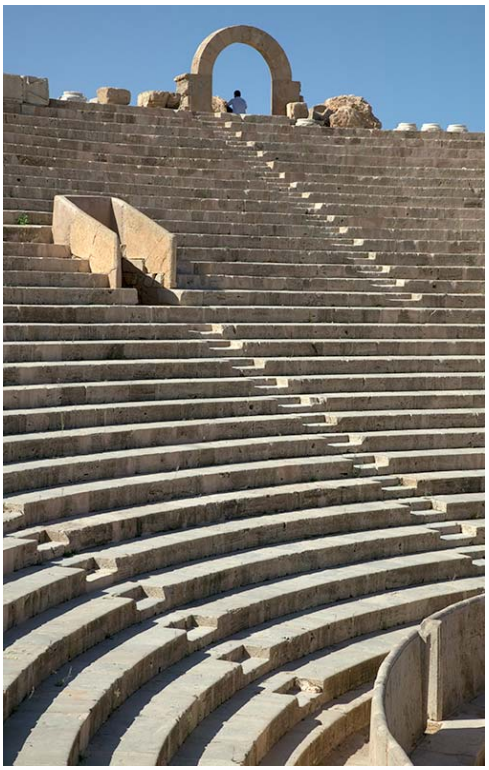
Do Your Curves Throw You a Curve?

The purpose of this essay is to explore whether one achieves superior image quality by [A] maximizing the use of White Balance and luminosity (contrast and brightness) adjustments in Adobe Photoshop Camera Raw (CR), followed by further adjusting luminosity of the rendered image in Photoshop (PS) using the RGB composite Curve (PS-RGBc), or instead [B] rendering the raw image with little adjustment in CR and using the PS individual channel curves to adjust White Balance and luminosity[1],[2].

In this essay I start by stating the issues, then explain in general terms certain relevant aspects of how the curves were designed to perform, followed by demonstrations of white/grey balancing, range setting (luminosity adjustments) and the hue/saturation issues associated with Curves adjustments.

The essay demonstrates that problems can sometimes be solved satisfactorily within the Basic tab of CR, without even resorting to Curves, but when we do need them, the CR or PS-RGBc Curves can work just fine, possibly supplemented with vibrancy or saturation adjustments as needed or to taste. There are, however, images that need more complex treatment in PS. The bottom-line is to maximize the use of CR for what it does best, and use PS for the rest.



Some Curves – Leptis Magna, Libya

[1] This question most recently arose from a series of posts on Dan Margulis's Applied Color Theory List (ACTL); however the format of that List does not permit the kind of exploration attempted here.
[2] "Luminosity" here refers to Brightness, Contrast, or more generally "dynamic range".

This essay comes at a time when CR and Lightroom have introduced major new tools for adjusting luminosity and colour, and people are interested in the relative merits of the raw converter or Photoshop for making these adjustments. I hope to shed some light on these questions (pun intended).

The demonstrations in this essay are based on adjusting raw images in CR 4.0, which has the same toolset as the Develop module of Lightroom 1.0.

Referring to workflow approaches [A] and [B] above, many photographers implement workflow [A]: they maximize post-capture processing in CR, then in PS use the PS-RGBc Curve for luminosity adjustments, and they get fine results.

There is, however, a question about whether these procedures actually do produce consistently high quality results, or instead do they damage the image, the latter hypothesis being that adjusting luminosity with the PS-RGBc causes two problems: for one, it shifts all three primaries equally regardless of the underlying proportions of the primaries in any of the affected pixels thereby causing a hue shift; and for another - an increase of contrast increases saturation of colours in the lightened areas – possibly to an extent that obscures image detail (the “damage”).

The alternative, the argument continues, is to not adjust the PS-RGBc, but rather alter the individual R,G and B channel Curves, or convert the image to Lab space, make luminosity changes to the L Curve, then convert the image back to RGB for other work. Recently, the same issues extended to CR when Dan Margulis said in several posts on the Applied Color Theory List (ACTL), June 2007, that CR Curves behave like the PS-RGBc, producing saturation effects that cannot be satisfactorily controlled with the tools in CR, and since it's not possible to limit the adjustment of CR curves to luminosity alone, CR cannot be relied upon for consistent professional quality – hence it would often be better to render the raw file to PS conservatively and make the luminosity adjustments there[3]. This position, if correct, would have similar implications for the Develop Module of Lightroom, where the toolset is the same as CR’s.

The thinking of those who use CR Point or Parametric curves and the PS-RGBc would be that the saturation effects of Curves adjustments are suitable, unwanted saturation effects can be readily controlled, there are luminosity edits in CR that either can’t be done or only done with greater difficulty in PS (one example being highlight recovery), there is less risk of introducing colour casts editing CR tone curves and PS’s PS-RGBc, versus custom-shaping individual channel curves, and these edits are not necessarily damaging.

Regarding damage, Bruce Fraser explains in “Real World Camera Raw” (2005 edition, pages 21~27) that White Balance and Exposure editing is less destructive in CR than it would in PS. None of this invalidates drawing Curves channel-by-channel in PS, or using more complex techniques requiring layer masks, channel blending, etc. for handling issues that easier edits in CR can’t accomplish. Fraser/Blatner, Kieran, Margulis[4] and

[3] The first Annex to this note provides specific reference to Dan’s position summarized above.
[4] References are in the first Annex.

others demonstrate situations calling forth these techniques and how to implement them. None of this, however, renders CR or the PS-RGBc unsuitable in professional or any other use for the adjustments they do well.

So how effective is CR at dealing with an image's tonal range, do CR Curves and the PS-RGBc Curve affect hue and saturation in ways that cannot be easily and effectively controlled, and how damaging is it not to draw the individual channel Curves instead?

There are two ways of answering these questions: from basic principles of the math behind the Curves and the CR adjustments, and demos on selected images. There are difficulties with both approaches. Regarding the basic principles, only those trained in the complex mathematics of digital imaging really understand how the math impacts the images. Regarding demos, each image is unique, hence images can be selected that demonstrate the merits of any approach, and like all art, beauty is in the eye of the beholder; therefore, identifying a representative sample from which to make general inferences is not straightforward. Aware of the risks, we plunge-in to see what we can.

(1) The Principles:

No math here – I wouldn't know where to start. I could select images, makes edits, track "before" and "after" pixel values in a spreadsheet and graph the results, but that's mapping outcomes from samples (a numerical complement to using demo images), not an understanding of the math generating the measured outcomes.

The next best thing was done: Thomas Knoll was asked how these Curves algorithms affect saturation and hue. His reply indicated that in both Photoshop and CR the Curves are designed to moderately boost saturation with contrast, resulting in saturation effects that resemble those from film tone curves, which many years of looking at photographs from film has taught our visual perception to like. He said the programming is easier without the saturation boost, but included it because after extensive testing they determined the results are generally not pleasing without it. The developers of "Raw Shooter" (since acquired by Adobe) came to the same conclusion independently. CR Curves have a hue lock. They map the minimum and maximum RGB values (in linear ProPhoto RGB) through the tone curve, and the middle value is interpolated to exactly preserve hue. The PS-RGBc does not have a hue lock. But setting the PS-RGBc to Luminosity Blend Mode preserves the colour of the underlying layer. Using the Lab L* Curve for this purpose has only fair colour consistency as L* is changed holding a* and b* constant. To corroborate this, one page from colour scientist Bruce Lindbloom is referenced: (http://www.brucelindbloom.com/index.html?UPLab.html).

(2) Demos on Selected Images:

I begin the demos showing things that CR handles particularly well – such as White Balance (WB) and "setting range": i.e. rescuing highlights, revealing shadow detail, and

generally improving luminosity. I then focus particularly on the impacts of Curves movements (CR and PS-RGBc) on hue and saturation[5].

All the images here start as raw files from a Canon 1Ds (11.1 MP) DSLR. I don't test JPEGs because those are already "baked" by the camera's firmware, hence there is little control over what gets done to the data in-camera, and pre-baked 8-bit files could be limiting in respect of adjusting them further in CR. As well, although CR 4 can open JPEGs and TIFFs, it is primarily a program for rendering raw image files, and should be evaluated as such.

White Balance:

Without the features of CR, one would depend on Photoshop's Curves, HSL, Selective Color and Color Balance tools for correcting colours. With raw captures, correcting WB in CR usually corrects a single prevalent colour cast very well; however, images with multiple colour casts, say due to mixed lighting, *may* require more complex treatment in PS.

There is a relationship between the tonal range of an image and its WB. For example, a histogram with no clipping given one set of WB values may show clipping with another, because as the WB values are changed the structure of the primaries in the image changes, possibly causing one or more primaries to exceed the gamut of the working space. By virtue of its compact set of powerful tools for individually addressing WB, highlights and shadows, CR helps to manage both WB and tonal range adjustments rather easily, often making recourse to Curves unnecessary for this purpose.

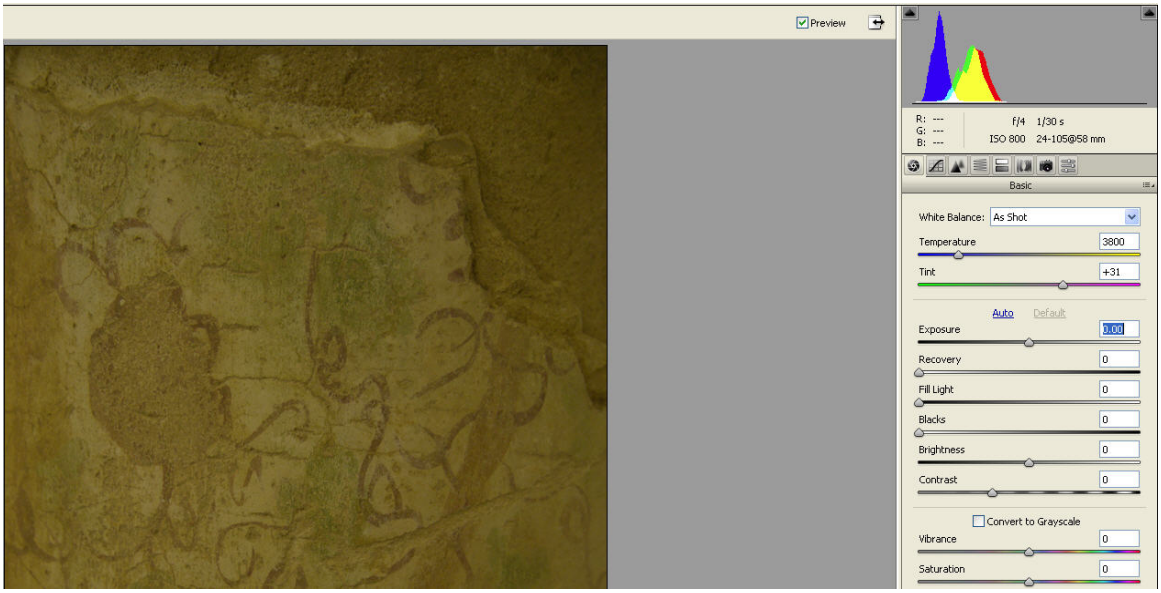
I preface this demo observing it is best to anticipate WB requirements at capture. For example, I use a credit-card size Checker, hold it arm's length and photograph it (Fig. 1). Post-capture, I download this image to CR, click the WB eyedropper on the second brightest of the middle grey patches and save the resulting settings as a WB preset (Fig 2). Then WB is done in CR by loading this preset with all images shot under essentially the same lighting conditions. If necessary, it can be tweaked with CR's temperature and tint sliders, which move hues between blue-yellow and green-magenta respectively. For some of the photos here, shot inside the museum of Roman relics at the archeological site of Tolmaitha, Libya, where the lighting was dim and very warm, this procedure was invaluable. (There are, however, many other situations where WB is a matter of taste, especially where one wishes to preserve a mood which a colour cast conveys – e.g. an evening warm glow. Whether in CR or PS, WB can be set to taste.)

