Capturing and Rendering Wide Dynamic Range Scenes

Selective Contrast Control
for Color Photography

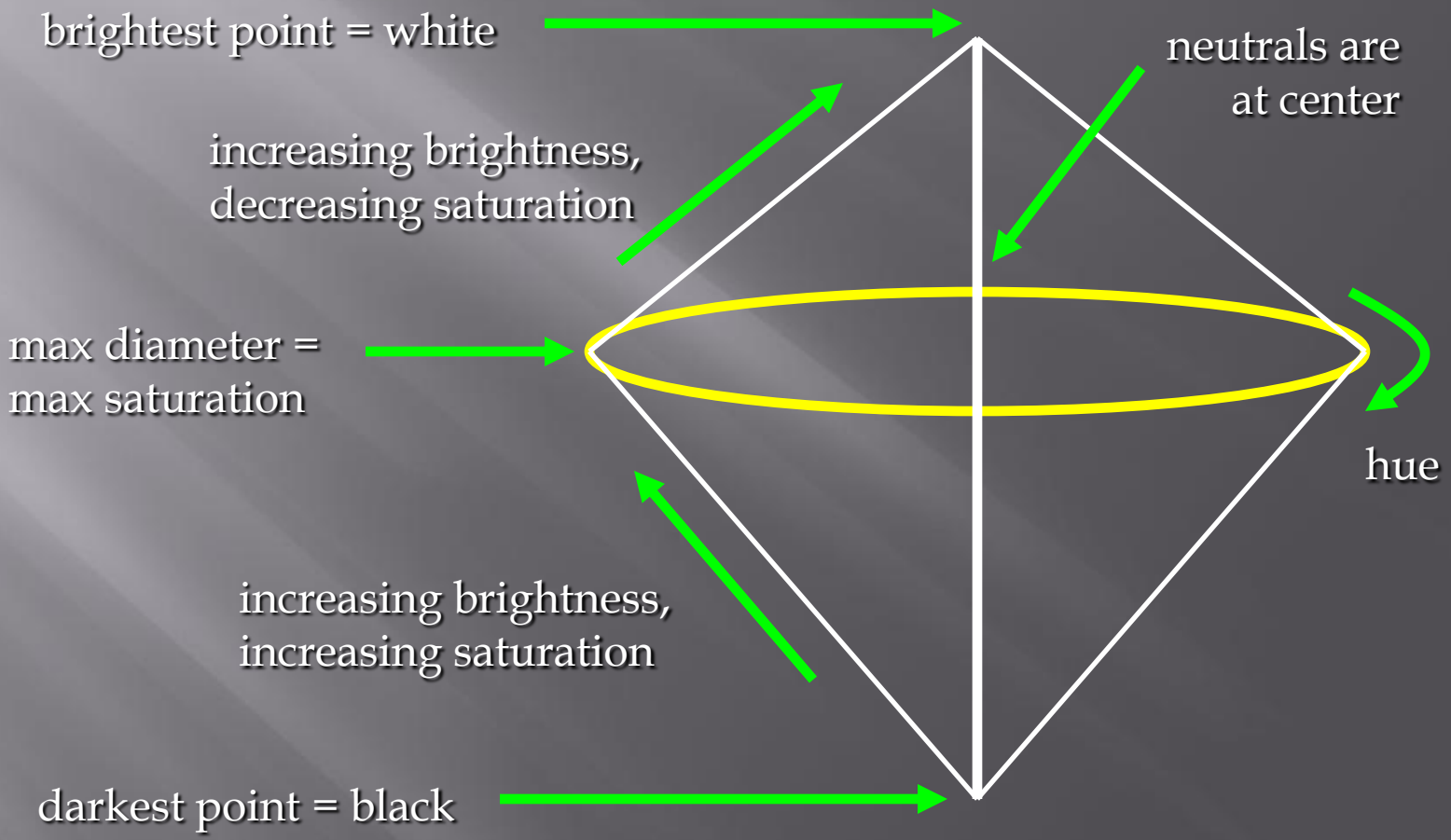
Since the Beginning…

Landscape photographers have been challenged technically and esthetically by high-contrast scenes having both direct sunlight and deep shadows

The Technical Challenge

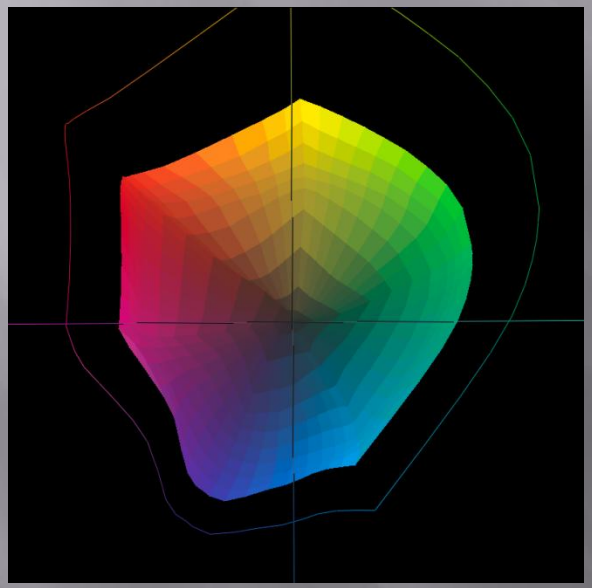
- Brightness range of scene is greater than the brightness range of the output medium
  - 10 f-stops of scene brightness = 1,000 to 1 range
  - Print density range of 1.5 = 32 to 1 range
  - Need method(s) for compressing brightness range
- Color rendition places even tighter limitations on output medium
  - Saturation changes with brightness and contrast
  - Brightest and darkest tones cannot render color

Theoretical Color Space

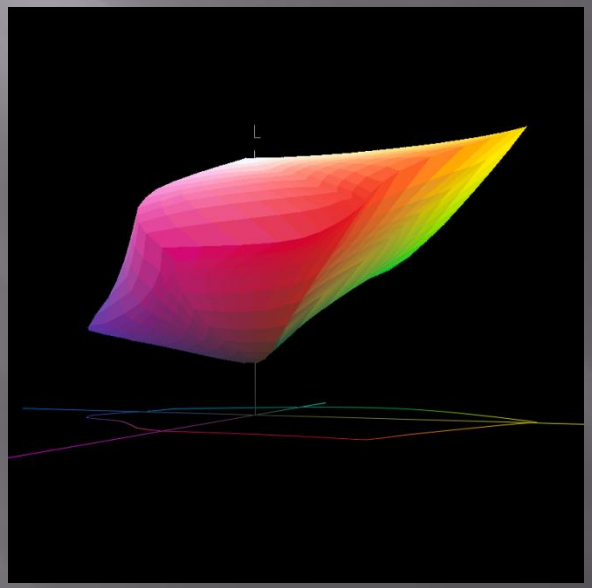


Actual Output Color Space

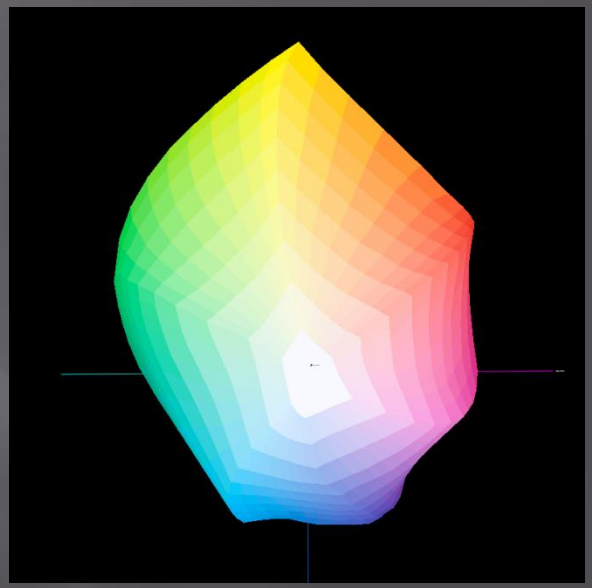
(HP Pro Matte Canvas)



Bottom (dark) view



Side view



Top (bright) view

3D profile views by ColorThink; www.chromix.com

The Esthetic Challenge

- Getting the output image to represent the photographer's vision of the original scene
- "Accurate" reproduction will not be possible
  - Original dynamic range larger than output medium
  - Original size often larger than output size
  - Original is typically three-dimensional
- "Capability" and "Fidelity" are still important
  - Capability to represent entire scene dynamic range
  - Image retains color and tonal nuances of the scene

Landscape Photography is not Art Reproduction

- Original scene dynamic range must be "interpreted" to have similar impact in a print
- Wide dynamic range and abstraction of B&W photography invites interpretation
- Color photography options were more limited prior to the arrival of digital imaging
- Now it is possible to apply B&W interpretation principles to color photography, with far more finesse and precision

In the Beginning…

…There was LIGHT, and DARK – sometimes, too bright and too dark to render gracefully in the same photograph

Photography B.C. (before color)

- Red filter over lens to darken sky and reduce distant haze
- Zone System to control overall negative exposure, contrast and tone
- Variable Contrast methods to control overall print contrast and tone
- Dodging and burning to control selective print contrast and tone

Photography A.D. (after digital)

- No color filters needed (just IR-blocking filter)
- Histogram/data/image evaluation to determine exposure
- Curve Layers with masking to control selective contrast, tone & color
- Image perfected digitally, prior to printing

