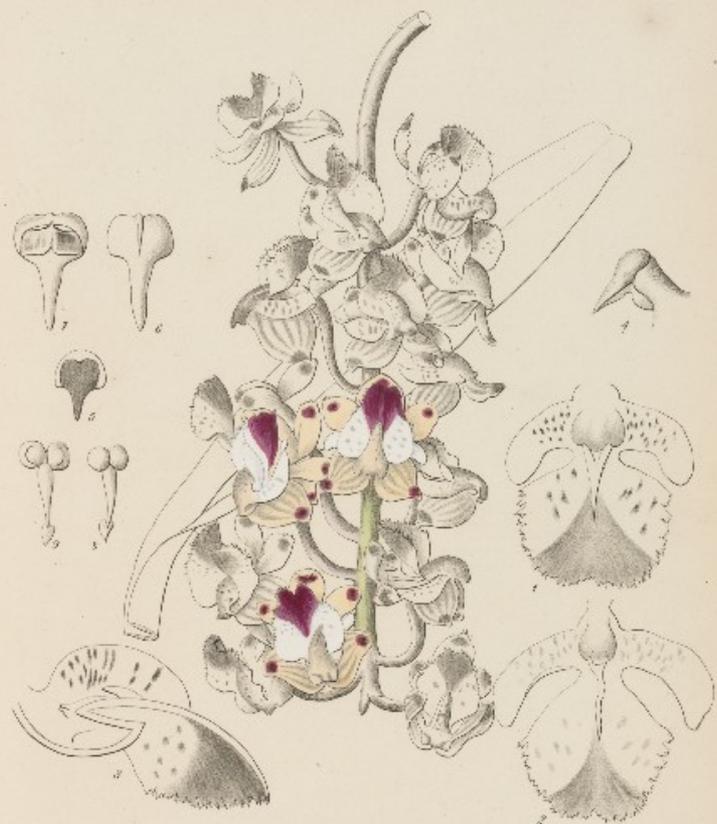


“But suppose Thomas Jefferson was to come back here now.”

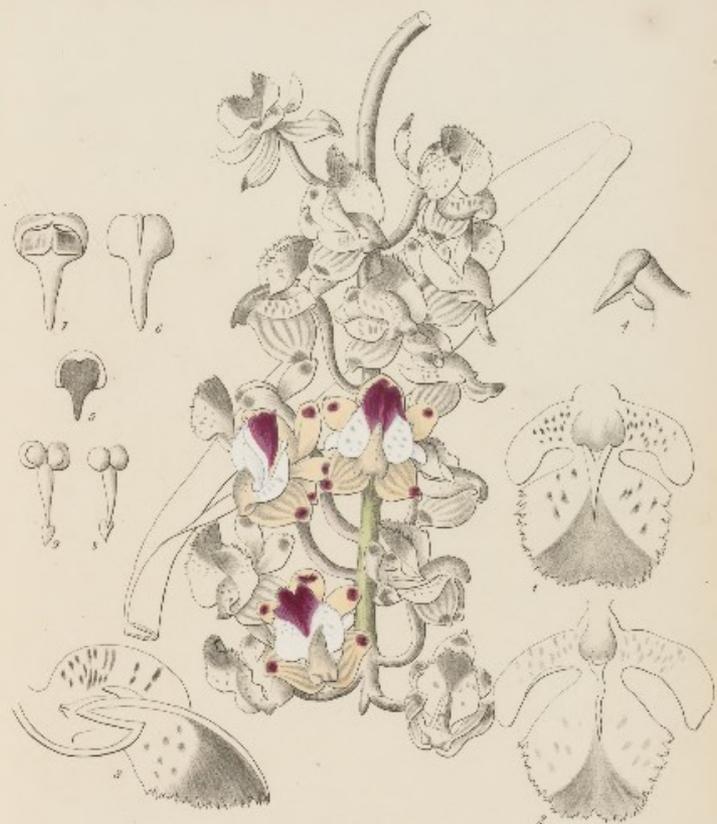


“But suppose Thomas Jefferson was to come back here now.”





*Anolis Houlletianum* Robt. Fil.



*Anolis Houlletianum* Robt. Fil.

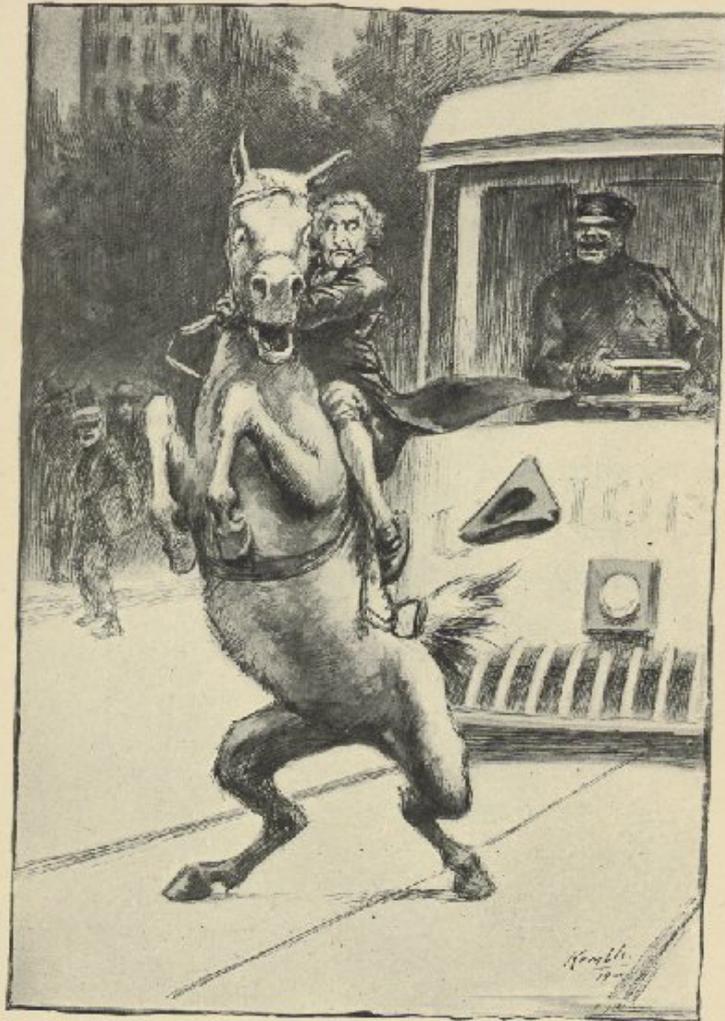
*M. Berthold sc.*

*M. Berthold sc.*



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# Measuring Difference



“ But suppose Thomas Jefferson was to come back here now.”