[5] All photographs by Mark D. Segal

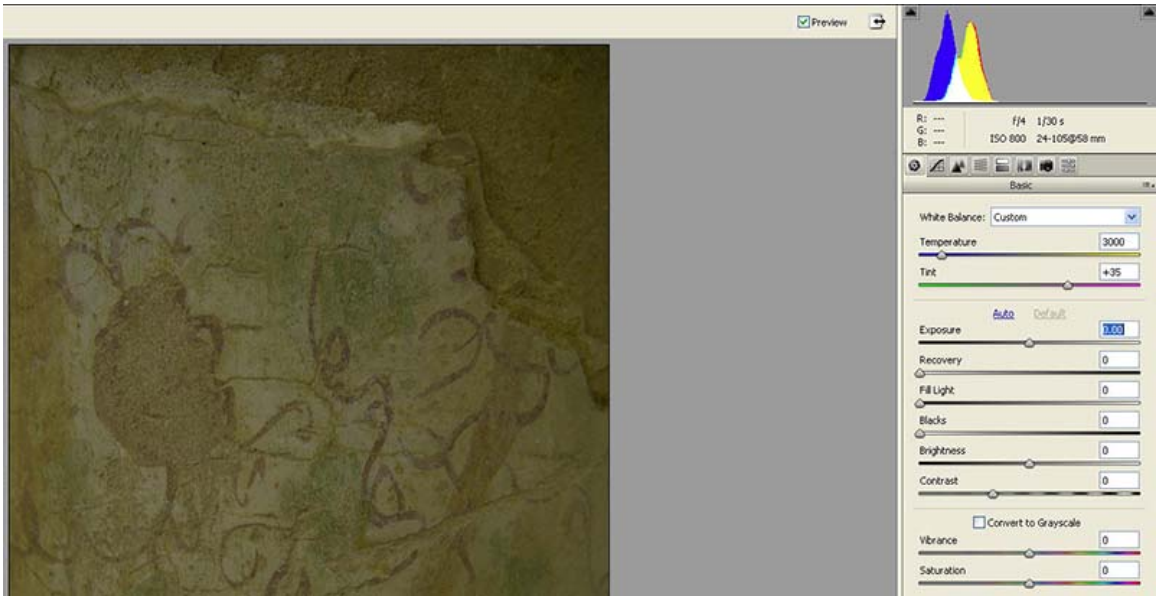
1. Color Checker before WB

2. Color Checker after WB only

With poor lighting and no tripod, I pumped the ISO to 800, exposed f/4 (maximum aperture) at 1/25th of a second (minimum hand-hold), still resulting in considerable under-exposure. CR rescued these images, as shown below with the photo of a delicately painted ancient pillar in the museum. Figures 3 and 4 show the effect of the WB adjustment loaded with the preset based on the WB of Figure 2.

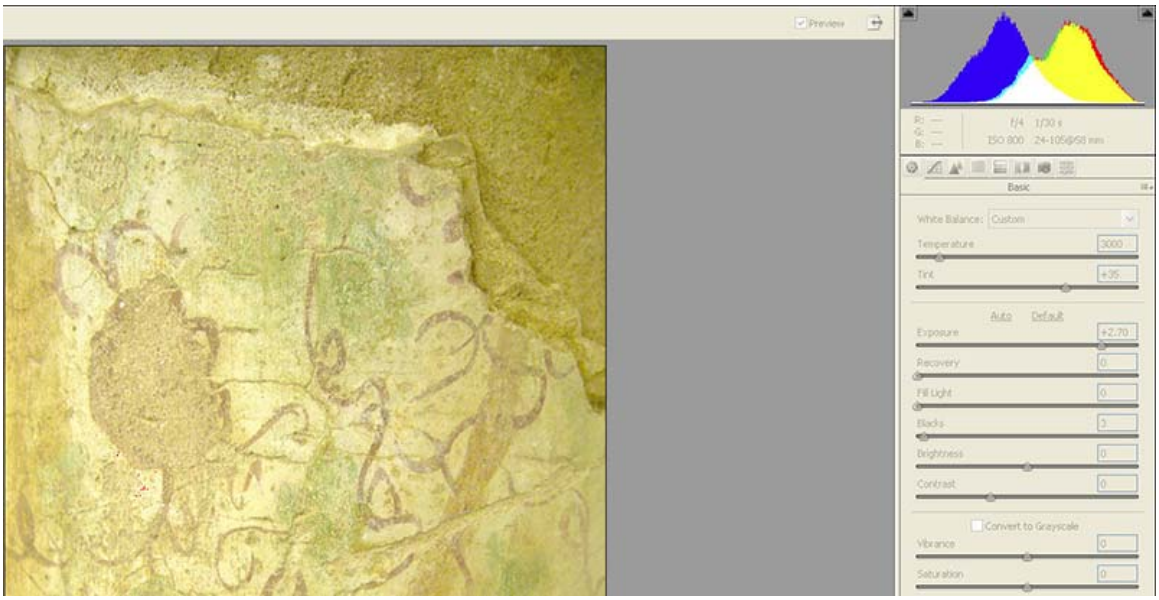


3. Before White Balance

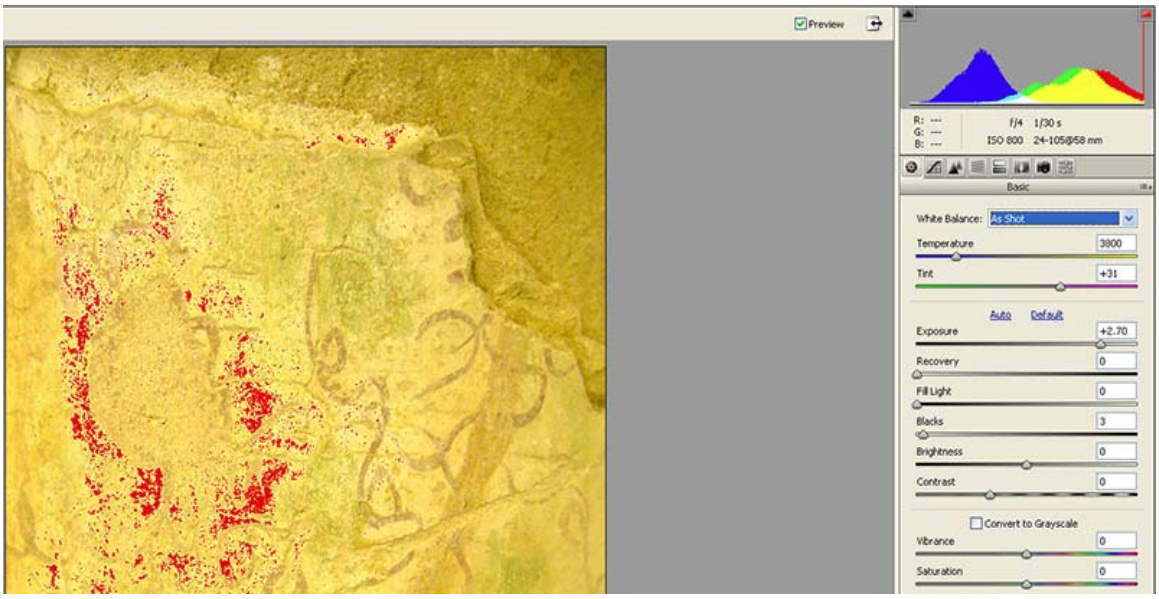


4. After White Balance

Notice how the histogram changed shape between Figures 3 and 4. More on this just now. In Figure 5 the exposure is corrected by moving the exposure slider from 0 to +2.70, so the histogram just occupies the luminosity range. If the WB were then reset to "As Shot" as in Figure 6, highlight clipping occurs in the red channel.