A Unique Approach to Rendering Wide-Range Scenes

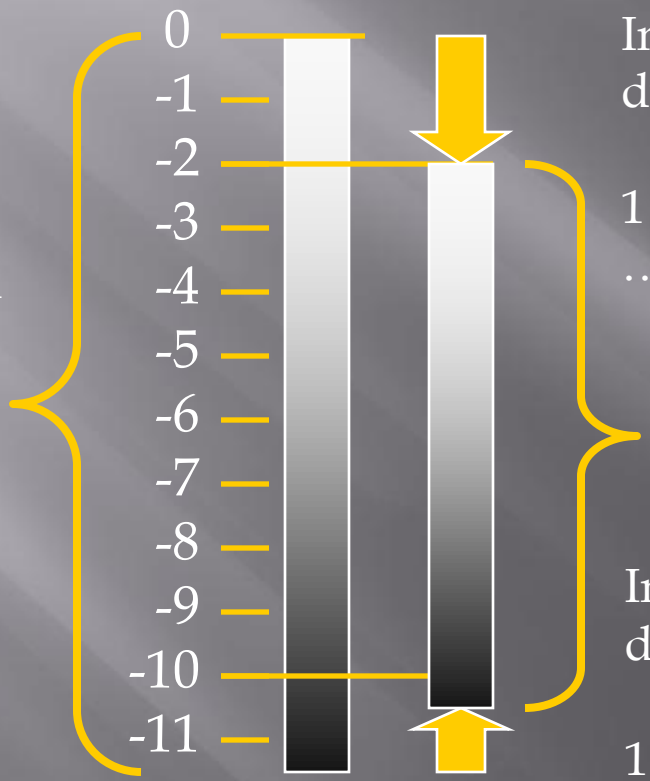
- Applying time-honored B&W interpretation principles to color photography
  - Exposure captures maximum scene information
  - Processing/printing translates scene as intended
  - Selective adjustments for visual emphasis
- Digital adds new capabilities
  - Nonlinear image compression/expansion
  - Easy, precise control of contrast and color
  - Selective masking with pixel-level accuracy
  - Undo…

Capturing Wide-Range Scene Information

- Scanning backs have wide dynamic range in many situations involving direct sunlight
  - Short exposure and low ISO provide over 11 f-stops
  - One optimized capture is usually sufficient
- Optimizing image capture
  - Push exposure as high as possible; avoid clipping
  - Consider time/noise tradeoff when setting exposure
  - Use a gentle S-shaped Tone curve to translate data

Dynamic Range Trade-offs

Optimum sensor dynamic range in f-stops



Increasing ISO sensitivity directly reduces dynamic range by the same amount:

1 f-stop of boost "costs" 1 f-stop of range
…but doesn't change the scan time

USABLE dynamic range with both ISO boost and longer Line Time

Increasing Line Time indirectly reduces dynamic range by a smaller amount:

1 f-stop of boost "costs" ½ f-stop of range
…but also doubles the scan time

Example shows two f-stops of ISO boost and two f-stops of Line Time boost, equivalent to 1/60 sec at ISO 800

Usable Dynamic Range

Calculated Usable* Dynamic Range in f-stops for various combinations of Line Time (fraction) and ISO settings

* Usable = minimum 10-to-1 signal to noise ratio

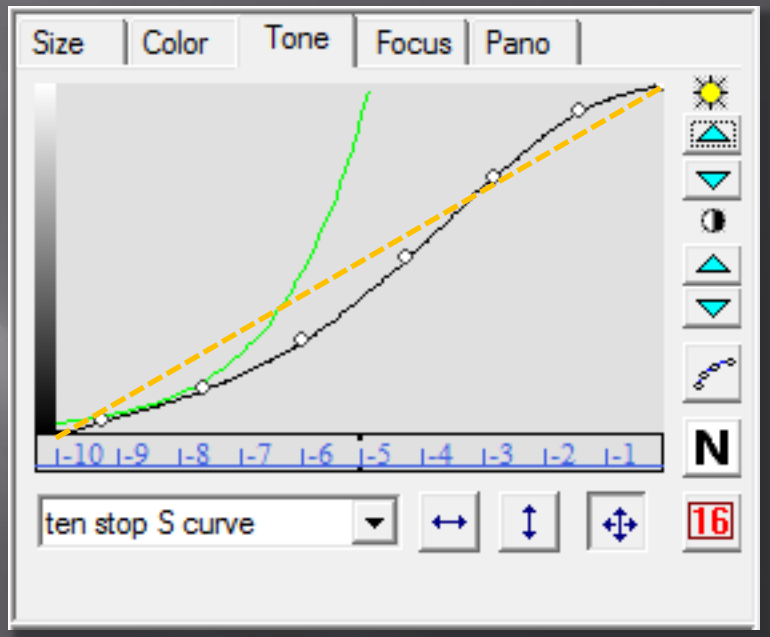
USABLE DYNAMIC RANGE, F-STOPS

GREAT
GOOD
FAIR

fraction \ ISO	200	400	800	1600	3200
240	11.5	10.5	9.5	8.5	7.5
120	11.0	10.0	9.0	8.0	7.0
60	10.5	9.5	8.5	7.5	6.5
30	10.0	9.0	8.0	7.0	6.0
15	9.5	8.5	7.5	6.5	5.5
8	9.0	8.0	7.0	6.0	5.0

The ten stop S Curve

This custom Tone curve smoothly translates ten f-stops of scene brightness into the full range of available data values



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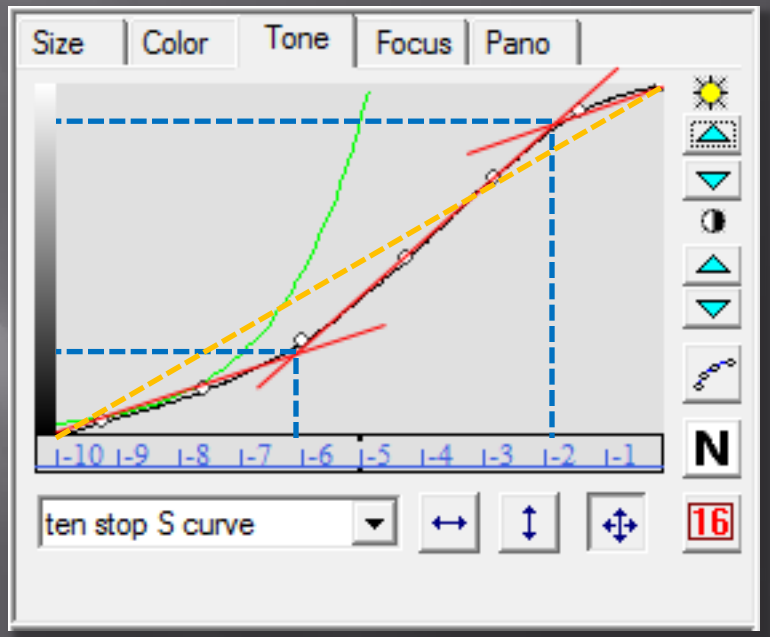


Highlights and shadows are compressed relative to midtones:
(top 2 f-stops = 1/8 of data values)
(middle 4 f-stops = 5/8 of data values)
(bottom 4 f-stops = 2/8 of data values)

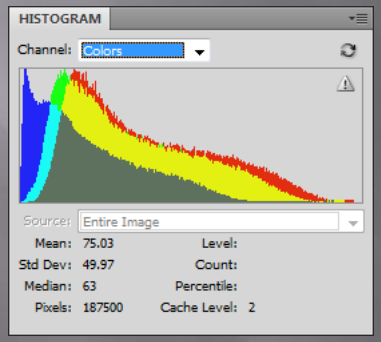
Using this Tone curve doesn't change the span of raw data values generated by a given scene, but does produce a more useful distribution of 16-bit data values for post-capture processing

Using the ten stop S Curve

- Wide dynamic range Tone curve lowers image contrast and color saturation
- Primary intent is preservation & optimization of image information (data values)
  - Image is not ready for viewing at this point
- Using a single wide Tone curve speeds capture
  - Can use a different Tone curve later, if desired
- Post-capture processing will recover contrast selectively while optimizing overall contrast

Hoh Rainforest, Washington

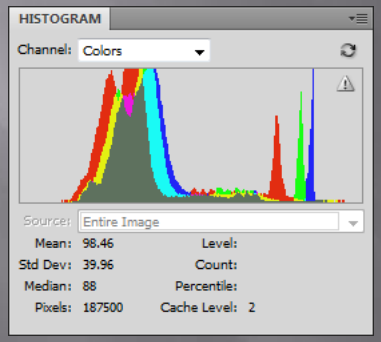
hoh 135mm f-16 006,
Mon Sep 24, 2007, 1:06:15 PM,
16C, 6000x8000 (0+0), 100%,
ten stop S cur,
1/80 s,
R80.5, G60.6, B61.6



Midday sunlight through the dense rainforest canopy produces extremes of contrast on these overgrown maple tree trunks

Zabriskie Point, California

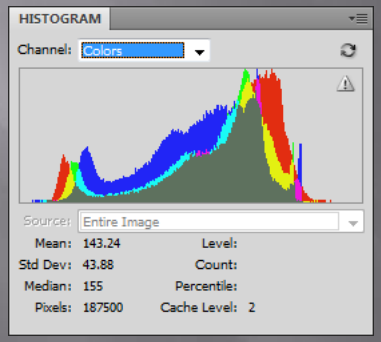
death valley 210mm f-11 017,
Sun Jan 20, 2008, 7:39:47 AM,
16C, 6000x8000 (0+0), 100%,
ten stop S cur,
1/240 s,
R69.0, G49.1, B50.1