Layers Channels Paths

Normal ▾ Opacity: 100% ▸

Lock:     Fill: 100% ▸

Background

Navigation icons:

Navigator Info Histogram

Channel: RGB ▾

Source: Entire Image ▾

Mean:	172.13	Level:	255
Std Dev:	52.23	Count:	0
Median:	190	Percentile:	100.00
Pixels:	198720	Cache Level:	3

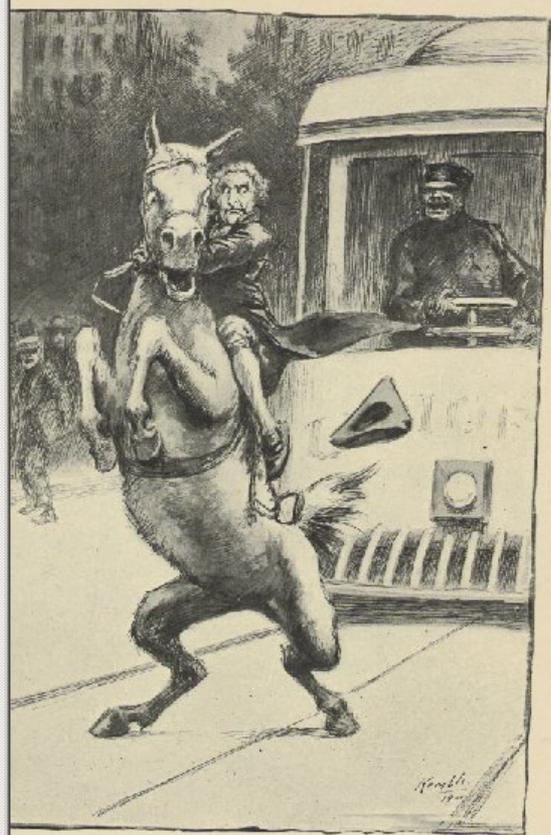
0217\_43.jp2 @ 33.3% (RGB/8)



"But suppose Thomas Jefferson was to come back here now."

33.33% sRGB IEC61966-2.1 (8bpc)

33.3% (RGB/8)



"But suppose Thomas Jefferson was to come back here now."

33.3% (RGB/8) sRGB IEC61966-2.1 (8bpc)

Layers Channels Paths

Normal Opacity: 100%

Lock: Fill: 100%

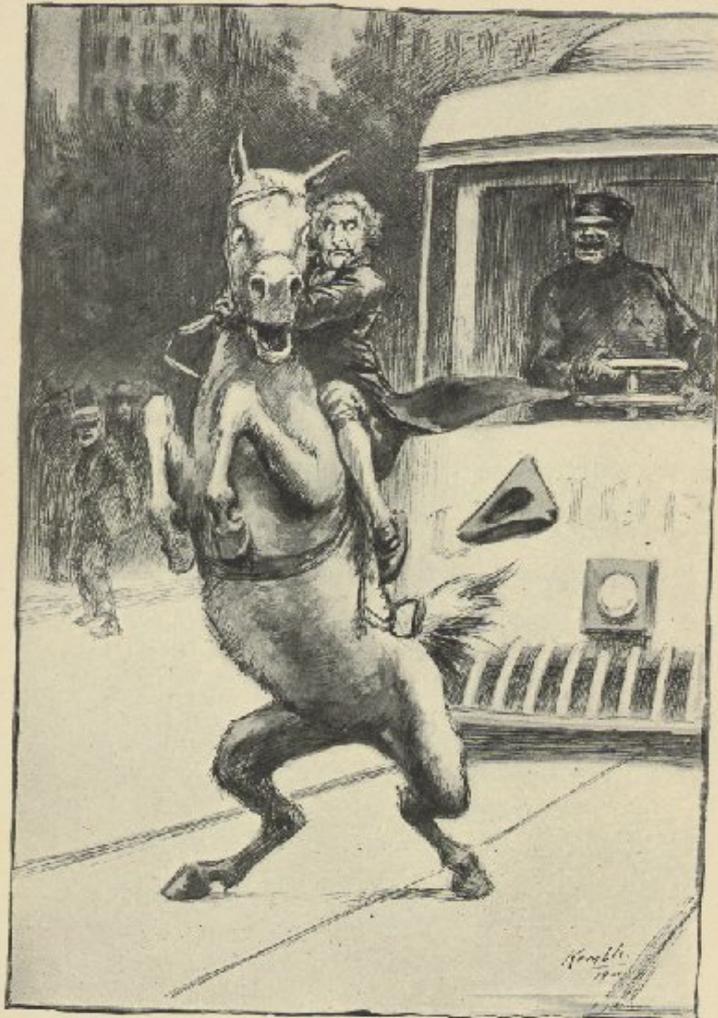
Background

Navigator Info Histogram

Channel: RGB

Source: Entire Image

Mean: 172.00	Level:
Std Dev: 52.11	Count:
Median: 189	Percentile:
Pixels: 198720	Cache Level: 3



“ But suppose Thomas Jefferson was to come back here now.”

Layers Channels Paths

Normal Opacity: 100%

Lock: Fill: 100%

- Layer 1
- Background

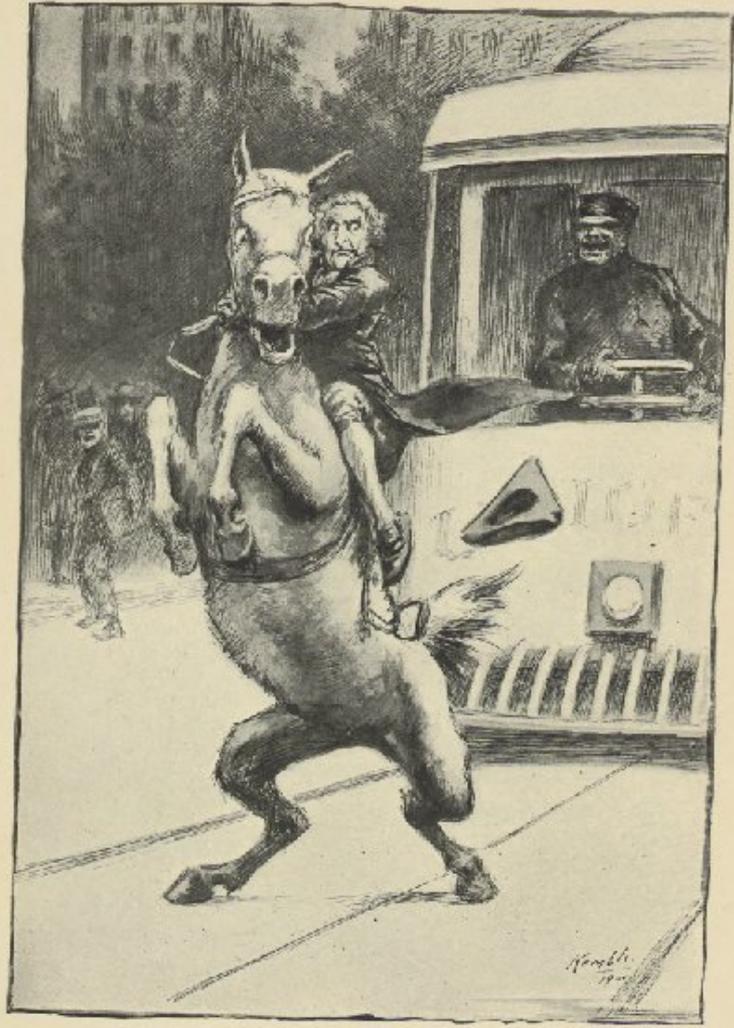
Create a new la

Navigator Info Histogram

Channel: RGB

Source: Entire Image

Mean: 172.13	Level:
Std Dev: 52.23	Count:
Median: 190	Percentile:
Pixels: 198720	Cache Level: 3



ome back

“ But suppose Thomas Jefferson was to come back here now.”