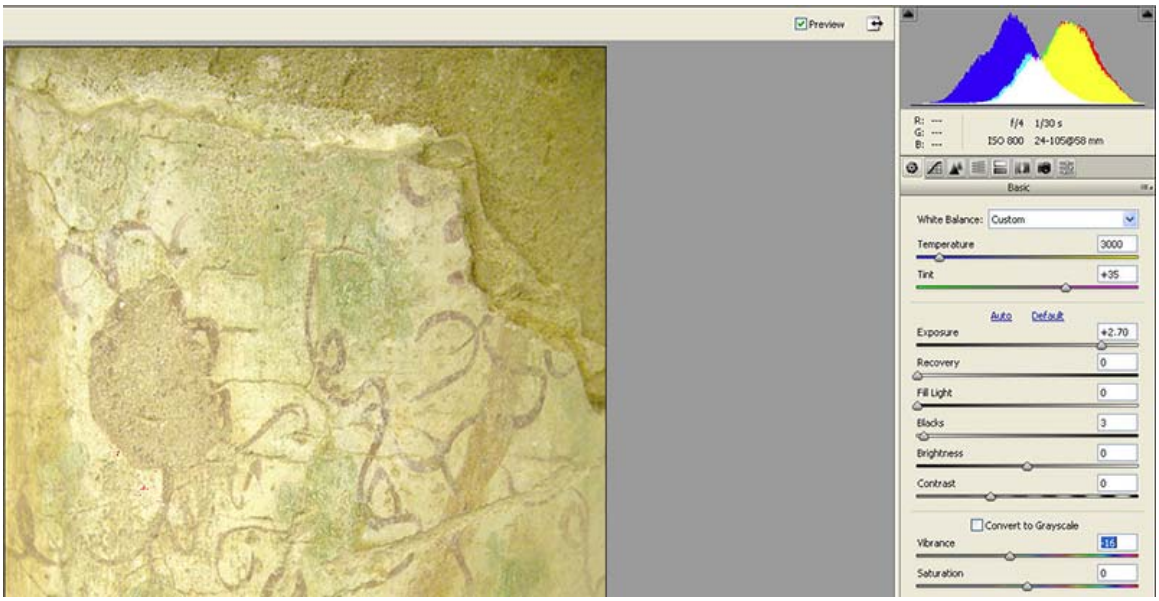


5. Fig 4 After WB and Exposure correction

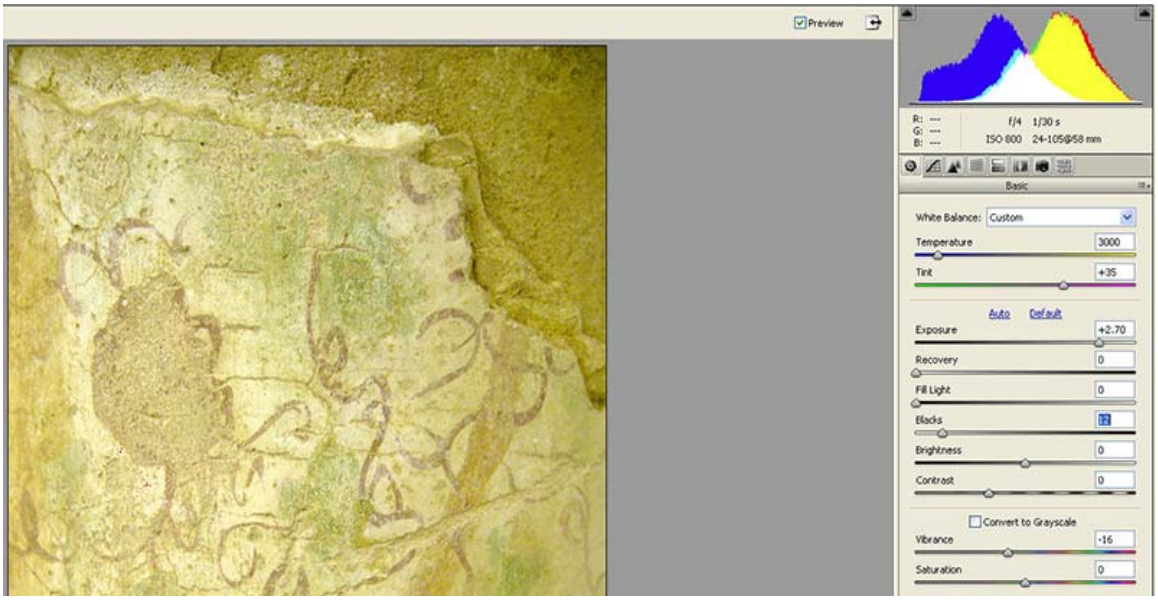


6. WB reverted to “As Shot”, clip-warning on

Reverting back to the Custom WB of Figure 5, we set Vibrance at -16 (Figure 7) reducing saturation mildly, then increased Blacks to 12 strengthening contrast mildly (Figure 8) with no clipping. This is done here to illustrate that Blacks and Vibrance (or Saturation) can be deployed together for fine-tuning contrast and saturation within an acceptable luminosity range for the image. No Curves were needed. All these controls are on the same interface and the process is “real-fast”.



7. Fig 5 w. Reduced Vibrance



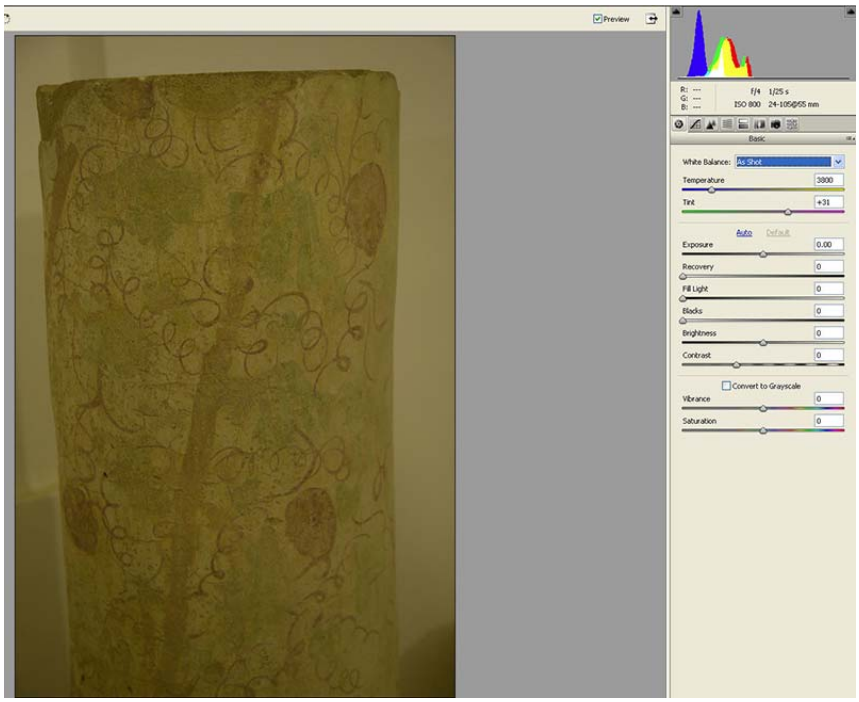
8. Fig 7. with Increased Blacks

The workflow recommended for CR is generally to proceed from "top to bottom" within each tab, and tab-by-tab from "left to right". This means starting with WB in the Basic tab, as I did above. In the following three examples, the WB step has been done, and I focus on luminosity issues.

Raw captures most often exhibit several general characteristics which post-capture processing is intended to either protect or correct. I cover the range in three possibly representative prototypes. The first, (Case "A") is an image that looks very dull, say because of poor lighting conditions and/or under-exposure. In this case the objective is to boost contrast, brightness and possibly saturation such that the scene has believable colour values and eye-appealing luminosity. The second (Case "B") is an image that starts life with a "decent" histogram (e.g. the tonal range is filled from near 0 upward with no more than minor highlight clipping), and contrast, hue and saturation are not bad. The objectives are to rescue the clipped sky highlight, punch-up the contrast a bit and open the shadows, without causing unwanted saturation, loss of mid-tone detail or clipping. The third (Case "C") is an image with an out of gamut tonal range, clipping at levels 0 and 255. The objective is to compress the tonal range by rescuing the clipped highlights and opening the shadows, while at the same time adding some mid-tone contrast. A fourth – special – case on "Range Opening" is the subject of Annex 2.

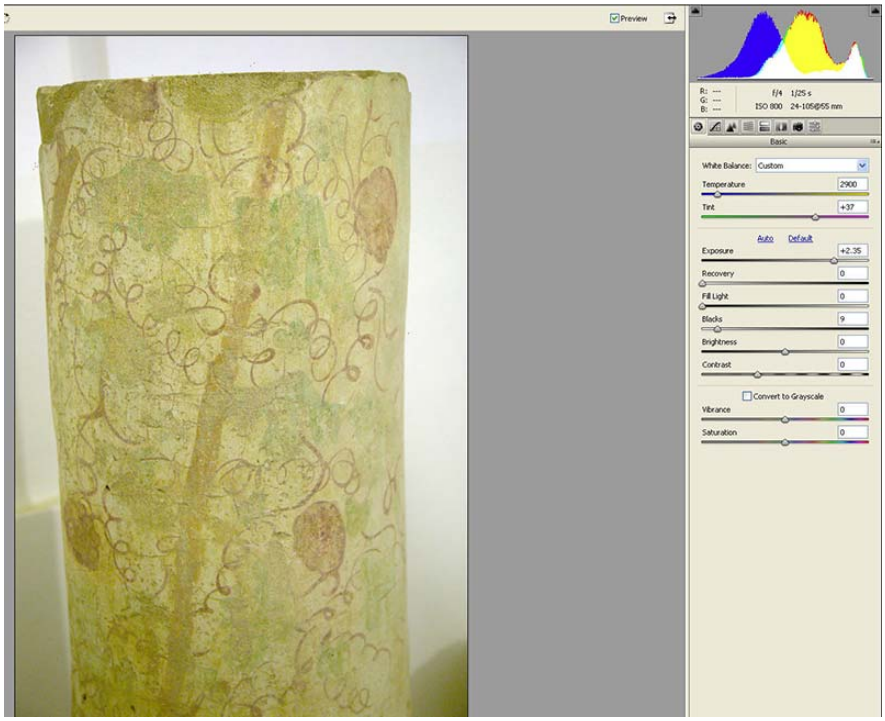
Case A – Under-exposed Image

Subject and Setting: A delicately painted ancient pillar in the archeological museum on the site of the Roman ruins at Tolmaitha, Libya, October 2006. No tripod; no flash; dim, yellowish lighting; ISO 800, exposure 1/25th at f/4 (lens: Canon 24~105mm f/4 L). The raw capture is correspondingly dull and yellowish (Figure 9).



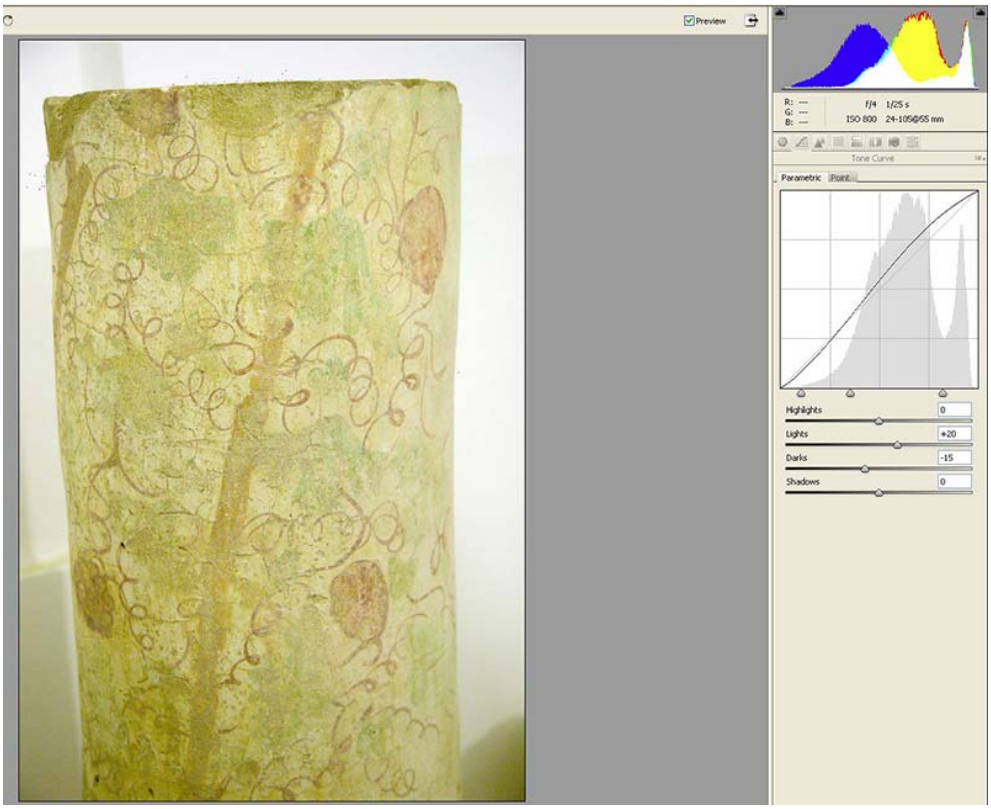
9. Case “A” Initial Conditions (before WB)

Adjustments: In the Basic tab, after setting the WB using the preset obtained with the Color Checker, I increased exposure from 0 to 2.35 and increased Blacks from 0 to 9. I haven’t used a tone curve yet, but these three rapid moves improved colour appearance, brightness and contrast to the extent shown in Figure 10.



10. Fig 9 After WB, Exposure and Blacks

Finally, knowing that prints emerge flatter than monitor images (discussed below Fig.15), and not being able to soft-proof in CR, I decided to punch the contrast a bit using the Parametric Curve. I did this first by isolating the range on the Curve over which each of the lightening and darkening moves should occur. One does this by adjusting the exposure zone spacers on the X-axis of the Curves box to match the distribution of tones in the image. Then I increased Lights from 0 to +20 and Darks from 0 to -15. I thought the resulting yellows a bit too saturated, so I entered the HSL tab and de-saturated Yellows from 0 to -10. Figure 11 shows the result.