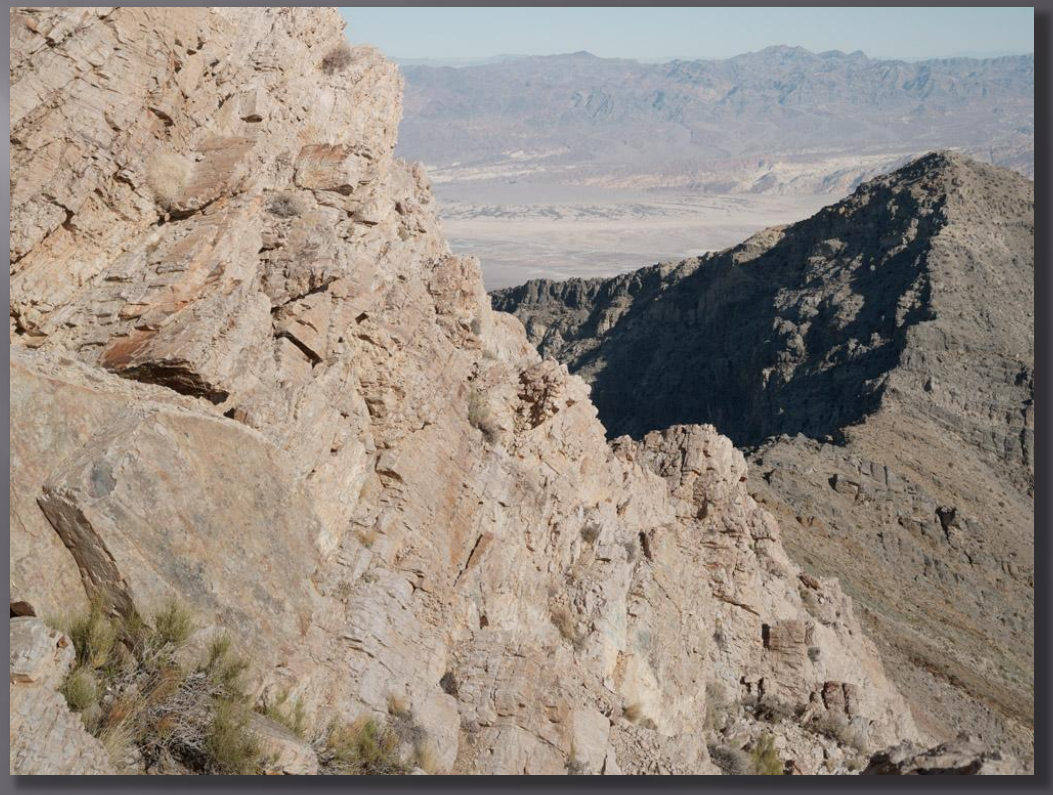


The first rays of sunlight skim colorful eroded badlands at Zabriskie Point in Death Valley for high contrast mixed lighting

Aguereberry Point, California

DV 005 135mm f-11,
Fri Jan 09, 2009, 12:56:46 PM,
16C, 6000x7998 (0+0), 100%,
ten stop S cur,
1/240 s,
R39.7, G19.9, B20.9

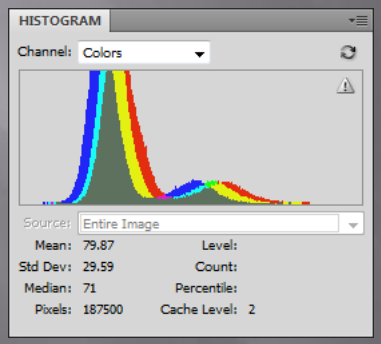




High altitude midday sunlight on light colored marble, deep shadows, and plenty of atmospheric haze obscuring the distant view

Gower Gulch, California

DV 027 135mm f-16,
Sun Jan 11, 2009, 1:30:10 PM,
16C, 6000x8000 (0+0), 100%,
ten stop S cur,
1/120 s,
R31.9, G12.0, B13.1



"Two separate pictures" – the canyon floor lit by direct midday sunlight, and the canyon wall lit by reflected light

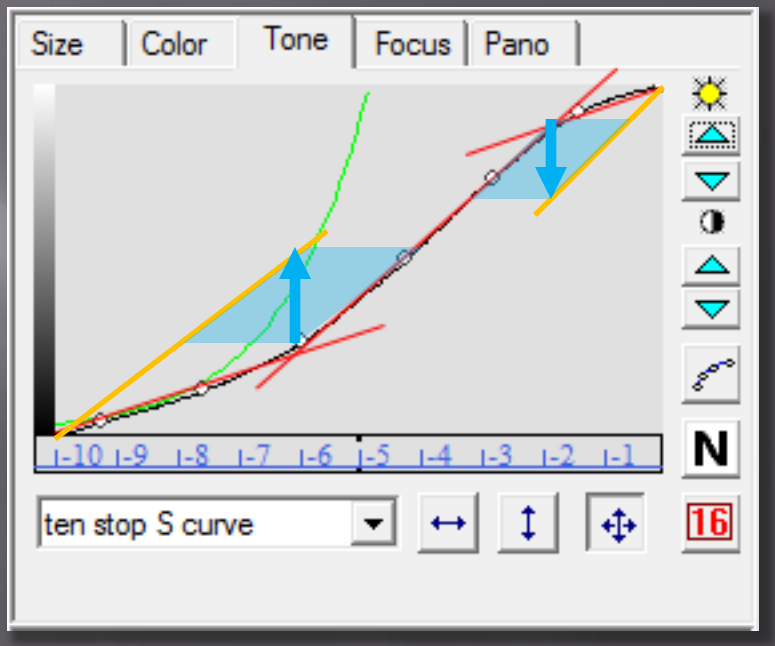
Post-capture Processing

- Highlights are selectively darkened using a masked Curves Adjustment Layer
- Shadows are selectively lightened using a masked Curves Adjustment Layer
- Overall contrast and brightness are controlled using a Curves Adjustment Layer
- Selected areas can be darkened or lightened using masked Curves Adjustment Layers

Restoring Local Contrast while also Reducing Overall Contrast

Selectively lightening the shadows and darkening the highlights increases the contrast in these regions without having as much effect on the midtones

This technique compresses the original scene dynamic range by essentially overlapping parts of the shadows & lower midtones, and parts of the upper midtones & highlights (cyan shading)

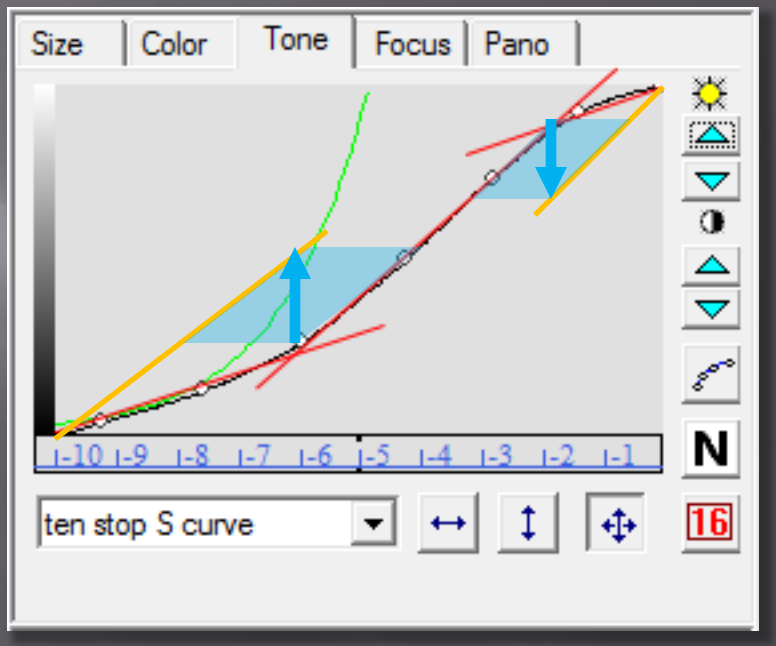


(graphic is simplified version of typical processing)

Restoring Local Contrast while also Reducing Overall Contrast

Selectively increasing contrast in this manner provides local contrast similar to what an observer might experience at the scene, where the eye/brain adapts to differences in local illumination

However, even the human vision system has trouble when very bright and very dark coexist in the same location (same field of view)

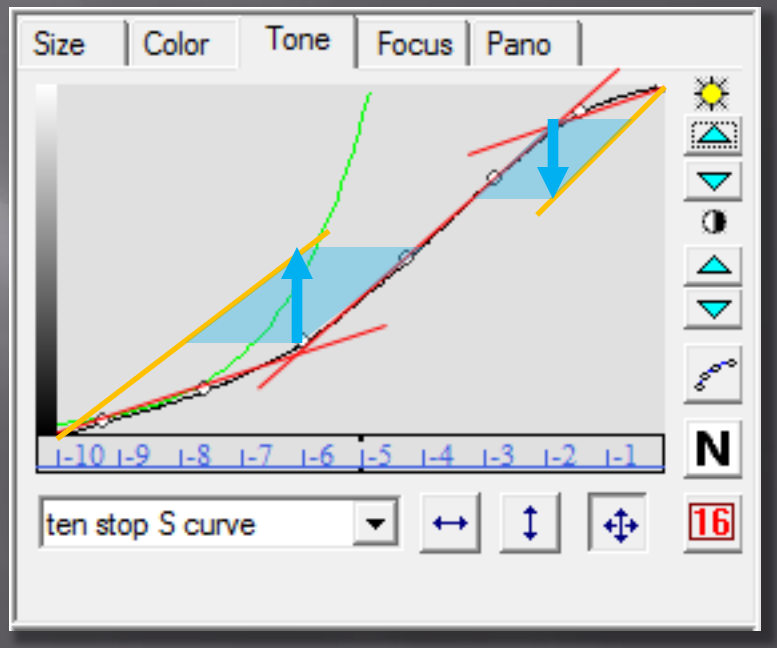


(graphic is simplified version of typical processing)