Layers Channels Paths

Normal Opacity: 100%

Lock: Fill: 100%

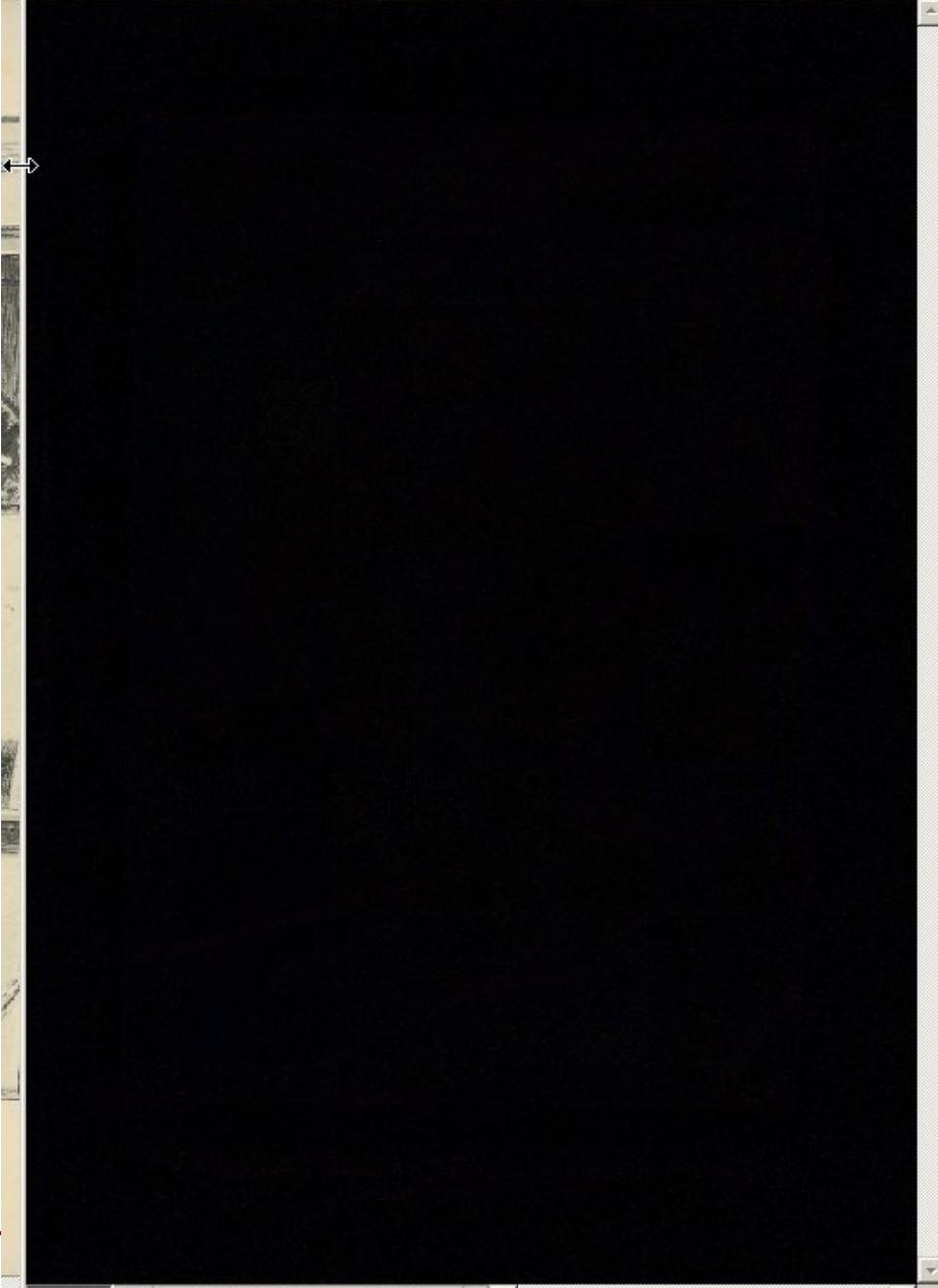
- JP2
- Background

Navigator Info Histogram

Channel: RGB

Source: Entire Image

Mean:	172.00	Level:	
Std Dev:	52.11	Count:	
Median:	189	Percentile:	
Pixels:	198720	Cache Level:	3