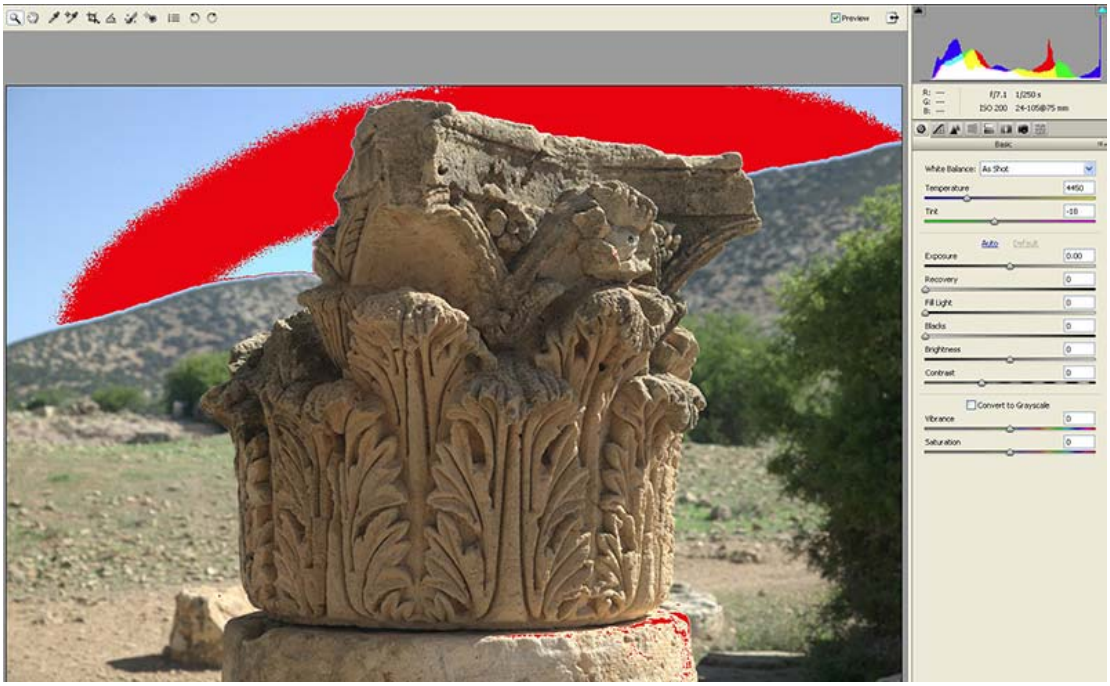


11. Fig 10 After Curve and HSL Adjustments

All the very delicate tones, soft colour and texture of this image are preserved without exaggerated saturation and no clipping. Individual channel curves in PS weren't needed. (Nice as it is, I find it likely that once I soft-proof in Photoshop, further marginal luminosity adjustments using the PS-RGBc are warranted.)

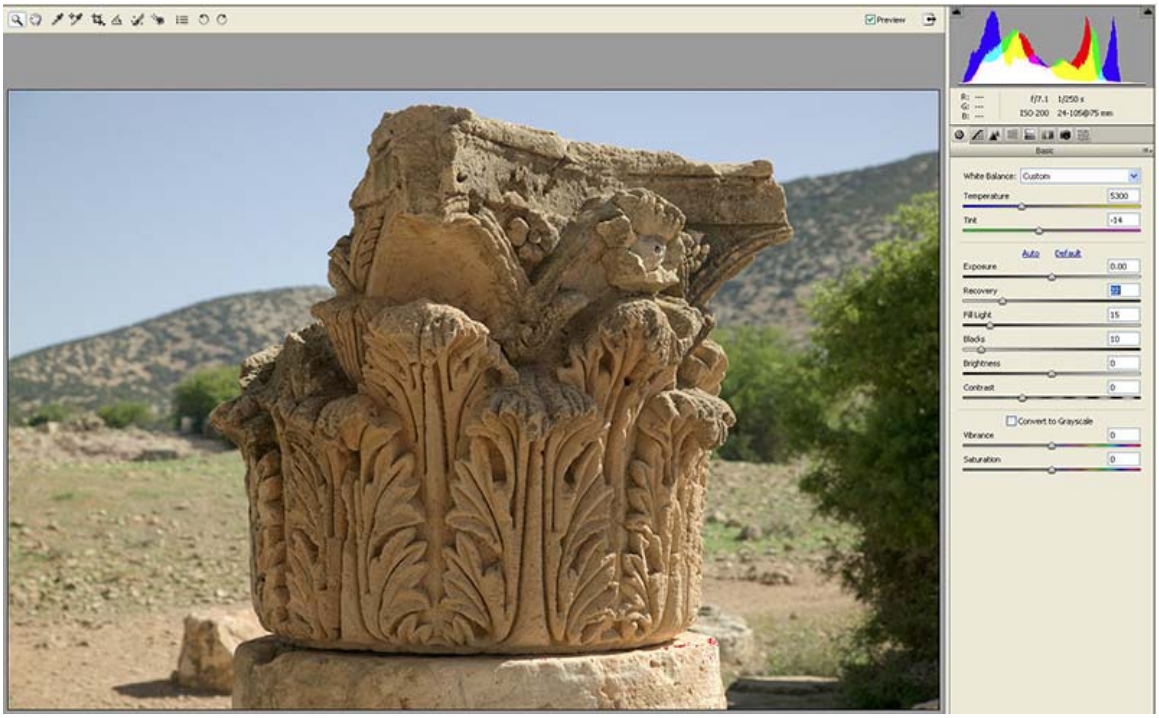
Case B: Decent Image, Improve without Damage

Subject and Setting: Capital of an ancient Roman pillar, Tolmaitha, Libya. Exposure f/7.1, 1/250th. Figure 12 shows the initial condition in CR, with gamut warnings active, indicating the blue primary (sky) is partly clipped and showing a slightly muddy shadow across the main subject, which would print more muddy-looking than appears on the monitor for reasons explained below Figure 15.



12. Case "B" Initial Conditions

Adjustments: The blown highlights are recovered by shifting the Recovery slider from 0 to +22. The Fill Light is increased from 0 to 15 for opening the shadows and Blacks are increased from 0 to +10 for improving contrast. We now have clear, open shadows with excellent architectural detail and a natural sky without blown highlights. No Curves were needed and the whole operation took less than 30 seconds (Figure 13).

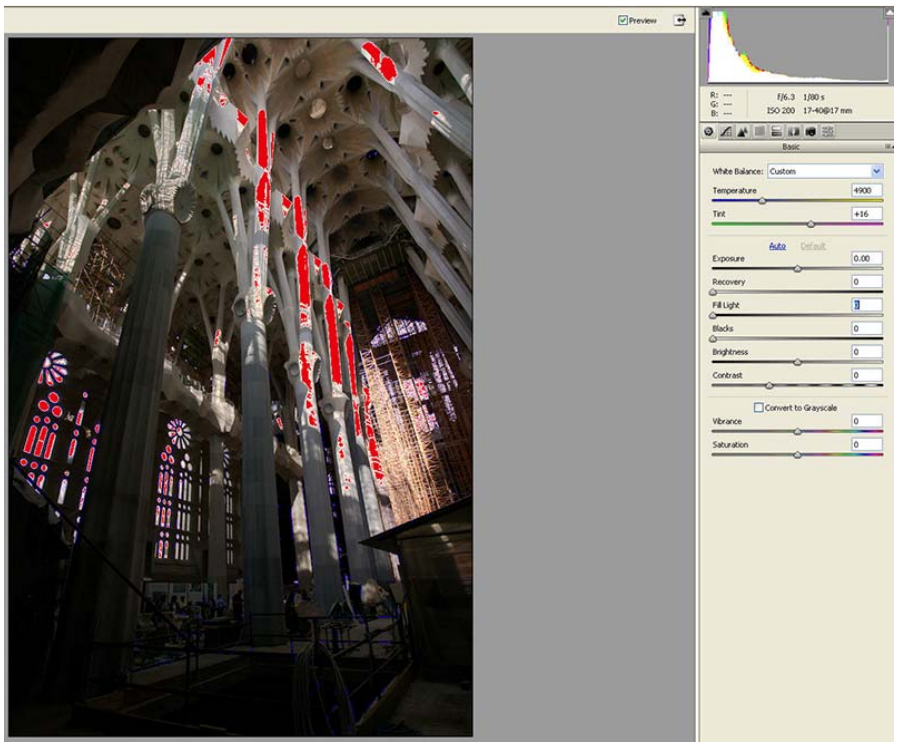


13. Figure 12 after CR Tonal Adjustments

Most of this can be done in Photoshop but it would take longer. This case demonstrates that substantial luminosity improvement (e.g. clear open shadows having depth and detail) to an already decent image can be implemented very quickly and satisfactorily in CR and without using curves. If one wanted more contrast in the sky, a sky layer could be created in PS, clipping to it a Curves mask with steepened PS-RGBc.

Case C: Large Tonal Range with Clipping

Subject and Setting: Inside the Sagrada Familia, Barcelona; object is to show the juxtaposition and scale of work in progress versus work done; extreme lighting conditions because of heavily shaded finished works and bright sunshine illuminating the works under construction. The objectives are to tame highlights, clarify shadow areas, insure adequate contrast and add some body to the colour of the scaffolding. The initial conditions are shown in Figure 14. The deep red shows CR's clipped highlight warning (level 255 exceeded in at least one channel). Detail in the blacks is smothered, with minimal clipping in unimportant places and the darkest values needing serious lifting – for example, an inkjet print on matte paper with Ultrachrome K3 won't differentiate much shadow detail below levels 12~15 on a scale of 0~255.

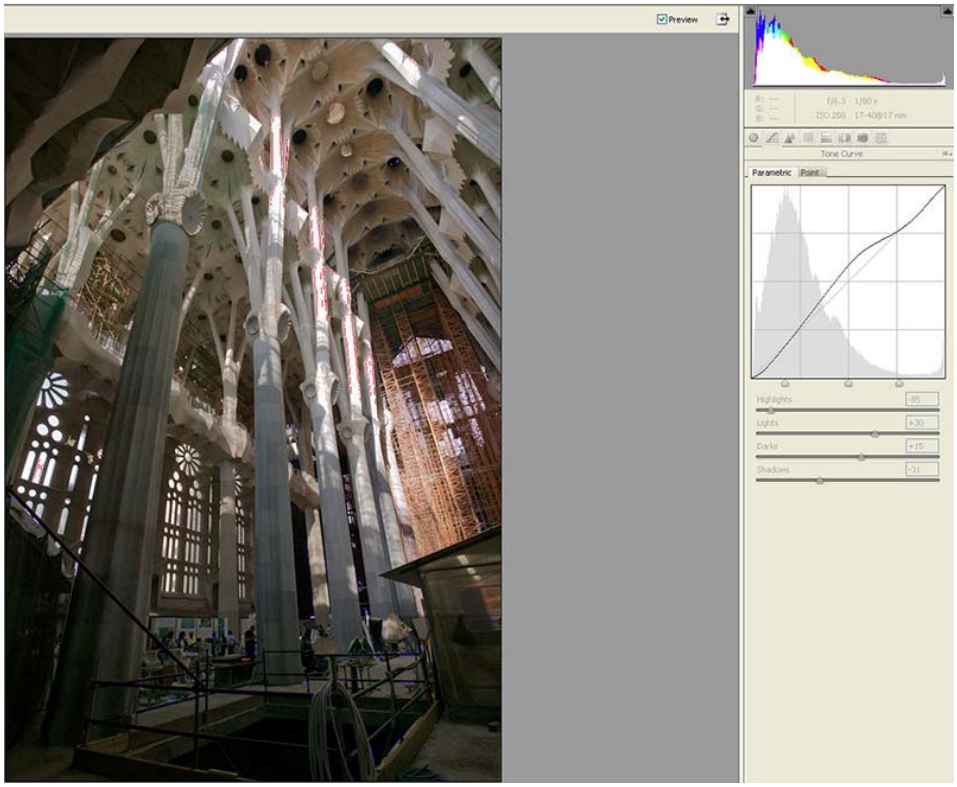


14. Case "C" Initial Conditions

Adjustments: First, the highlights are recovered – in this extreme case requiring the "Recovery" value set to 100. This brought almost all the clipped material from >255 down to a range within 252~245. Second, "Fill Light" was increased to 40; how much to fill is a matter of individual judgment. Too much "Fill" makes the shadows artificially

light and flat. Adding “Blacks” to rescue contrast is not very helpful on this image, which is highly sensitive to shadow clipping.