The Importance of Masking

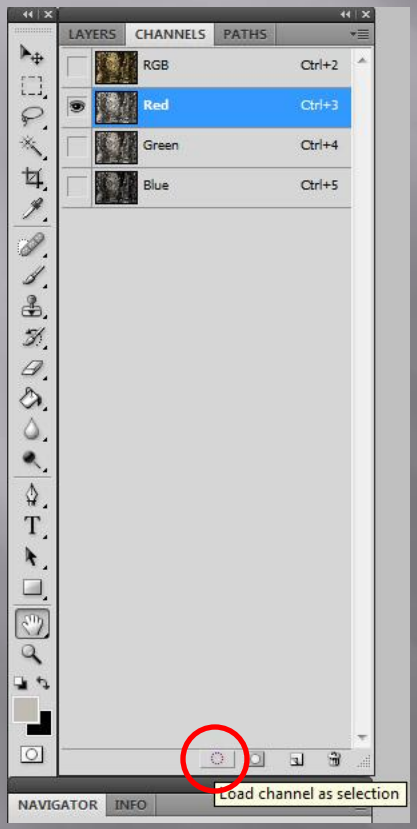
Because parts of the shadows and highlights are “stretched” into the same data values as parts of the midtones (cyan shading), it is important to either keep these overlapping data regions spatially separated from each other, or to modify the effect of the contrast boost when spatial separation is not possible

Otherwise, image detail will be lost in the overlapping regions



(graphic is simplified version of typical processing)

Making a Mask

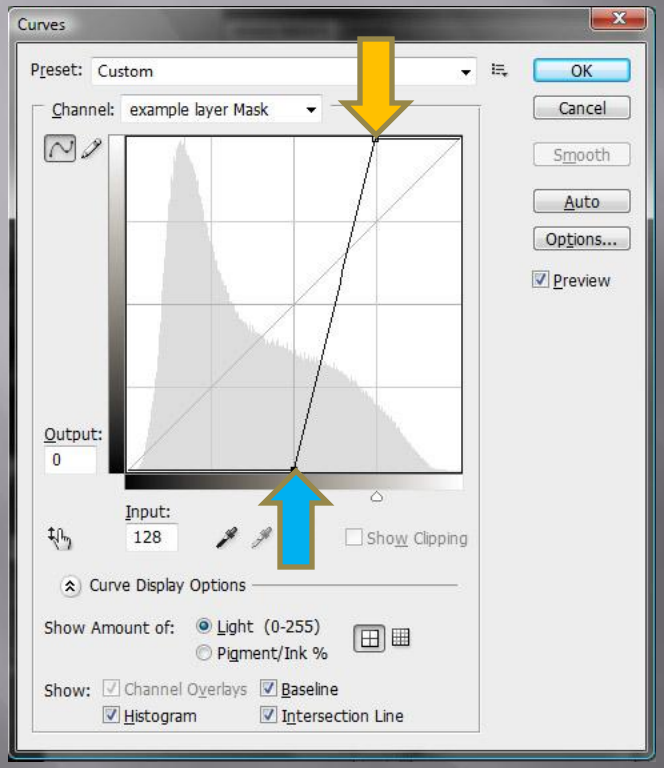


After loading the desired channel(s) as a selection, make a new Curves adjustment layer and the current selection becomes a mask for the new layer

Modifying the Mask

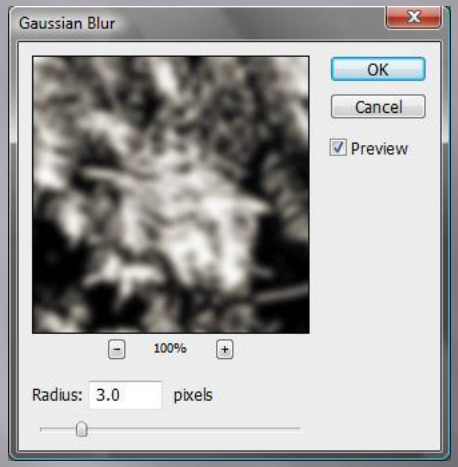
- Alt-click on the mask to make it visible
- Invert the mask to select shadows instead
- Apply a Curve to the mask to emphasize or exclude desired ranges of data
- Blur the mask to decrease flattening of detail
- Paint over the mask to modify its effect
  - Reduce flattening of detail
  - Soften/blend edges of large adjustments
  - Add or exclude specific areas

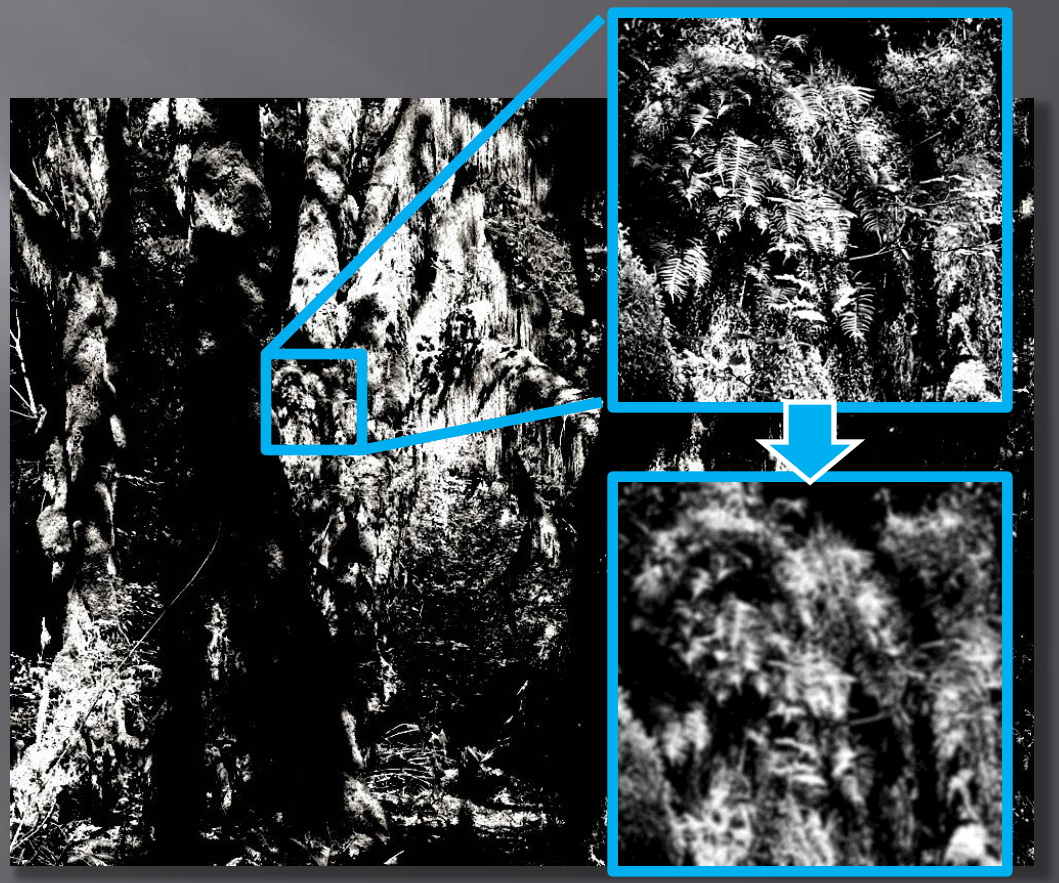
Applying a Curve to the Mask



Move the Curve endpoints to force parts of the mask to white (gold arrow) or black (cyan arrow), with a transition region in between (sloped section)

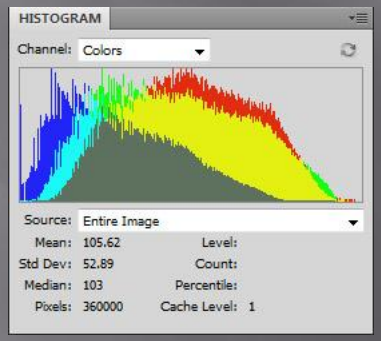
Blurring the Mask

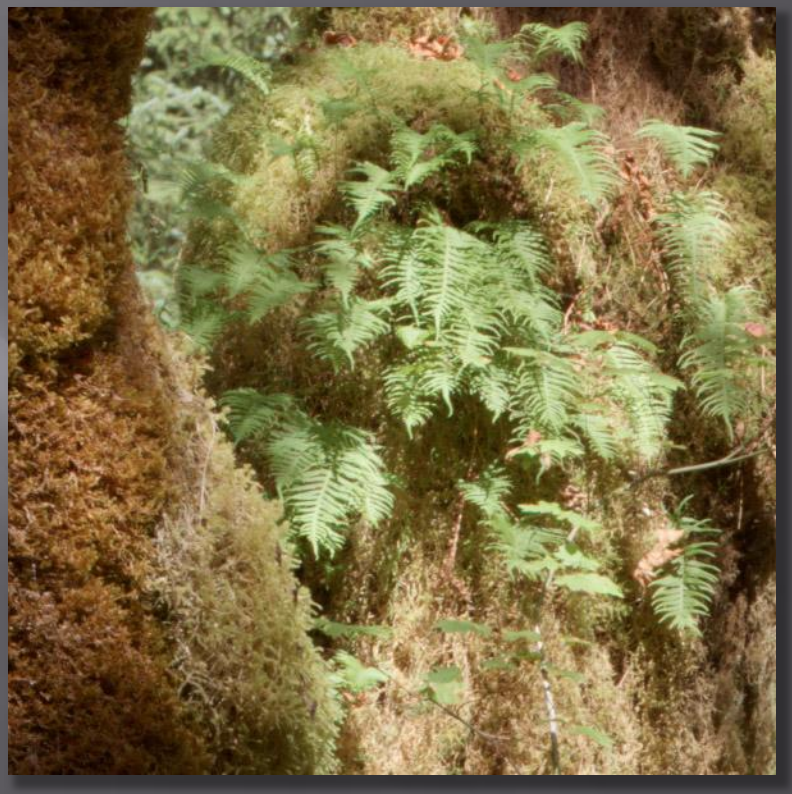




Apply a Gaussian Blur to the contrast-adjusted mask to soften its edges and reduce the effect of the adjustment layer at transitions