Layers Channels Paths

Difference Opacity: 100%

Lock: [ ] [ ] [ ] [ ] Fill: 100%

- JP2
- Background

33.33%

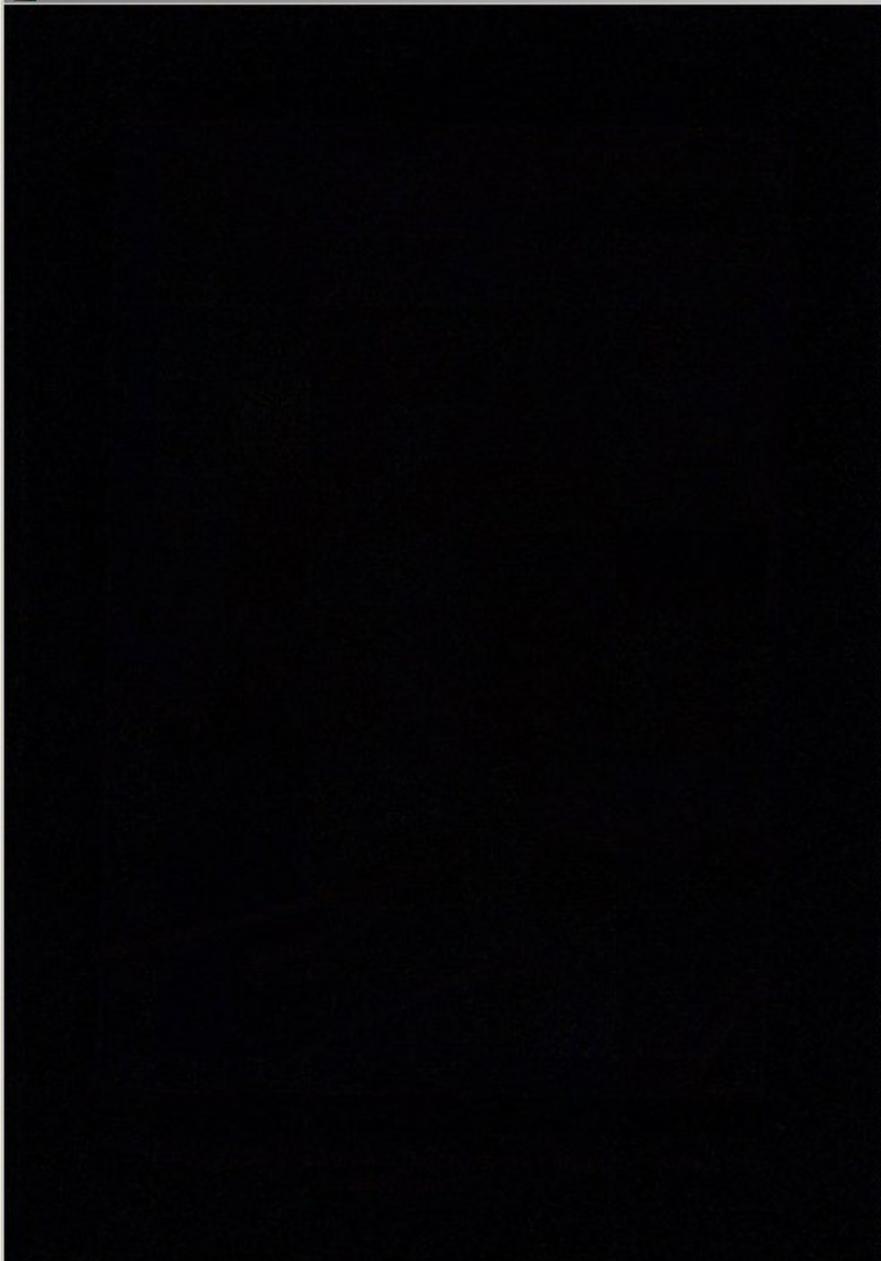
Navigator Info Histogram

Channel: RGB

Source: Entire Image

Mean: 0.73	Level:
Std Dev: 0.75	Count:
Median: 1	Percentile:
Pixels: 198720	Cache Level: 3

0217.tif @ 33.3% (JP2, RGB/8)



33.33% sRGB IEC61966-2.1 (8bpc)

Layers Channels Paths

Difference Opacity: 100%

Lock: Fill: 100%

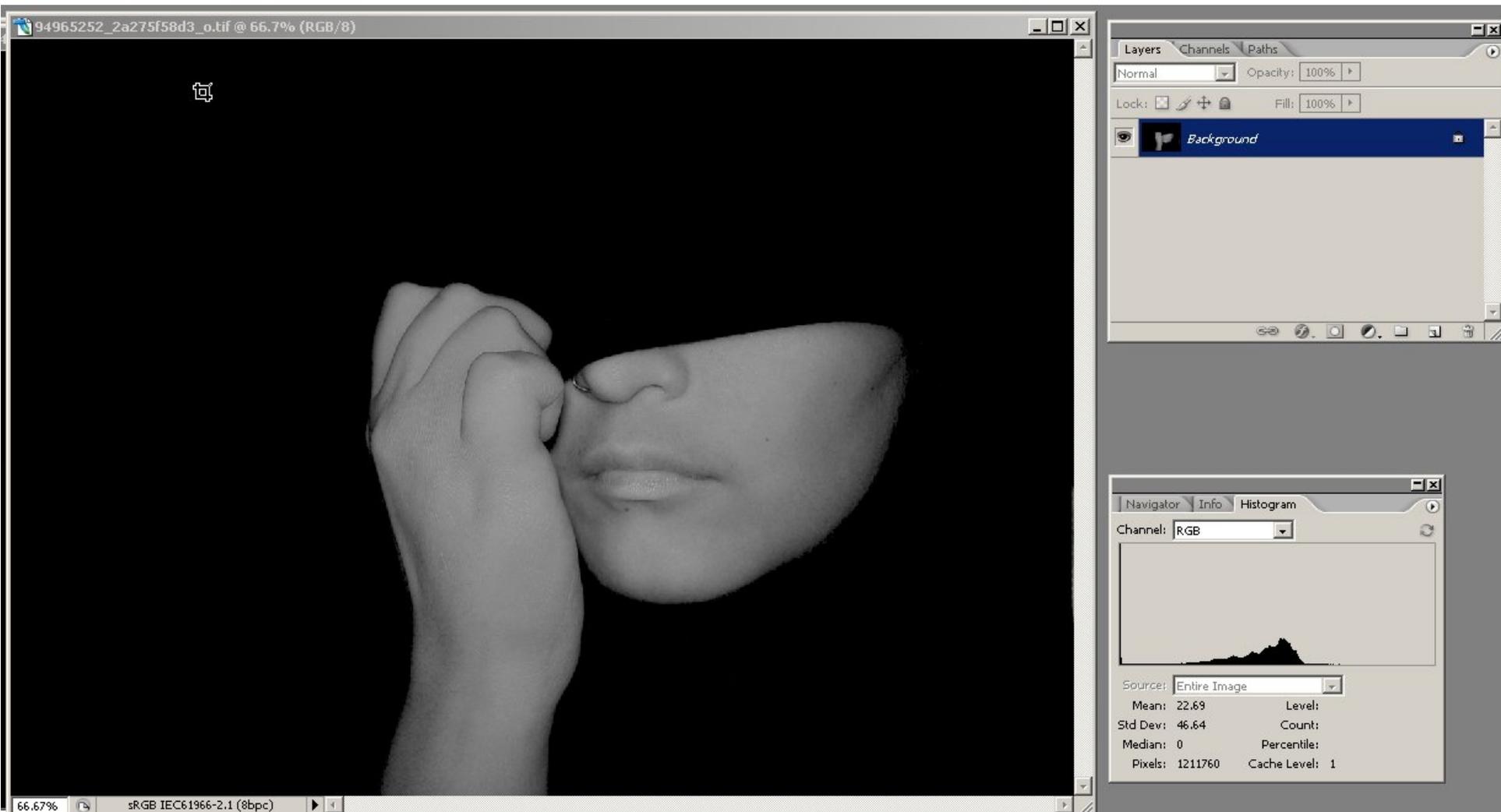
- JP2
- Background

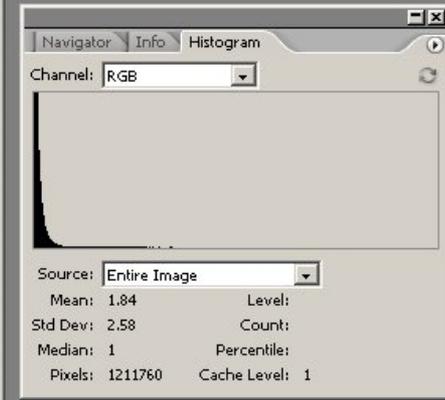
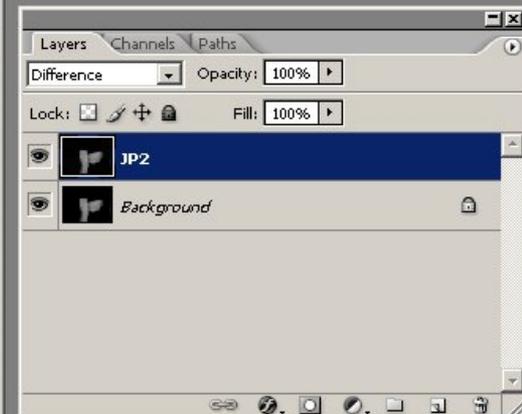
Navigator Info Histogram