Hence at this point I flip to the CR Parametric Curve and make a set of rapid adjustments: (1) for the reason explained in Case “A”, examine how to place the break-points between Shadows, Darks, Lights and Highlights on the horizontal axis of the Curve window to suit the distribution of luminosity in the image. (2) Reduce the Highlights to -85, providing additional headroom to add contrast without re-clipping the highlights. (3) Add contrast by increasing the Lights to +30, increase the Darks to +15 and reduce the Shadows to -31(these are all Curve steepening/image brightening moves). Finally, I found the colour of the scaffolding rather weak, so I flipped to the HSL-Luminance tab and decreased “Oranges” to -20. The results are shown in Figure 15.



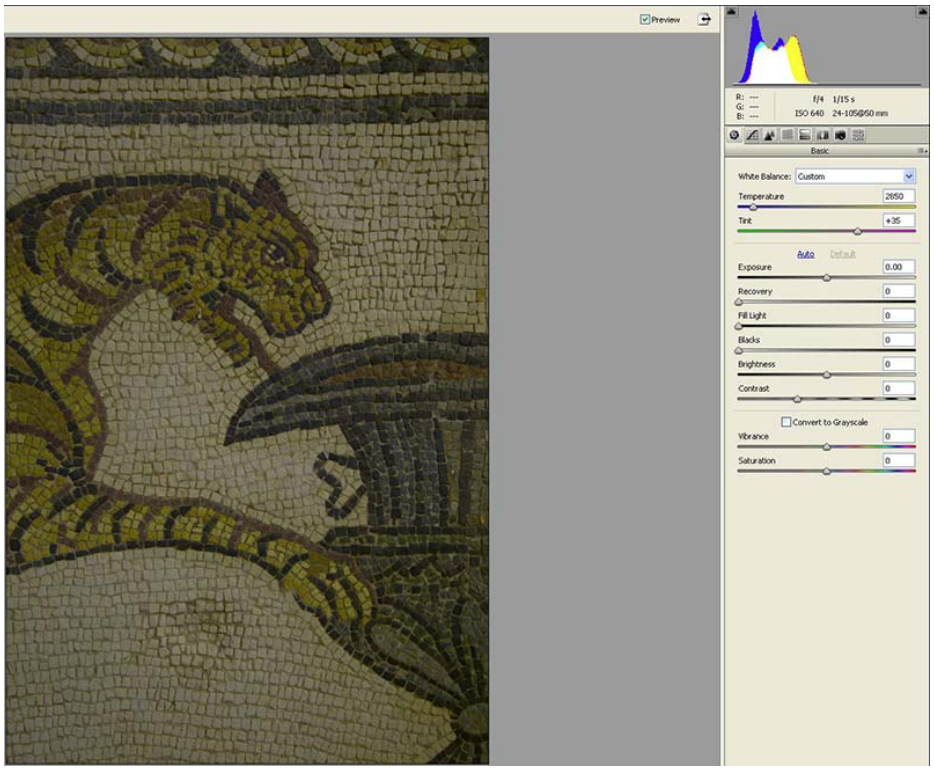
15. Figure 14 After Adjustments

Very localized additional colour in the scaffolding should be added in PS, without also reddening similar hues in the ceiling cavities. A raw converter is not meant for this kind of very selective “retouching”. The key objectives stated above have been achieved; the shadows and mid-tones are nicely opened without exaggerated saturation effects. In all three of these examples, there was no need to adjust the individual R, G, and B channel Curves in PS to achieve high-quality results.

Powerful as the new features in CR 4 happen to be, this is not an argument for not using PS – rather it is an argument to exploit CR for what it can do well, and use PS for things CR wasn’t designed for or can’t handle as well. One of these is the fact that we cannot

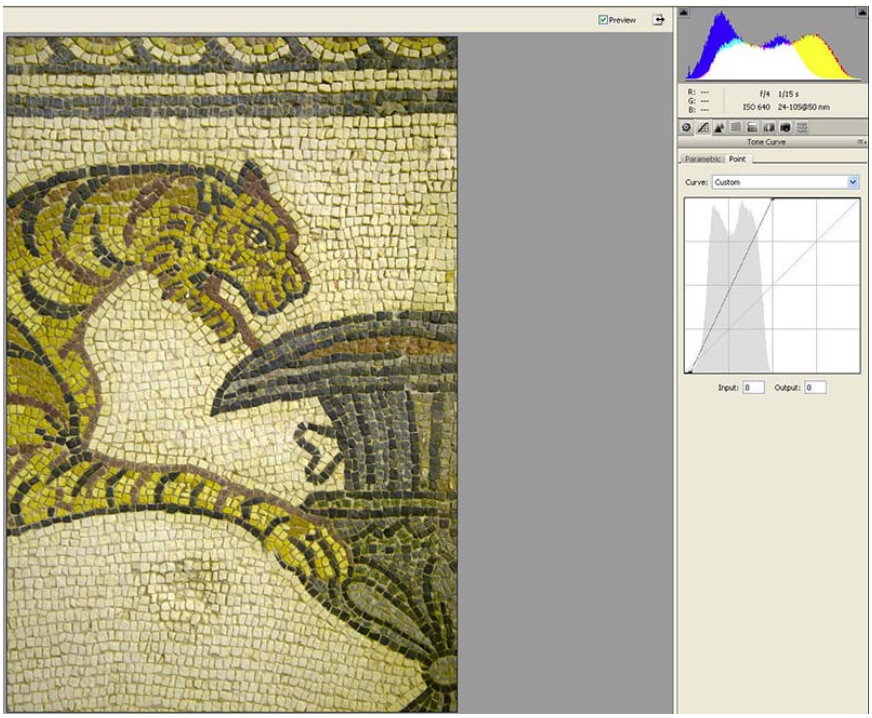
soft-proof in CR, partially frustrating the intent of colour management between the image file, the monitor and the printer. Even with good colour management, there are unavoidable differences between the apparent vibrancy and dynamic range of monitor images versus prints partly because of the natural differences between radiated and reflected light. This is managed by making final luminosity adjustments under soft-proofing in PS. Another is the need for adjustments which are too specific for either the luminosity or colour controls in CR, hence requiring PS for advanced selection, masking and channel blending techniques not available in a raw converter.

At this point it remains to further illustrate the hue lock in CR Curves, and the specific issue of the relationship between contrast and saturation when adjusting Curves in CR and PS. We start with an under-exposed image (due to very constrained shooting conditions – not the incompetence of the photographer!) of an ancient Roman mosaic shot in the same museum at Tolmaitha, Libya. It needs brightness and contrast, as shown in Figure 16.



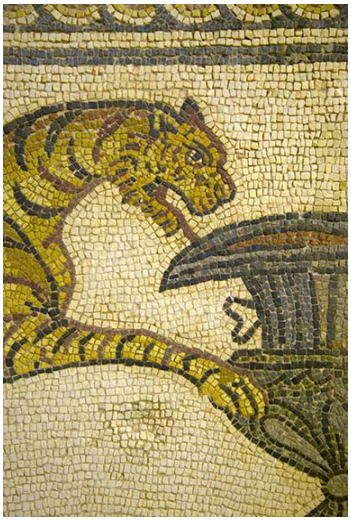
16. Initial Conditions

Key here is to observe that the leopard's hide is in various shades of yellow tiles and the stripes in various shades of red and blue/grey. The colour of the background tiles is a bit creamy. But the whole thing is dim and dense. A real quick-fix for both brightness and contrast (skipping the Basic tab because this demonstration is about Curves) is to linearly steepen the CR Point Curve as shown in Figure 17. The result is a vastly improved display of brightness, colour and contrast, but there is a saturation boost.

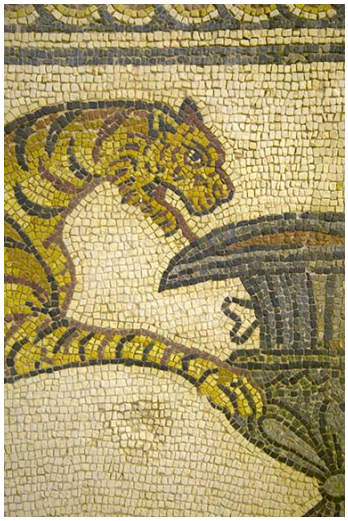


17. Figure 16 After Curve Adjustment

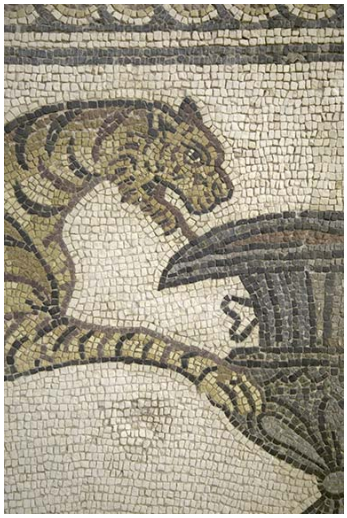
An alternative approach is to simply use CR as a converter, making no changes to the basic settings (zeros for all the luminosity values and unadjusted linear curves), then use the PS-RGBc to adjust contrast and brightness, as was done with the Point Curve in CR. The comparative results are shown in Figures 18, 19 and 20.