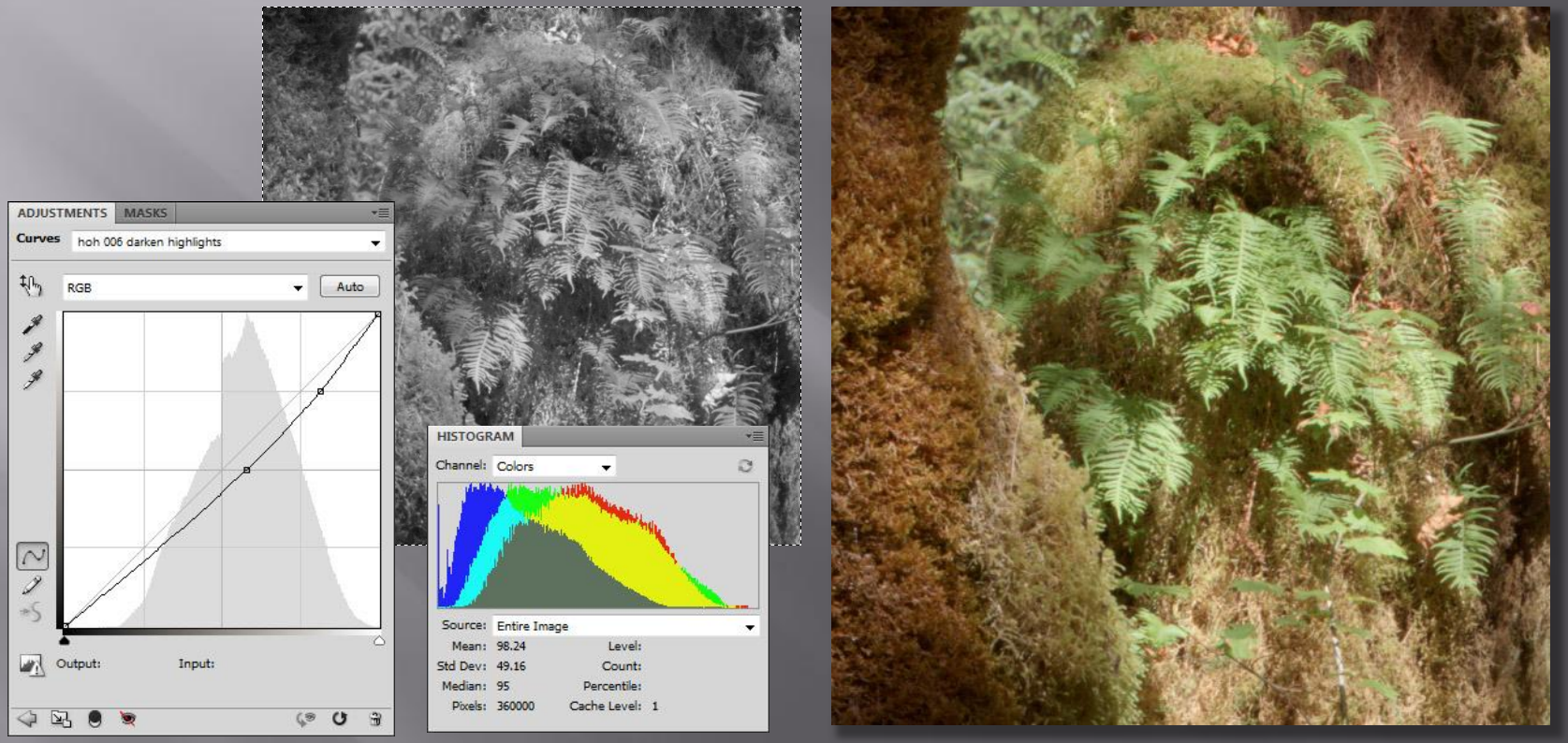
Making the Adjustment





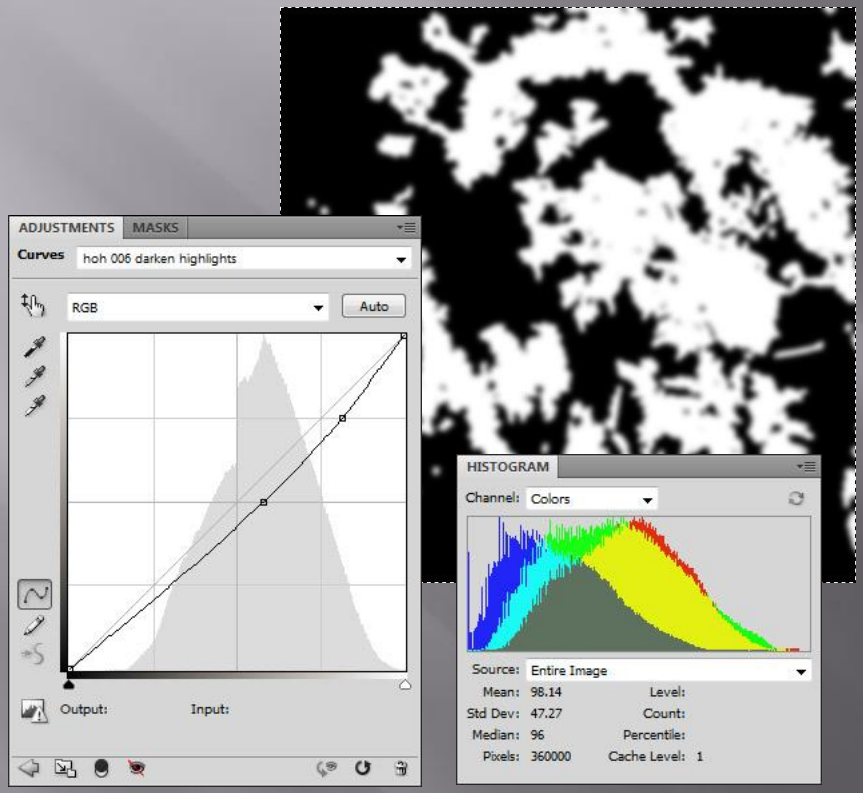
Full-resolution detail from an image captured using the ten-stop S curve
The histogram shows a full distribution of data values in this detail

Making the Adjustment



Make a masked Curves adjustment layer and darken the highlights
The grayscale mask applies the Curve adjustment linearly and crisply
Highlights darken, but so do midtones; local contrast reduced

Making the Adjustment



Modify the mask by boosting its contrast and blurring
The modified mask applies the Curve adjustment nonlinearly and softly
Highlights darken more, midtones less; local contrast enhanced

What About Color?

- Contrast changes also affect hue and saturation
- Restoring the contrast of shadows & highlights essentially "restores" their color as well
  - More uniform overall contrast = more uniform color
- Color can be interpreted just like brightness and contrast
- Color (hue) sometimes needs adjustment
  - Mixed lighting at sunrise and sunset
  - Blue shadows & distant haze

Hoh Rainforest, Washington

hoh 135mm f-16 006,
Mon Sep 24, 2007, 1:06:15 PM,
16C, 6000x8000 (0+0), 100%,
ten stop S cur,
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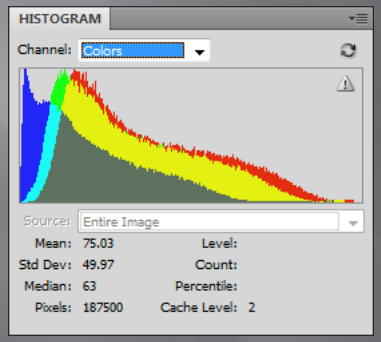
R80.5, G60.6, B61.6



Midday sunlight through the dense rainforest canopy produces extremes of contrast on these overgrown maple tree trunks

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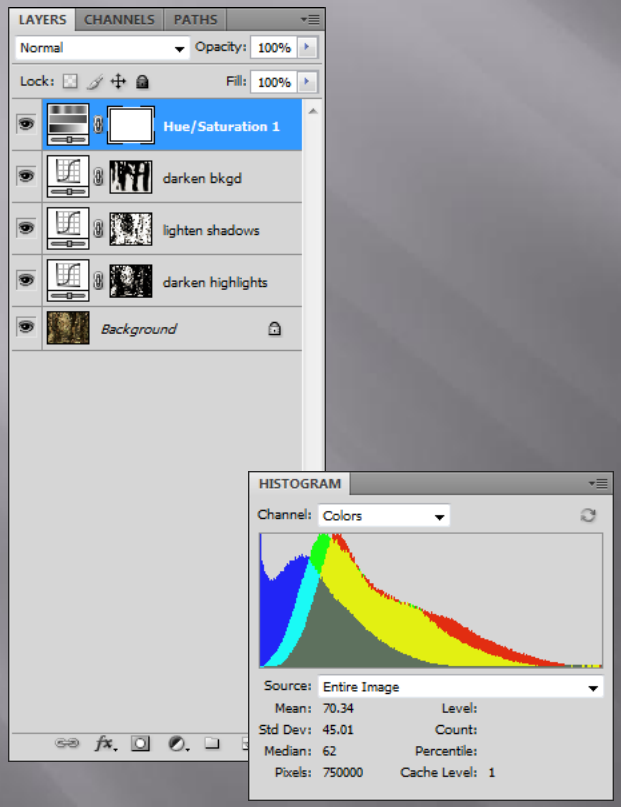