Channel: RGB

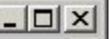
Source: Entire Image

Mean: 2.10	Level: 248
Std Dev: 2.38	Count: 0
Median: 1	Percentile: 100.00
Pixels: 3175104	Cache Level: 1





94965252\_2a275f58d3\_o.tif @ 100% (RGB/8)

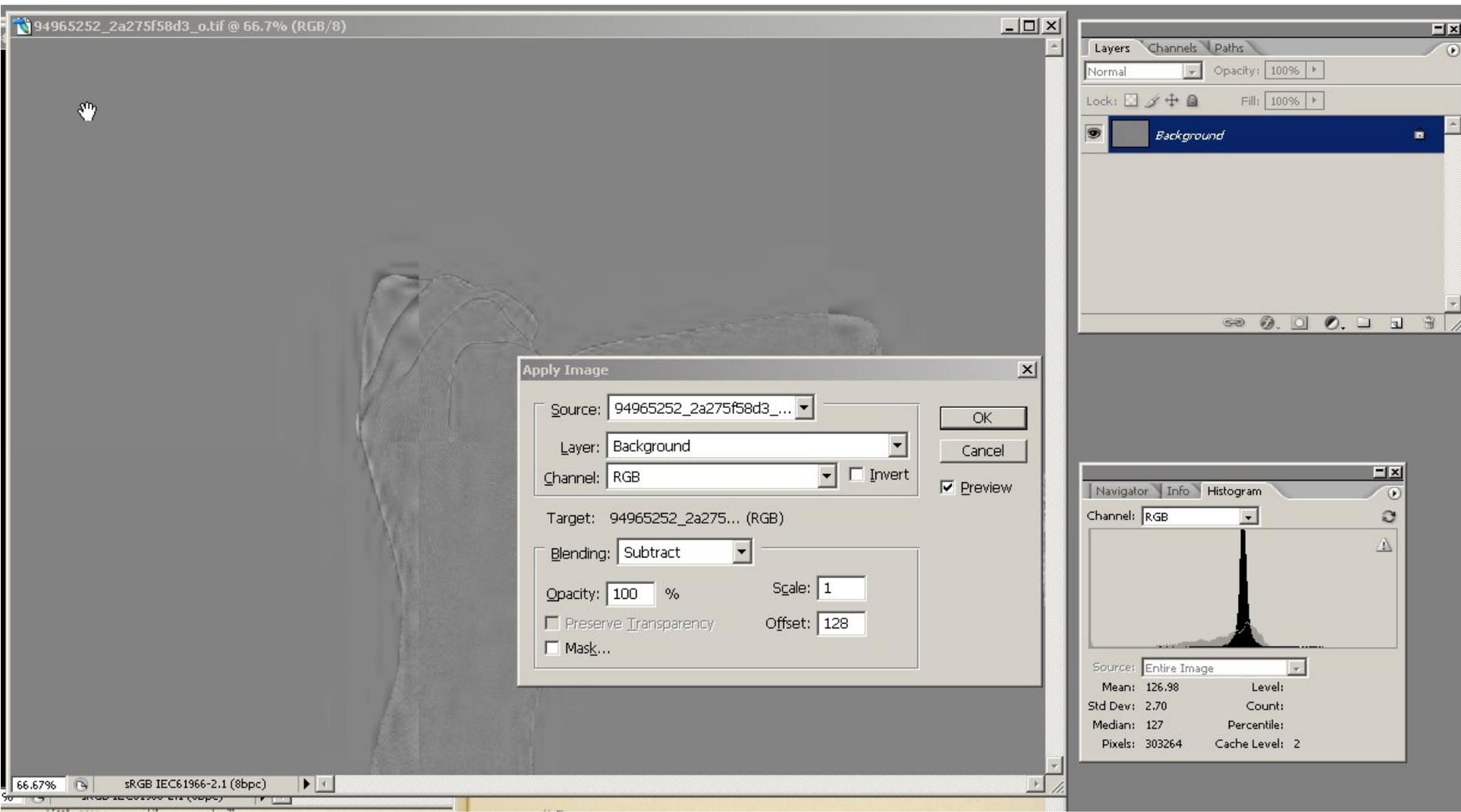


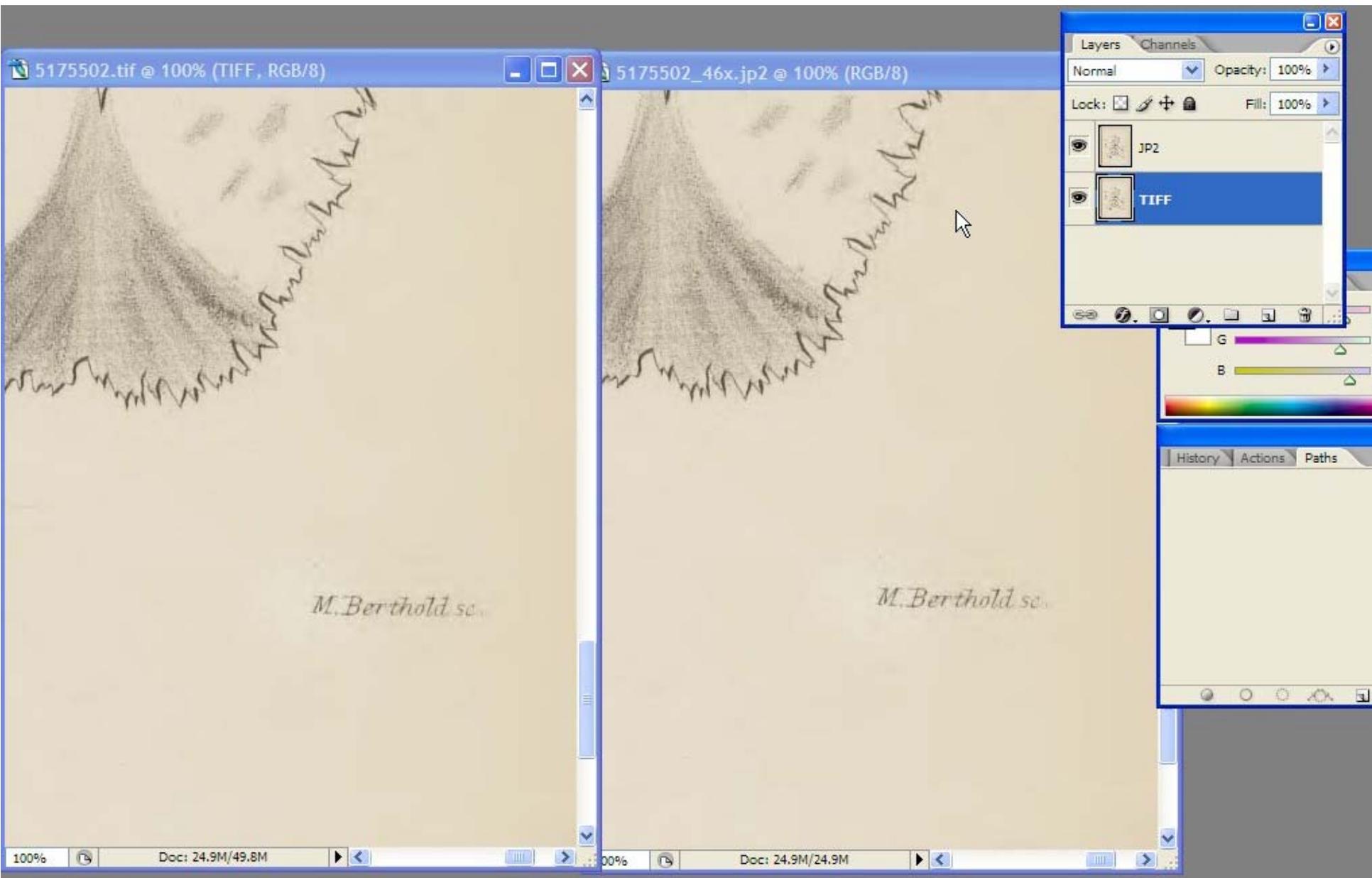
100%

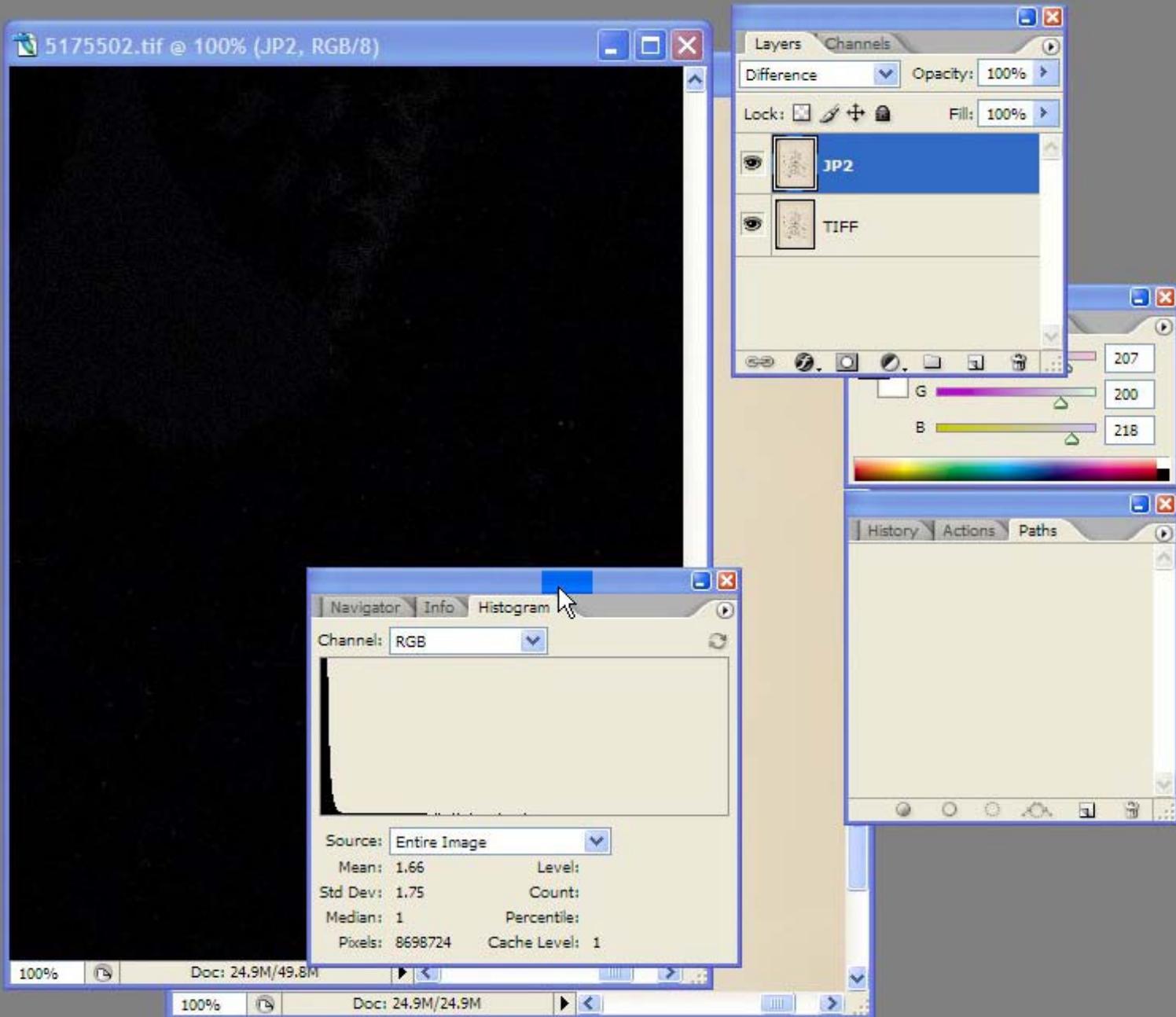


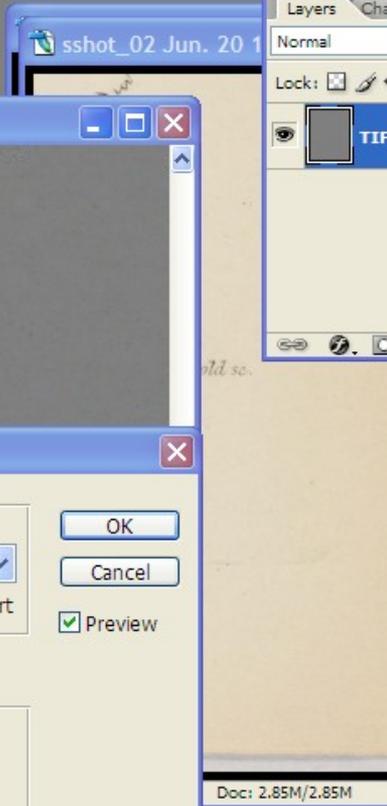
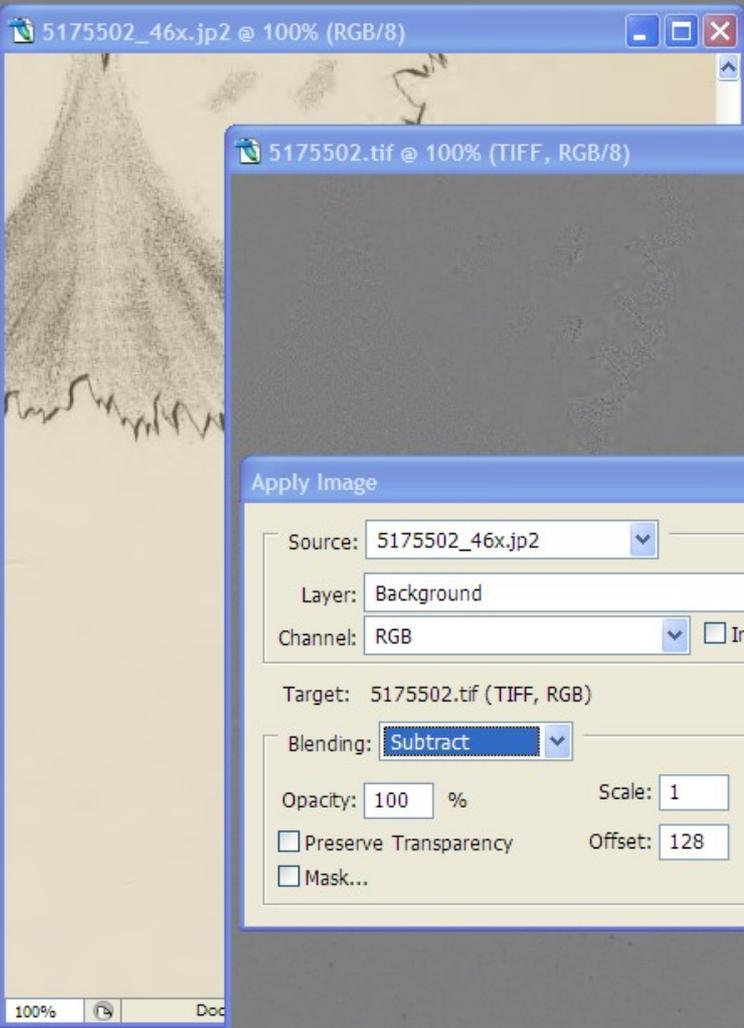
sRGB IEC61966-2.1 (8bpc)