18. CR Linear Curve



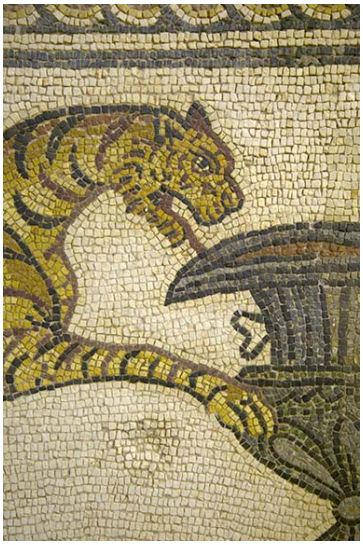
19. PS-RGBc Linear, Normal



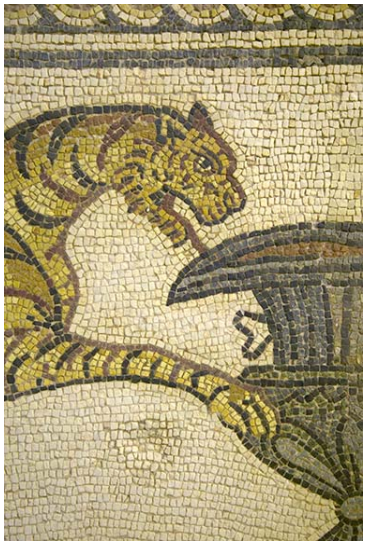
20. PS-RGBc Linear, Luminosity

The CR Point Curve linear shift (Fig. 18, from Fig. 17) produced a slightly higher contrast image than that produced by a similar linear adjustment using the PS-RGB composite curve (in Fig 19), yet they were done such that in both renderings the ends of the histograms are similarly positioned; but the saturation effect is not very different

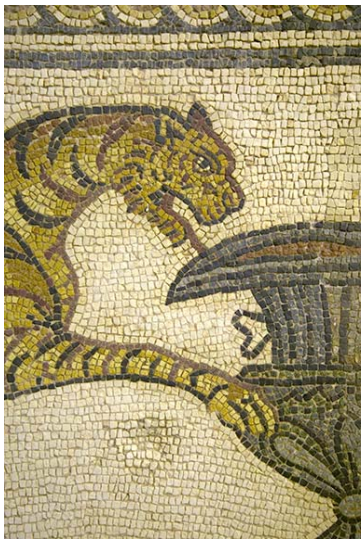
between them. As discussed above, should the saturation effect of the PS-RGBc adjustment be considered excessive, there is the option to use the PS-RGBc Curve in Luminosity Blend Mode, the effect of which is shown in Figure 20. It is not satisfactory, as the colour is under-saturated. So, a reaction to this situation is: “wouldn’t it be nice if there were something in-between?” No, there is no “Fade” command or “Blend If” sliders operating between Normal Mode and Luminosity Mode in the PS Curves dialogue, and there are no blend modes in CR. But there are other things. We can get this tiled cat to be saturated “correctly” in both applications, as shown below.



21. CR, Reduced Vibrance



22. PS Luminosity Curve, > Saturation



23. PS Normal Curve, <Saturation

Figure 21 is rendered from CR adjusted as in Figure 18, but with CR’s Vibrance reduced by -25. Figure 22 is the PS-RGBc Luminosity Curve with an added Saturation Adjustment layer in which Saturation is boosted to +52. Figure 23 is the PS-RGBc Normal Curve with Saturation reduced to -21. Figures 22 and 23 were adjusted to match Figure 21 as closely as I could. On the whole, I find Figure 21 has a very slightly crisper look; however it’s a quibble, and with more time spent fine-tuning all three, they could become almost indistinguishable.

I used this image, starting in its unadjusted state, from which to measure the impact on hue, saturation and brightness of a radical linear Curve steepening to increase brightness and contrast without clipping (as illustrated in Figures 18 and 19) in two ways – one to test the impacts of a CR Curve shift, and the other a PS-RGBc Curve shift. For the CR test (Figure 24) I start with the unadjusted image rendered from CR[6]. Then I layered onto that a duplicate of the image this time rendered with the CR Point Curve linear adjustment of Figures 17~18. For the PS-RGBc test (Figure 25) starting with the unadjusted version of the same image, I layered the PS-RGBc adjusted linearly as in Figure 19. In both cases the top layer increases contrast substantially. To measure the

[6] The CR defaults are WB “As Shot” Curves linear and not changed, all luminosity and colour adjustments set on zero.

HSB impacts, I selected the HSB read-out in the PS Info palette[7]. Then with the eyedropper (in cross-hair format) I placed three control markers for three measurement points (same pixels for both images), as shown in Figures 24 and 25 below – one yellow, one red and one blue/grey. Then, by turning the top layer (adjusted version) off and on, I measure the "Before" and "After" HSB values of these pixels. Two measurement exercises are done: one for the CR adjusted version in Figure 24, and another for the PS version adjusted with the PS-RGBc Curve (Figure 25).

24. Control points – CR Curve

25. Same control points PS-RGBc Curve

The results of these measurements are as follows:

26. IMPACTS OF RADICAL CONTRAST ENHANCEMENT ON HSB VALUES OF SELECTED PIXELS

		ACR Set						Photoshop Set				
		Before			After			After			pixel locations	
Marker	Colour	H	S	B	H	S	B	H	S	B	X	Y
1	Yellow	56	75	25	56	88	54	56	84	54	6330	6267
2	Red	25	24	18	25	30	35	24	28	36	5255	6117
3	Blue/grey	246	6	14	246	8	27	246	7	28	6455	4680

26. Test Data

These results indicate that CR and PS are delivering as promised: (1) there is no hue shift (except for an extremely mild reduction of the red result in PS); (2) there is a saturation boost (somewhat more pronounced in the CR set), the extent of which is variable between the three colour samples, but subtle texture is maintained; and (3) the Curve steepening delivers a major brightness increment in each case.

The three key points emerging from this demonstration, (where a yellow-dominated image was selected on purpose because yellow saturation has such a marked visual

[7] I use it because it is the only read-out Photoshop provides that directly and easily distinguishes between Hue, Saturation and Brightness; however it's accuracy for measuring hue has been questioned.

impact), are: (1) in both CR and PS, while composite curves may boost saturation, the effect can be well-controlled either colour-specifically or overall in both applications; (2) CR is at least as good as PS for making refined adjustments to image luminosity and saturation, unless special problems such as multiple colour casts are involved, and (3) the demo shows that even with large shifts there can be zero or minimal hue shifts resulting from the Curves adjustments. Finally, with controllable saturation, smashed image detail should be avoidable.

I mentioned above that selecting images from which to make generalizations is an issue. Adjustments which clip previously unclipped channels should produce a hue shift. Also, had I selected an image with saturated bright red containing image detail and boosted its contrast substantially with either the CR or the PS-RGBc Curve, detail in these reds may well have been suppressed because of excessive saturation. This is a known issue which Dan Margulis had written about long ago (referenced in the first Annex) and which I observed and discussed several times last year on ACTL[8] (the "Chinatown Red" syndrome); I believe the solution is to control saturation of red whether in CR or in PS. I do not consider such images representative enough to invalidate the general quality of the image adjustment procedures discussed here.

Concluding Comments

The information and demonstrations in this note indicate that CR has evolved into being a Raw rendering tool with extremely capable image adjustment functions, resolving many luminosity and colour adjustment issues easily and to a professional standard, sometimes without recourse to Curves at all. At the same time it is not a substitute for Photoshop, and like Lightroom, should not be thought of as such. As for Curves in CR, given the luminosity controls in the Basic tab, the Point and Parametric Curves in the Tone Curve tab and the 8-colour palette of adjustments in the HSB tab, the lack of individual R, G and B channel Curves in CR is not a critical limitation to the program's overall effectiveness; however, it would be a useful future feature if feasible. Having used this program for adjusting about one thousand images over the past several months the two features I would love to see added in the next release are (i) soft-proofing capability allowing one to adjust images under soft-proof conditions, and (ii) a way to map the location of exposure zones along the Parametric Curve as one can do by control-clicking the eyedropper around the image while in the Point Curve; this would greatly simplify setting the zone spacers at the bottom of the Parametric Curve box. Finally in Photoshop, the PS-RGBc Curve, whether in Normal or Luminosity mode, remains a very useful tool for overall luminosity adjustments, provided one is aware of the saturation effects it produces in Normal mode and knows how to manage them.

Mark D. Segal
Toronto, July 2007

[8] References are in the first Annex

Annex 1

Here are views from Dan Margulis about CR, extracted from the recent ACTL discussion thread “Color Theory and Practice”.

cf. Margulis, Dan; ACTL Message # 17891 of June 4, 2007:

- The white balance routine, by contrast, is well thought out and original AFAIK. In CS2, however, I think a lot of people would have trouble figuring out how to use it properly. I am glad to see that it has been made more self-explanatory in CS3. But the range-opening routines are inferior, and range opening is the most fundamental operation of the module, the one function that can't be omitted in most images. All the add-ons in the world can't compensate for improper ranges……
- After testing around 100 images, I concluded that in some cases opening the range in Camera Raw actually damaged the image to the point that it was no longer possible to get a good result without excessive effort, if it was possible at all…….
- With respect to White Balance, Brightness, XXX, and curves, I also scripted a routine to batch open multiple variants and spreadsheet the results, to reveal the exact mathematics behind the command. This was necessary because, as noted in the post you responded to, I simply could not believe that a major vendor was using a method this crude to open range. (Ed. The math and spreadsheet are not available at time of writing.)
- I also tested around a dozen images where the capture had serious exposure defects, as I had thought that recovering from such difficulties might be a strength of the module. Most of the time such pictures aren't very important. At such times Camera Raw offers an attractive way to get close to the desired result quickly. However, if time is not a factor, better results are often achievable by acquiring conservatively and then assigning a false profile.
- An image of an elderly couple shot indoors showed a yellow cast. After a conservative, flat-looking acquisition in Camera Raw, the image can be corrected to my satisfaction with one set of curves. I showed what happened if an attempt had made to correct the problem with Camera Raw's range- opening and/or White Balance routines. Doing so introduced the common digital defect of conflicting casts at different darknesses.

cf. Margulis, Dan; ACTL Message # 17927 of June 7, 2007:

- "Range" has been a standard term in the prepress industry for at least a quarter of a century. It can be used to refer either to a picture as a whole or to certain important object(s) contained therein. It denotes how different the lightest and darkest significant areas are.
- All editions of PP5E have a chapter about range control entitled "The Steeper the Curve, the More the Contrast". All editions label this, "the principal secret to professional color reproduction." The statement remains as true today as it was in the 1980s: without proper range control, consistent professional quality is not possible. What this thread has suggested is that Camera Raw does not offer sufficient control in this critical area.

cf. Margulis, Dan; ACTL Message #17990 of June 10, 2007:

- The point is not how many commands have been added, but how well they can address the specific problems that have repeatedly been pointed out to you in specific images--problems that any professional-level program from around 1985 on does not encounter. As far as I can determine, for all the nice new functionality that has been added in CS3, the fundamental problems in range extension have not been remedied.

cf. Margulis, Dan; ACTL Message #17994 of June 11, 2007:

- There is a lot of terminology being bruited about, but it sure sounds like we can now agree on the following statement: "When one lightens an image in CR, saturation increases. The operator can not modify or turn off this effect."
- If you agree with this statement then I cannot see any possible way of avoiding agreement with the statement I made early in the thread to explain why I had tested the module thoroughly: "I simply could not believe that a major vendor was using a method this crude to open range."
- Similarly, if we agree on the first statement--that the command increases saturation, and the operator cannot modify it, then I reiterate my recommendation to those skilled in color correction that it is better to acquire the image in CR conservatively.

Other References:

Kieran, Michael, “Photoshop Color Correction”, Peachpit Press, 2003, chapters 4, 5 and 6 deal extensively with the use of individual R, G, and B channel curves for editing images in Photoshop. **Fraser, Bruce & Blatner, David,** “Real World Photoshop CS2, Peachpit Press, 2006, pages 256~294; **Margulis, Dan**: “Professional Photoshop Fifth Edition”, Peachpit Press, 2007, Chapter 3, where “Curves” is discussed extensively.

“Chinatown Red” is discussed between Andrew Rodney and me in ACTL messages 12417, 14400, 15660 and 15664 between November 2005 and November 2006.

Annex 2
"Range Opening"

In the notes above, Dan Margulis speaks of "Range opening" as increasing the range of the lightest to darkest significant areas of the image. This is also known as increasing dynamic range. He says above that CR does not provide proper range control, because when curves are used to increase contrast the brighter tones undergo increased saturation.