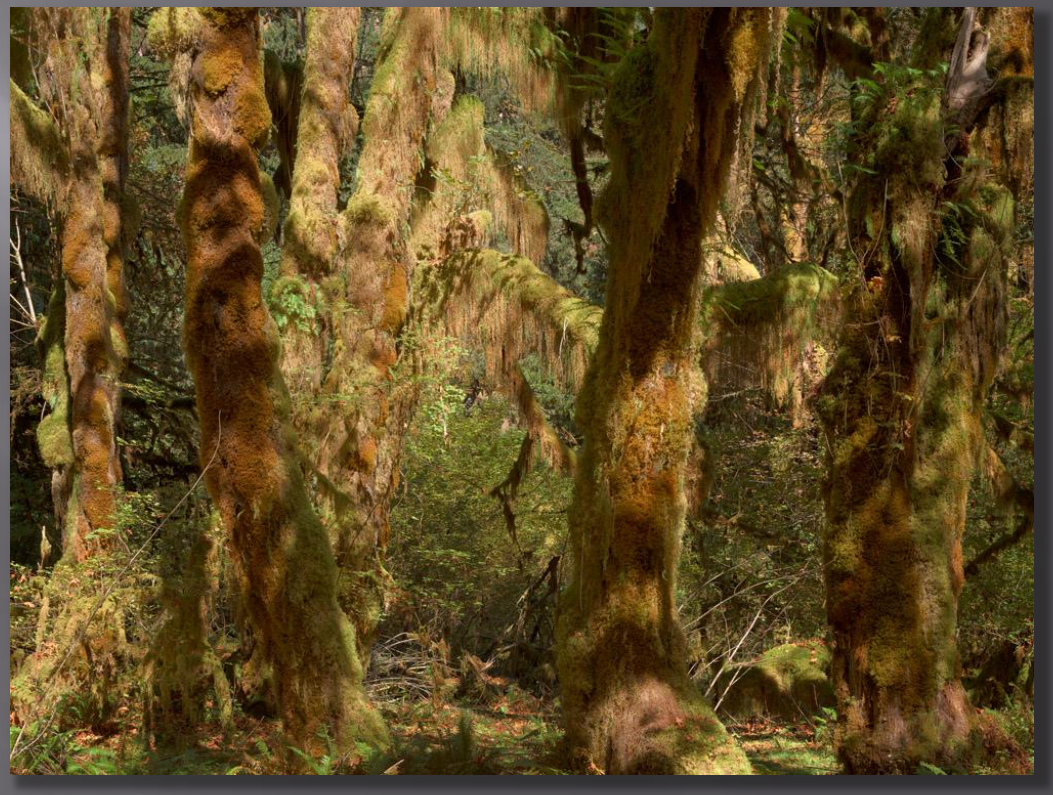

Moderately darken highlights and lighten shadows; boost saturation
Darken background clutter to add dimensionality

Zabriskie Point, California

death valley 210mm f-11 017,
Sun Jan 20, 2008, 7:39:47 AM,
16C, 6000x8000 (0+0), 100%,
ten stop S cur,
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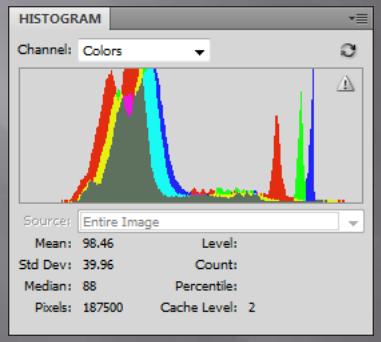
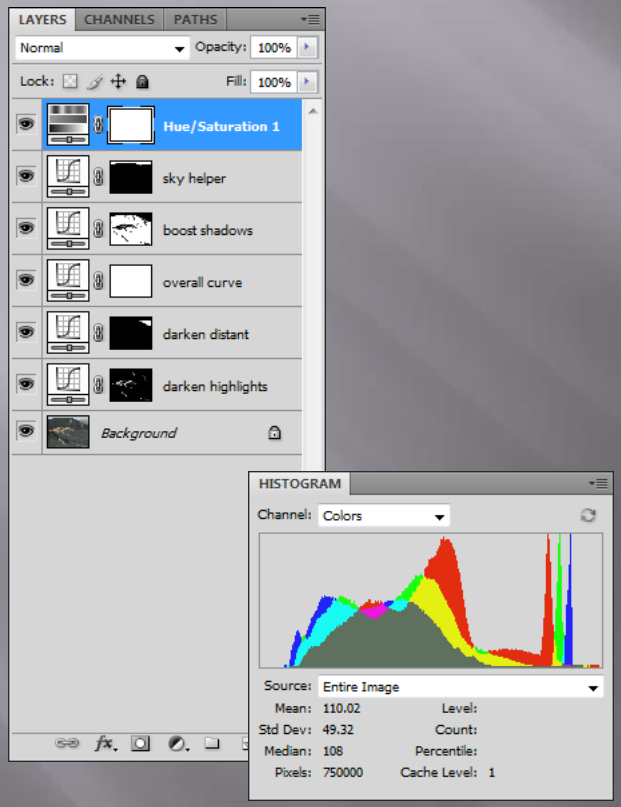


The first rays of sunlight skim colorful eroded badlands at Zabriskie Point in Death Valley for high contrast mixed lighting

Zabriskie Point, California



Darken highlights; significantly boost shadows and remove excess cyan
Darken distant mountains; lighten sky; boost saturation

Aguereberry Point, California

DV 005 135mm f-11,
Fri Jan 09, 2009, 12:56:46 PM,
16C, 6000x7998 (0+0), 100%,
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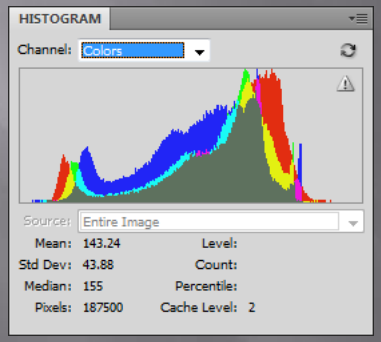
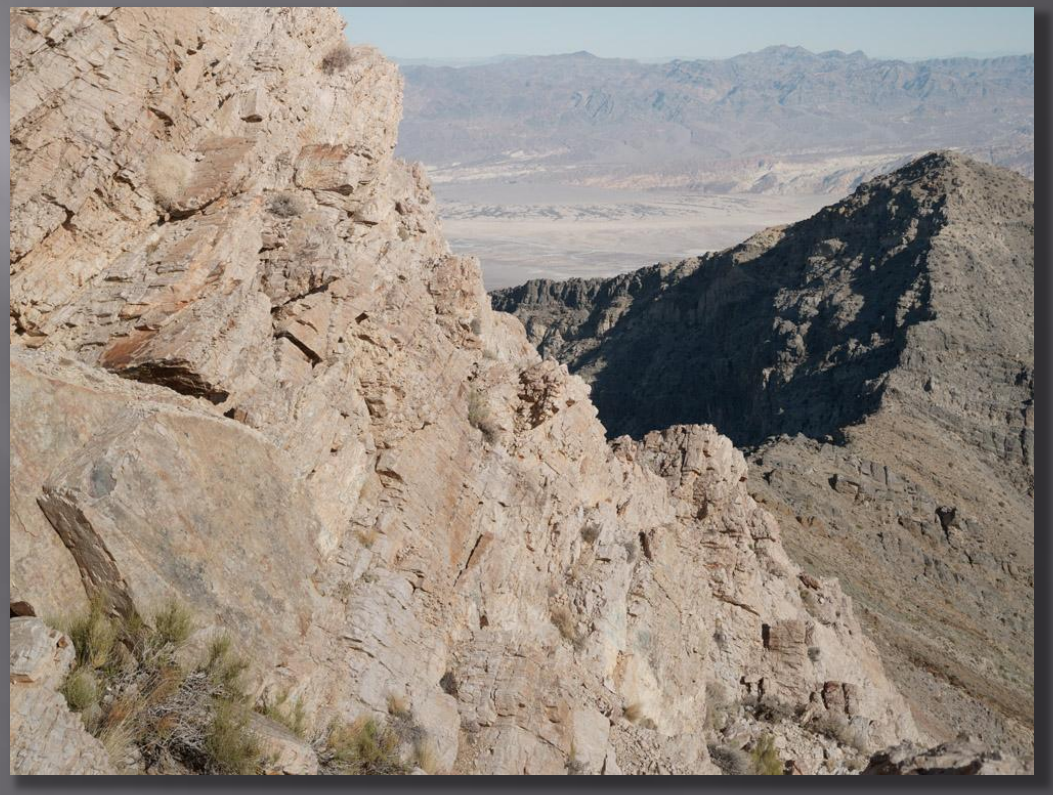
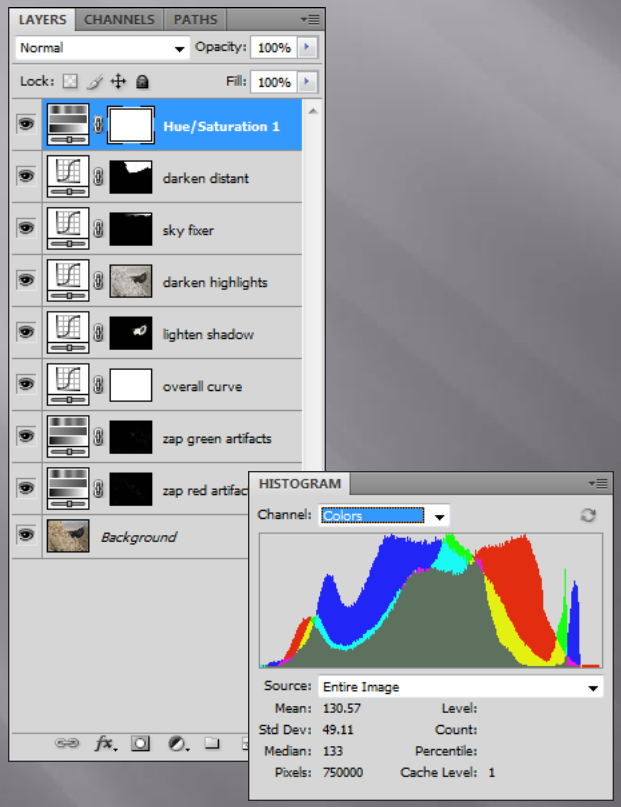