### Apply Image

Source: 5175502\_46x.jp2

Layer: Background

Channel: RGB  Invert

Target: 5175502.tif (TIFF, RGB)

Blending: Subtract

Opacity: 100 % Scale: 1

Preserve Transparency Offset: 128

Mask...

OK Cancel Preview

### Layers Channels

Normal Opacity: 100%

Lock:     Fill: 100%

TIFF

### Swatches Styles

R 207

G 118

B 218

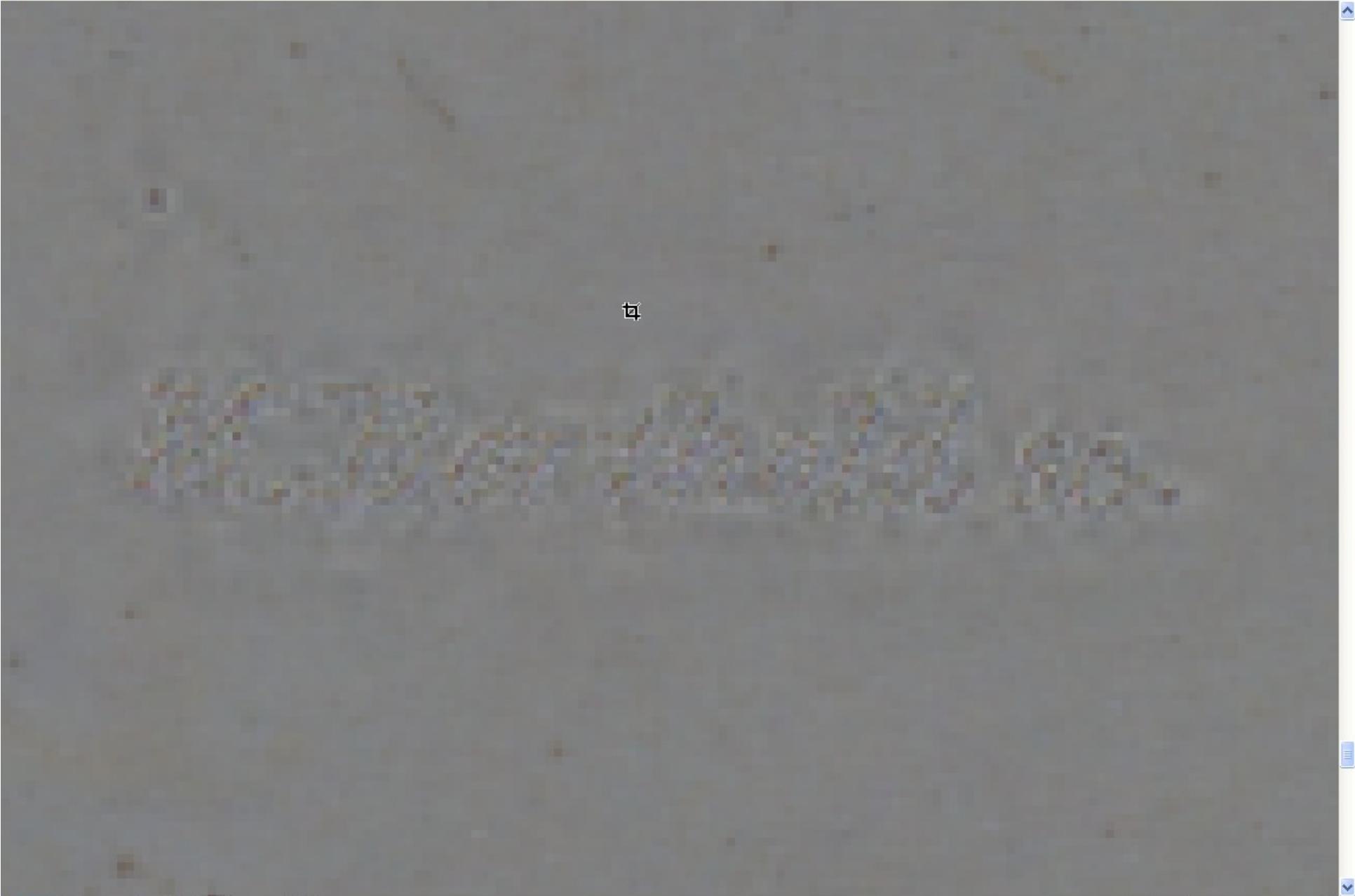
### History Actions Paths

### Navigator Info Histogram

Channel: RGB

Source: Entire Image

Mean: 128.31	Level:
Std Dev: 0.89	Count:
Median: 128	Percentile:
Pixels: 136104	Cache Level: 4