Testing this hypothesized limitation of CR proved to be a challenge, because I found it hard to find very low contrast samples from my thousands of images that would make good demo material. This is because more often than not, one is faced with the need to reduce (rather than expand) the dynamic range of a scene because it exceeds that of the camera sensor or ones' output devices. Anyhow, Dan wrote a whole book on Lab color (*Photoshop Lab Color - The Canyon Conundrum*) in which there is a major focus on "range opening". Canyon scenes start life as low-contrast images with dull colors. As such they are visually unexciting to the mind's eye. Dan successfully demonstrated how to use the Lab space for improving the contrast and color vibrancy of such images. Here I intend to demonstrate that CR can do this very well too – in effect to suggest that it can expand dynamic range in a very controlled manner, such that knowledgeable users can achieve contrast and saturation to taste in the CR module.

The closest I have to "canyon" images is a number of photographs shot in a shady valley of sandy hillsides and cliffs in Iceland. So I selected part of one of them that conveniently meets the need: contrast is low, colour vibrancy is low, it does not have an overall color cast and it hasn't been sharpened, but it does have the potential for its contrast and colour to be emphasized yet still look natural. To see its low contrast, the image is best viewed in grayscale (easy to do in CR by clicking on "Convert to Greyscale"). If the image looks "blah grey" with little evidence of blacks or whites, it is of interest here. The starting point of this image in both colour and grayscale is shown in figures 1 and 2 below:

Fig. 1 Initial conditions

Fig. 2 Greyscale version

I'd say this is about as "blah" as it gets, but when I saw the scene it really looked much more exciting, otherwise I would not have bothered photographing it. So now I need to convey that excitement in the language of photography – using CR.

I did the following, all in CR:

In the Basic tab, increase Blacks by 15, which brought the left tail of the histogram to the left end of the scale without clipping blacks. In the Parametric Curve tab, set Highlights to +5, Lights to +15, Darks to -10 and Shadows to -15. All of this steepens the curve to individual specification for each of these four zones. The result is in Figure 3 (colour) and Figure 4 (grayscale).

Fig. 3. More contrast

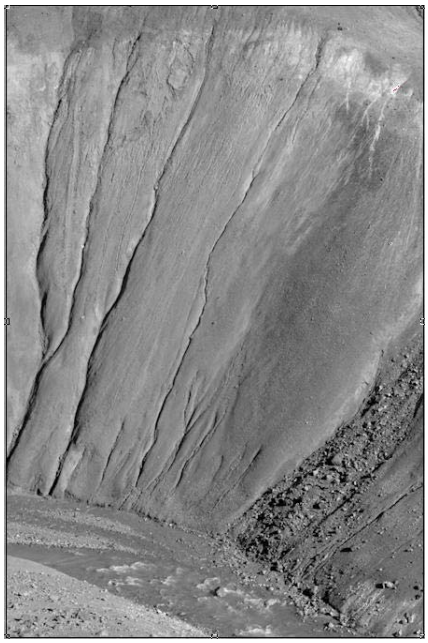


Fig 4. Greyscale version

This image now looks much as I thought it should. There is more tonal variation and the colours are more vibrant. I could have taken these adjustments much further, because the scales' range is +/- 100 in the Parametric Curve tab, and +100 in the Blacks adjustment of the Basic tab. Reverting to the saturation issue – now that I have brightened this image so considerably, suppose I thought the colours were overly saturated – and for this kind of photography it really is a matter of judgment. Every change in lighting conditions in that valley would produce a different visual impression of colour saturation. In Figure 5, I reduced the Vibrancy (Basic tab) by -20, and I provide its grayscale version in Figure 6. Compared with Figure 3 contrast is untouched (compare Figures 4 and 6), but the colours aren't as strong. One can't really say in this kind of situation whether Figure 3 or Figure 5 is the higher quality result. The points are that this is a matter of individual judgment, a whole range of such conditions would make equally good photographs, and they are obtainable in CR alone.

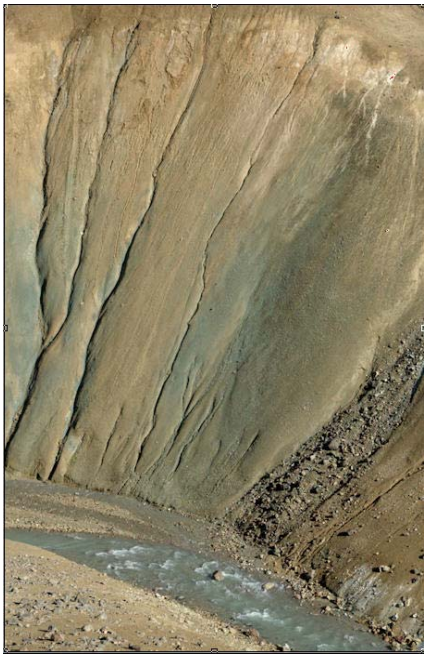


Fig. 5. Fig 4 with Vibrancy -20

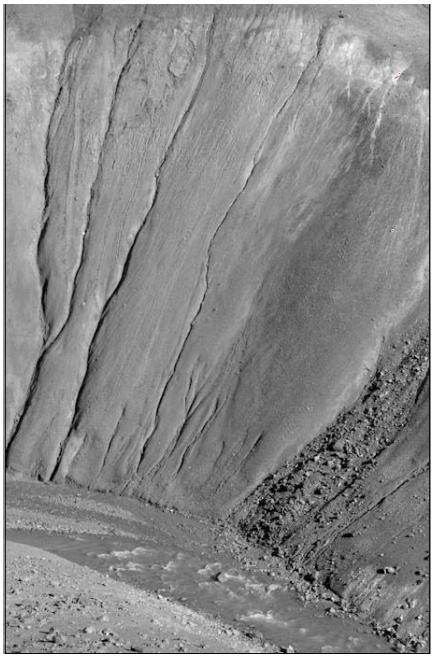


Fig. 6. Greyscale version

Now, I can do all this in Lab and get excellent results (Figure 7, without trying to exactly replicate Figures 3 or 5). To achieve it I need to convert the image to Lab, iterate between the three channels, and I don't know what I'm getting until I've done all three; then for any work that Lab doesn't support, flatten the image and convert it back to RGB, baking-in that set of adjustments. In CR, I see what I'm getting in real time, so there is less iteration; and, the moves are saved as metadata and re-doable without destructive edits on image data.

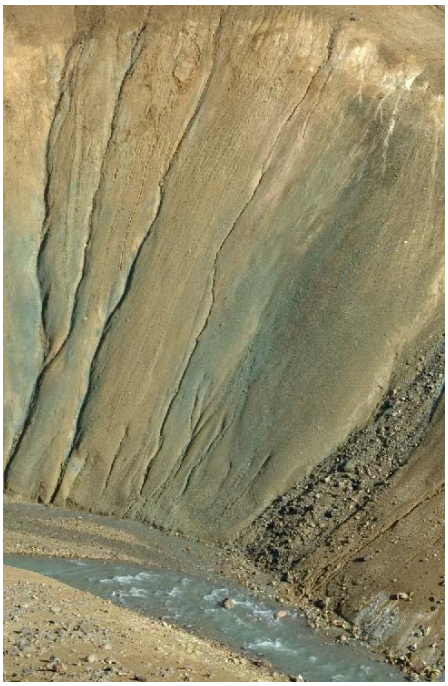


Fig. 7. Lab version

Annex 3
Adjusting Images with Pronounced Colour in Camera Raw

Since the essay was published on July 25th, inevitably there has been some discussion about the influence of the selection of images on the results. In particular, on ACTL Dan Margulis suggested three kinds of images that would reveal CR's "range setting" limitations. These are, quoting from Dan's message:

"1) They contain large, important areas of pronounced color that also carry important detail.
2) They have conflicting casts due to unusual lighting or reflections.
3) They have a single uniform cast, but also important detail that resides in several ranges."

I do not deal with item (2) here because I've already mentioned that CR is not configured to resolve this unaided by Photoshop. Item (3) isn't worth evaluating further, because it describes routine conditions - almost every image needs some white balancing, contains detail along the tonal range worth preserving and gets adjusted very satisfactorily in CR with "room to spare" for further work in Photoshop. If desired, we eliminate the cast with the White Balance tool, perhaps further tweaked by the Temperature and Tint sliders. Then we implement the luminosity adjustments as appropriate. Item (1), however, is of interest, because in some of these images there is a risk of losing detail by implementing increases of contrast which trigger enough of a saturation boost to suppress image detail. I believe this is what Dan means by "damage" to the image.

I created an image which I believe fits the description of item (1), but further challenged it with the "single uniform cast" element of item (3) – so double-billed challenge. This is a photograph of oranges and grapefruits – Citrus 5165 - (pronounced orange and orangey-yellow), with much texture on the surface of the peel, sitting in a basket under 400 watts of halogen illumination, which has a strong warm cast. Apart from grey-balancing, it needs considerable adjustment because it is both somewhat underexposed and lacks enough contrast to be a visually appealing photograph. It was made with a Canon 1Ds, set at ISO 400, hand-held 1/60th of a second at f/4, 58 mm focal length, quite close-up, therefore some depth of field constraint, but enough in-focus areas for present purposes. The image is not sharpened and not noise-reduced.

The object of the exercise is to see whether in CR we can neutralize the cast and produce satisfactory contrast without blown highlights, plugged shadows, excessive saturation and sacrificed detail on the peel. One advantage making these adjustments in CR is that all of them are sets of meta-data instructions performed on the raw image data before rendering; the original raw file never gets damaged. The approach here is the same as that which I implemented for the other demos in the paper. All CR renderings are in ProPhoto RGB space, 16-bit depth. The image starts life as shown in Figure 1. Figure 2 shows Figure 1 after white-balancing done by clicking the CR white balance tool in the second lightest grey square of the Color-Checker. The colour cast is now neutralized – notice Temperature was reduced from 3200 to 2450 and Tint changed from -14 to 0.