High altitude midday sunlight on light colored rock, deep shadows, and plenty of atmospheric haze obscuring the distant view

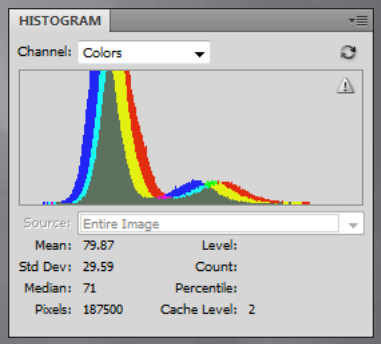
Aguereberry Point, California



Darken highlights and lighten shadows; boost saturation
Darken distant; reduce sky gradient; suppress air motion artifacts

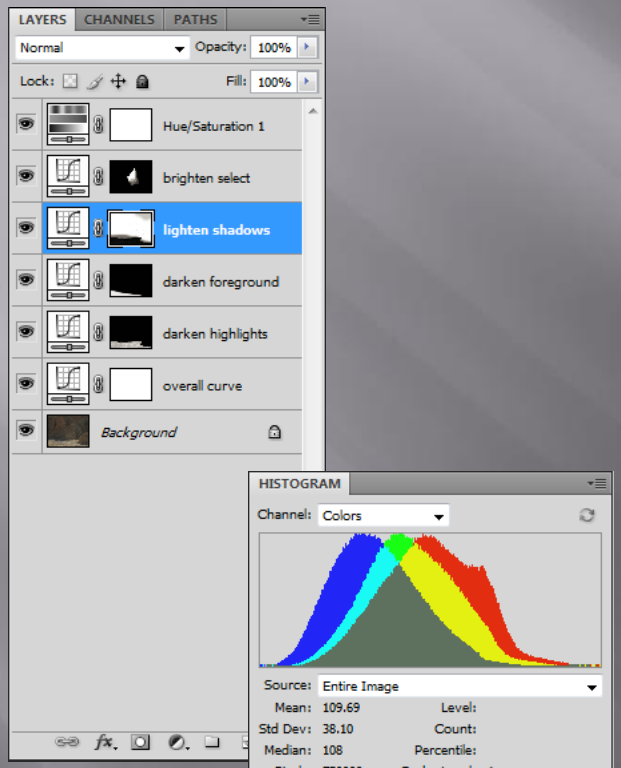
Gower Gulch, California

DV 027 135mm f-16,
Sun Jan 11, 2009, 1:30:10 PM,
16C, 6000x8000 (0+0), 100%,
ten stop S cur,
1/120 s,
R31.9, G12.0, B13.1



"Two separate pictures" – the canyon floor lit by direct midday sunlight, and the canyon wall lit by reflected light

Gower Gulch, California

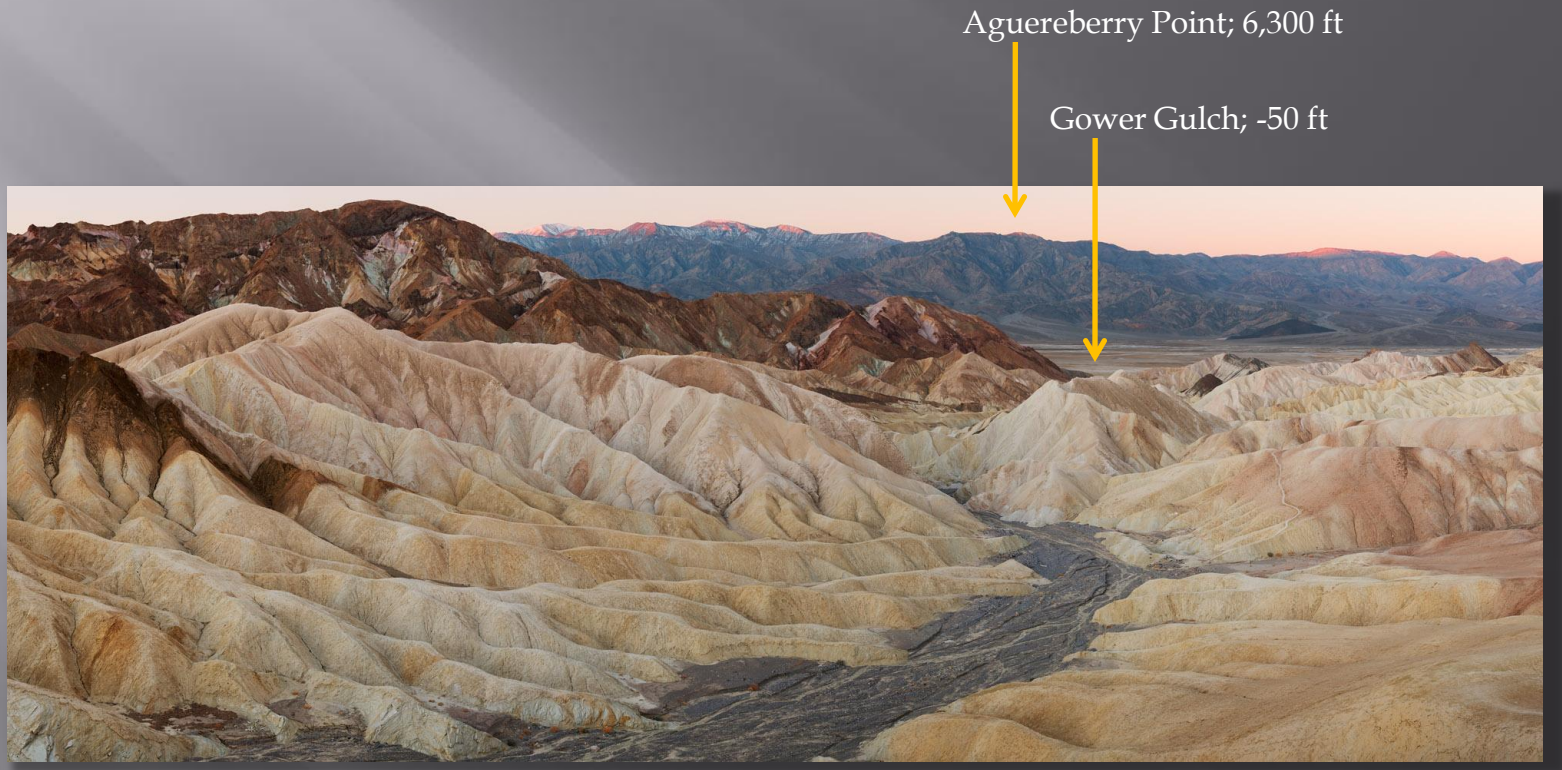


Significantly darken highlights and lighten shadows; boost saturation
Darken foreground and lighten center

Discovering Better Light

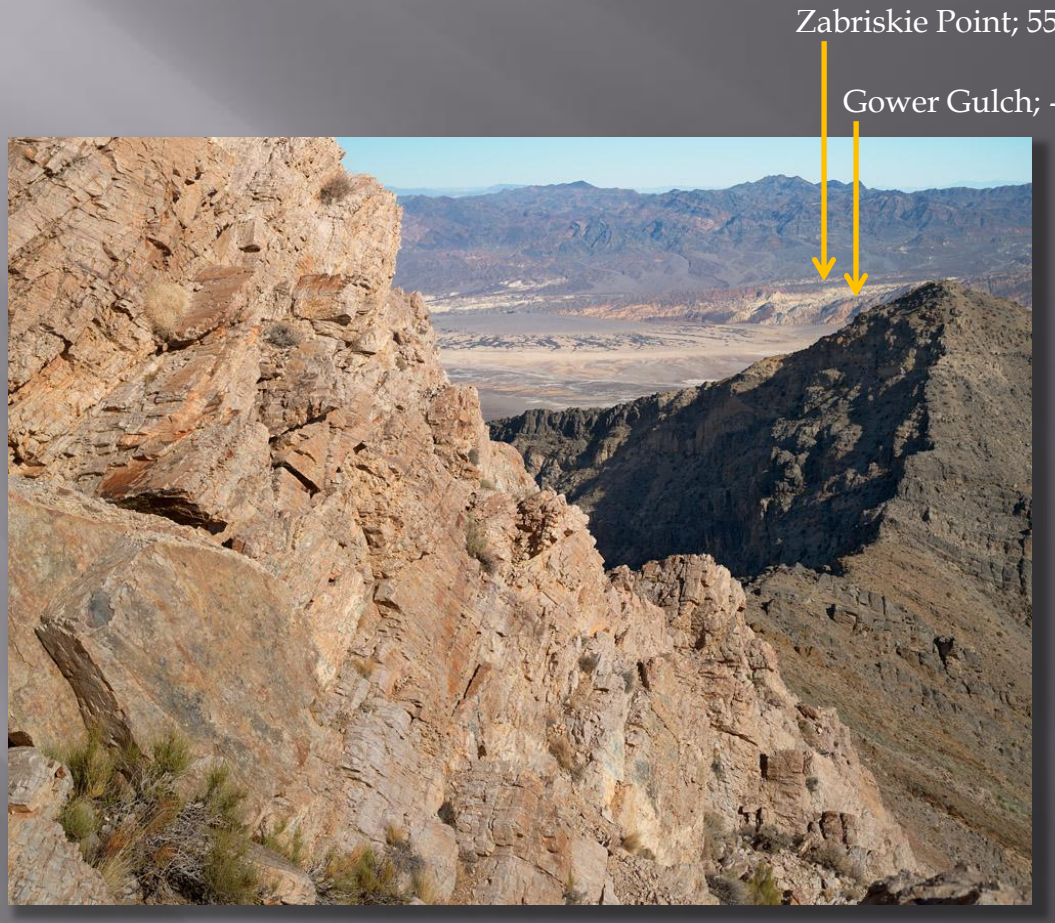
- This technique facilitates expressive color photography in formerly “bad” lighting
  - High contrast scenes controlled gracefully
- The greater part of every day was often considered “bad” lighting
  - Now more time and possibilities for photography
- Scanning backs prefer abundant light
  - Faster scans, enormous dynamic range
- Shadows can be used as part of a color composition, instead of being avoided