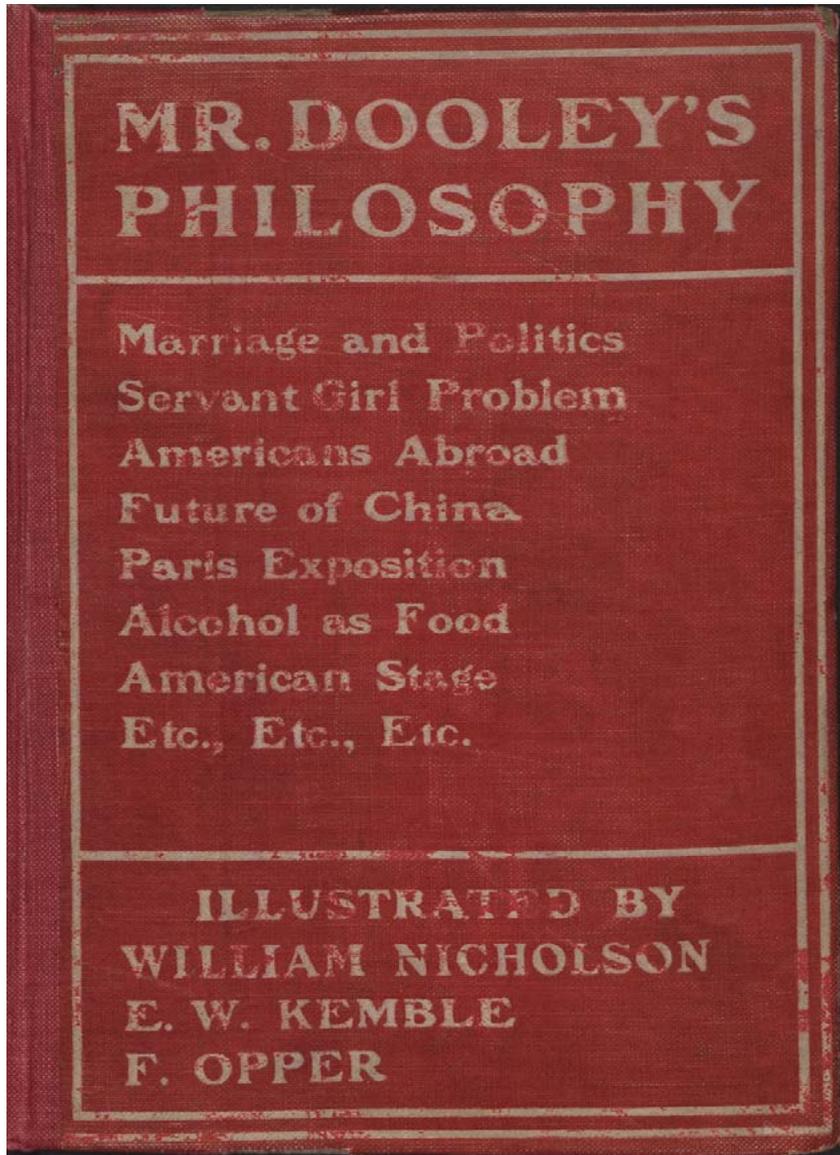
---

# Wrapped in a shell script

## OPTIONS

- pm value set the minimum PSNR value
- pt continue on if over maximum ration and PSNR > 50
- rt value set the maximum allowed filesize ratio
- th size set the maximum thumbnail size
- ts size set the tile size
- log generate a summary file
- h display this message

# Statistics



- **Compression starting db: 40**
- **Compression ratio boundary: 25**
- **Total compressed files: 274**
- **Average compression ratio: 14.3430656934307**
- **Median compression ratio: 13**

---

## Compression ratio / file count

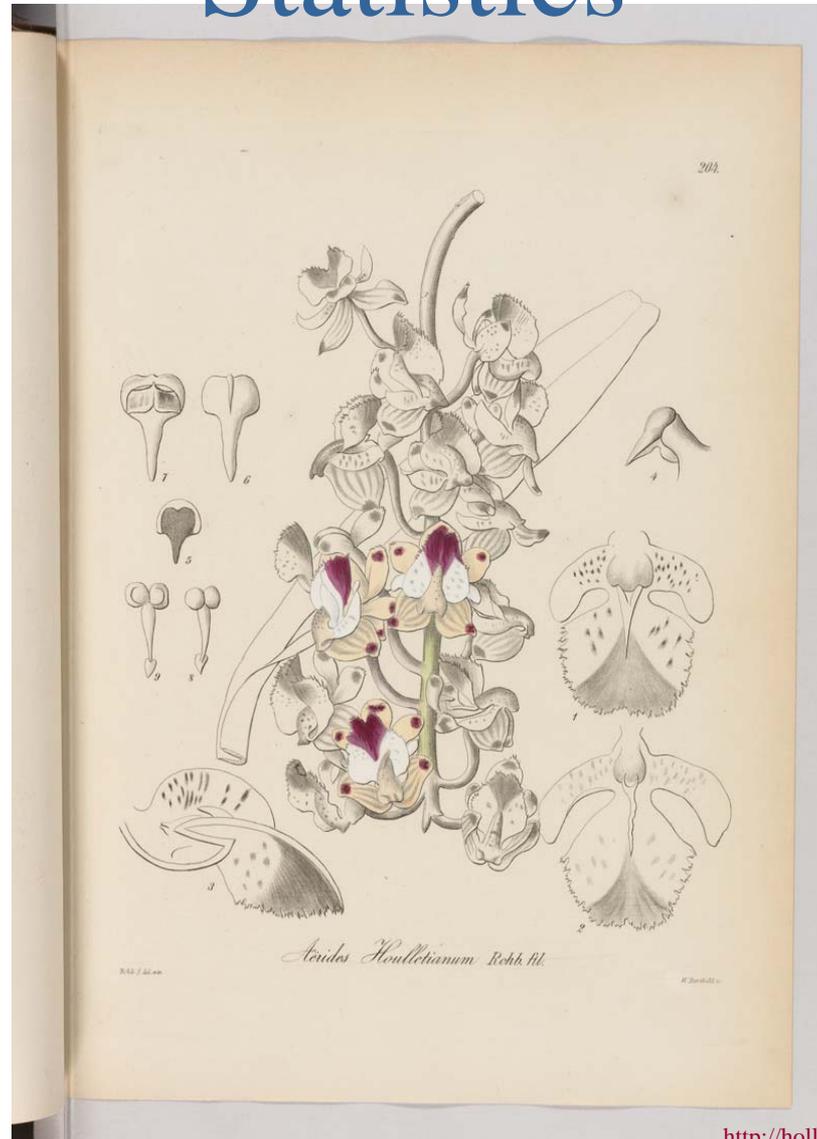
Ratio	Count
6	1
7	2
8	2
10	9
11	21
12	51
13	58
14	27
15	20
16	21
17	16
18	16
19	8
20	9
21	1
22	2
23	6
24	2
25	2

---

## Compression ratio / file count

db Value	File Count
40	248
41	25
42	1

# Statistics



<http://hollis.harvard.edu/?itemid=|library/m/aleph|006545348>

---

## Compression ratio / file count

Ratio	Count
17	3
18	4
19	2
20	1
21	4
22	3
23	1
24	3
25	1

---

# Tools & Utilities

- Free tools

- [GeoJasper](#): "GeoJasper is a free and open source geo-supporting extension for JPEG2000 [JasPer](#) library and a command line transcoder."
- [JHOVE](#): an extensible framework for format validation.
- [IrfanView](#): Freeware image viewing application (Windows) that supports JPEG2000 rendering. You'll need all the [plugins](#).
- [Cygwin](#): A Unix-like environment for Windows.

- Commercial applications

- [LuraTech](#): image encoding and server-side decoding software
- [Aware, Inc.](#): image encoding and server-side decoding software

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# Thank you

- Mingtao Zhao, *Systems Analyst and Applications Developer*, Harvard College Library
- Andrea Goethals, *Manager of Digital Preservation and Repository Services*, Harvard University Library Office for Information Systems
- Ronald Murray, *Digital Conversion Specialist*, Library of Congress
- Ralph Tiede, *Director Research & Development*, Content Conversion Specialists GmbH
- Alexis Tzannes, *Senior Engineer*, Advanced Products Group, Aware, Inc.