Trip to Death Valley, Jan 2009



Looking Southwest from Zabriskie Point at Dawn; 550 ft

Trip to Death Valley, Jan 2009



Looking Northeast from Aguereberry Point at midday; 6,300 ft

Trip to Death Valley, Jan 2009

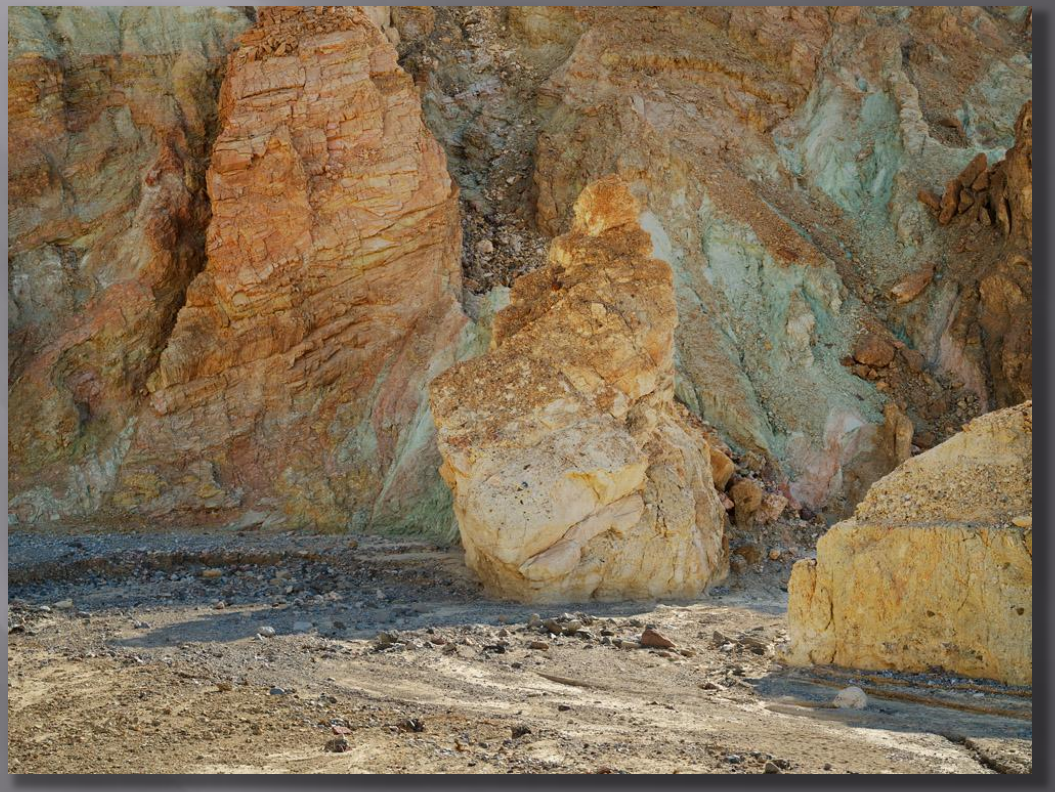
In Gower Gulch at midday (shady side); 200 ft

Unlike the other images presented here, this low contrast wall of cracked clay in the shade was accentuated by using a 4 f-stop Tone curve with even more boost during processing

Trip to Death Valley, Jan 2009

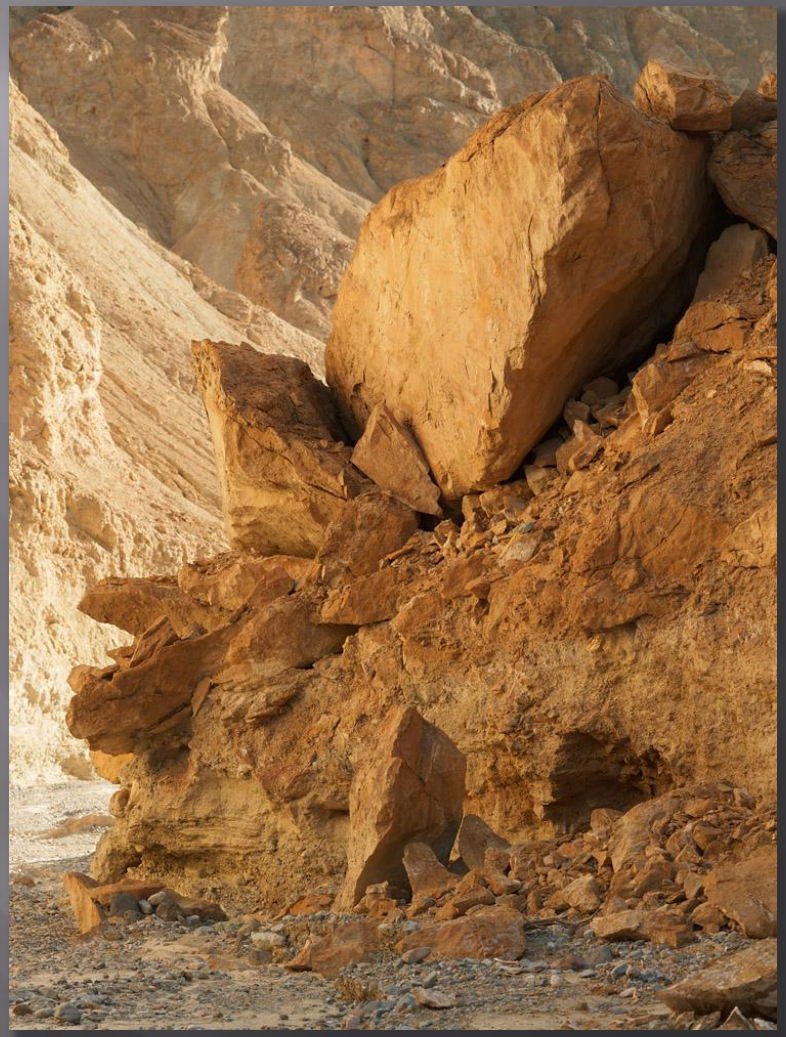
In Gower Gulch at midday (sunny side); 200 ft

Trip to Death Valley, Jan 2009



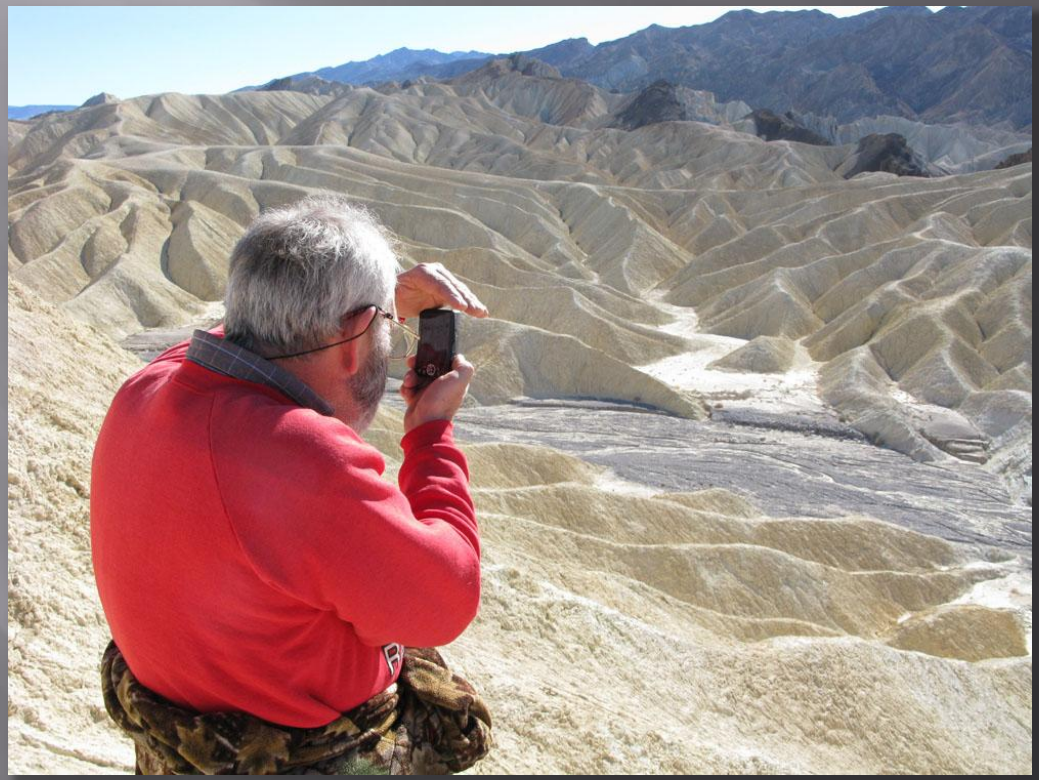
In Gower Gulch at midday (sun and shade); 150 ft

Trip to Death Valley, Jan 2009



In Gower Gulch at midday (sun and shade); sea level

Trip to Death Valley, Jan 2009



Greg Kalajian at Zabriskie Point (Canon G9 photo)

Scouting trip:
Greg Kalajian and I hike about 4 miles from Zabriskie Point down the canyon to Gower Gulch armed with point & shoot cameras, water, and a GPS

Trip to Death Valley, Jan 2009



Scouting trip photos allow study of possible compositions



Trip to Death Valley, Jan 2009

Greg Kalajian at Gower Gulch (Canon G9 photo)

Trip to Death Valley, Jan 2009

Greg Kalajian at Aguereberry Point (Canon G9 photo)