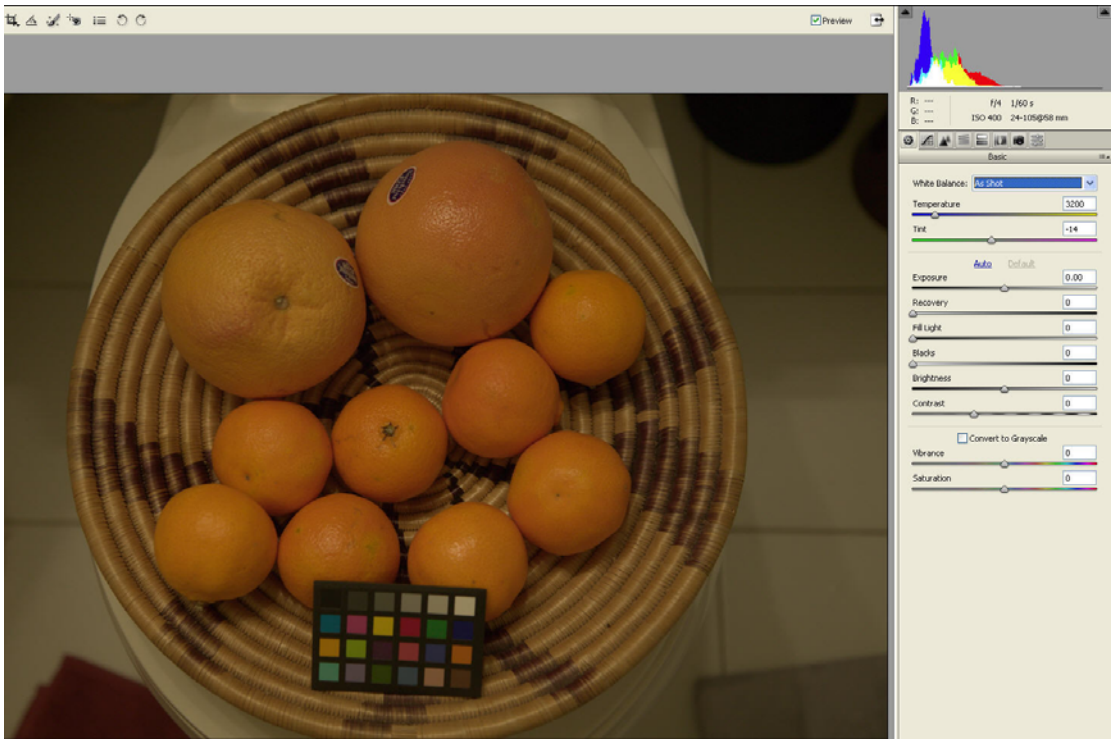


Figure 1. Initial Conditions

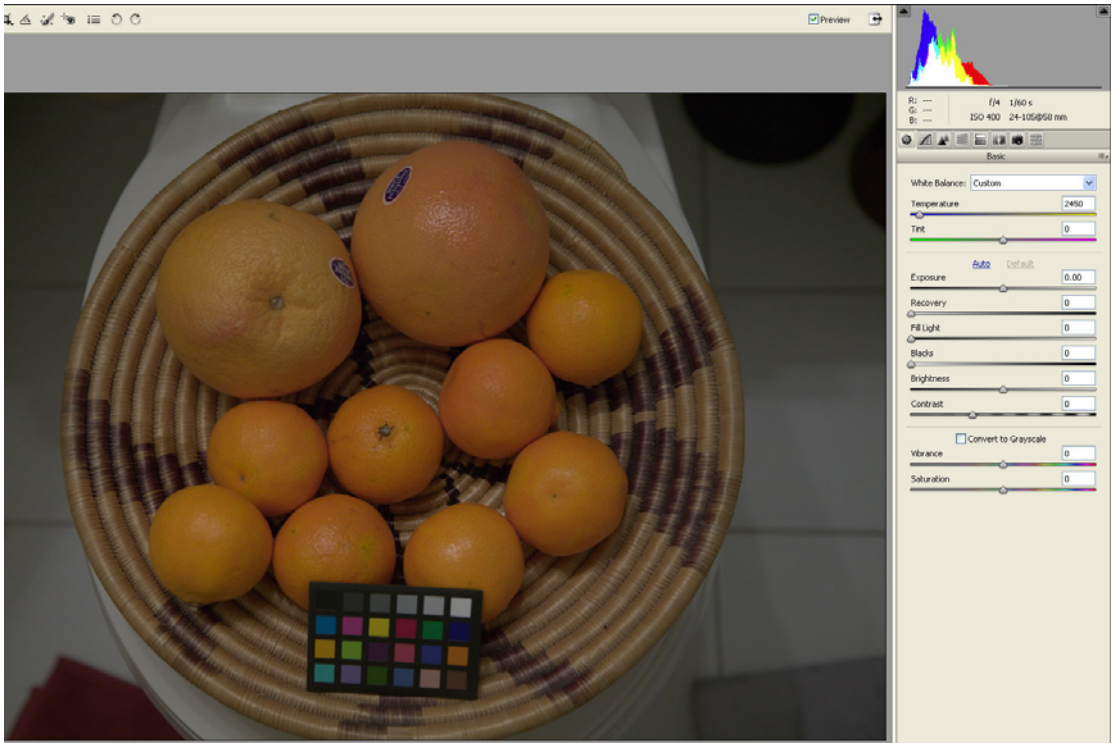


Figure 2: Figure 1 with White Balance

The next adjustment is to correct the exposure. With the clipping warnings on, I increased the Exposure to +1.75., the result being Figure 3.

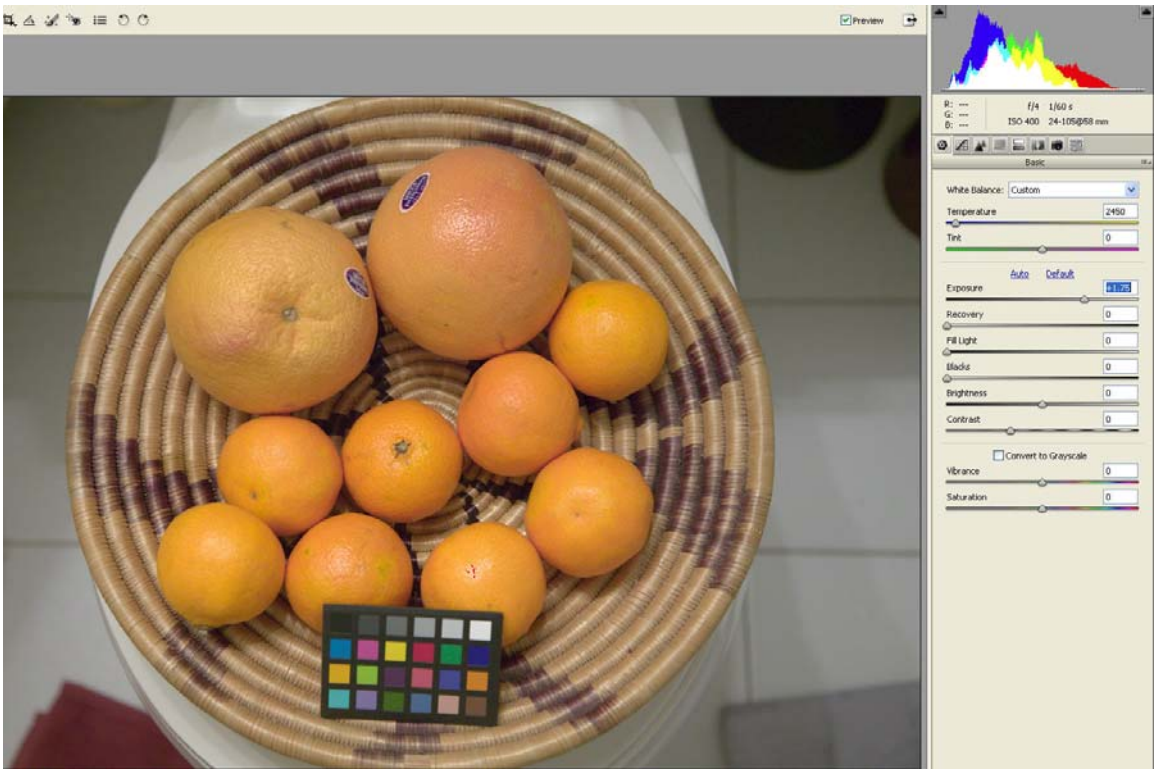


Figure 3: After WB and Exposure Correction

Notice there is just a faint trace of specular highlight clipping in the right-hand orange just behind the Color-Checker. That's fine. Not only because this basket of citrus sits on a toilet seat (sorry, that's where the strong halogen lighting was) it really isn't too appetizing yet because it lacks adequate contrast. So I adjusted the Parametric Curve to create a sufficient "S" for adequate contrast, as shown in Figure 4. The result is an image with more "pop", open shadows, no clipped highlights (except for the unimportant specular highlight), a saturation boost and very good detail retention.

Figure 5 shows this result as a rendered PSD file (brought into JPG format for reproduction here). The red-circled reference points are to be used below for HSB measurements. Figure 5 takes the contrast and brightness of this image as far as my taste (and comparison with the original subject) tells me it should go. Examination of the Parametric Curve in Figure 4 shows that indeed one could make far more radical adjustments. There is no question that excessive contrast increments will increase saturation to the point of blocking image detail we wish to preserve. This is shown in Figures 6, 7 and 8. The point is though, that more often than not one wouldn't want to do this and needn't. Figure 8 is a blow-up comparison at 100% of the impact on detail of the Figure 5 mild "S" curve versus the Figure 7 strong "S" Curve. Figure 8-Left shows that while texture in the grapefruit is well preserved, it suffers in the oranges. But Figure 5 is a better photograph than Figure 7.

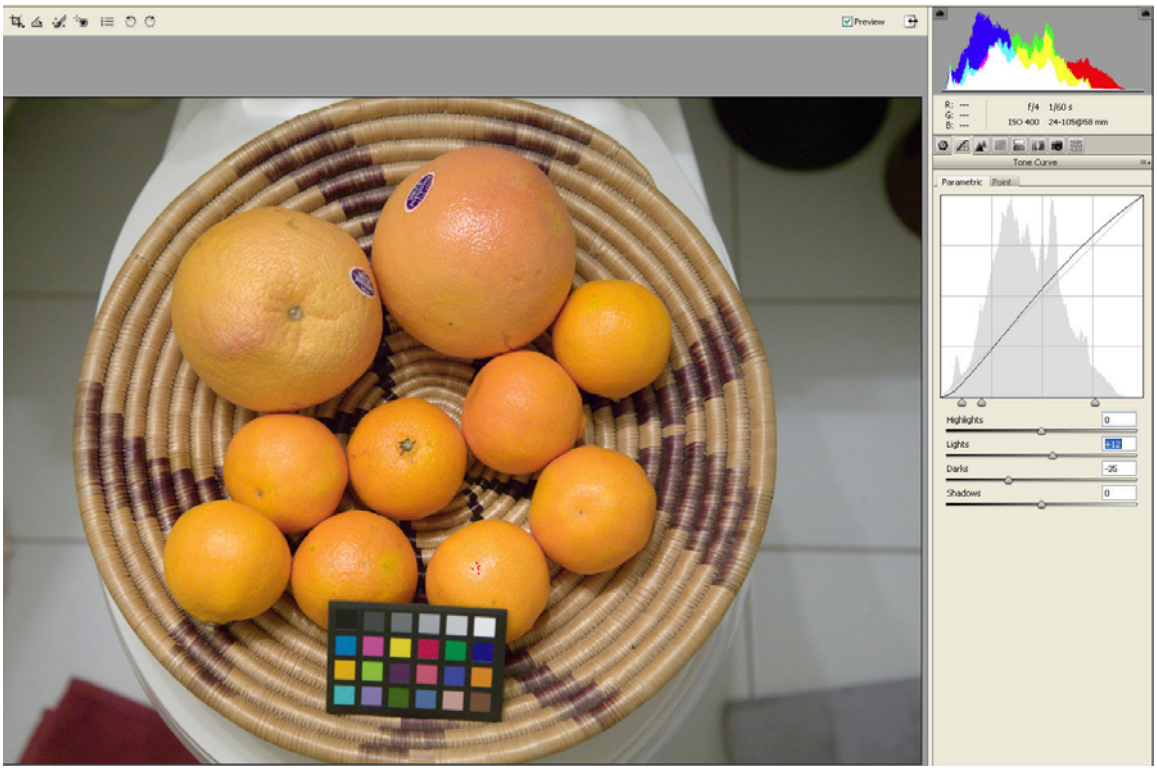


Figure 4. Figure 3 with Contrast Boost

Figure 5. Rendered version of Figure 4

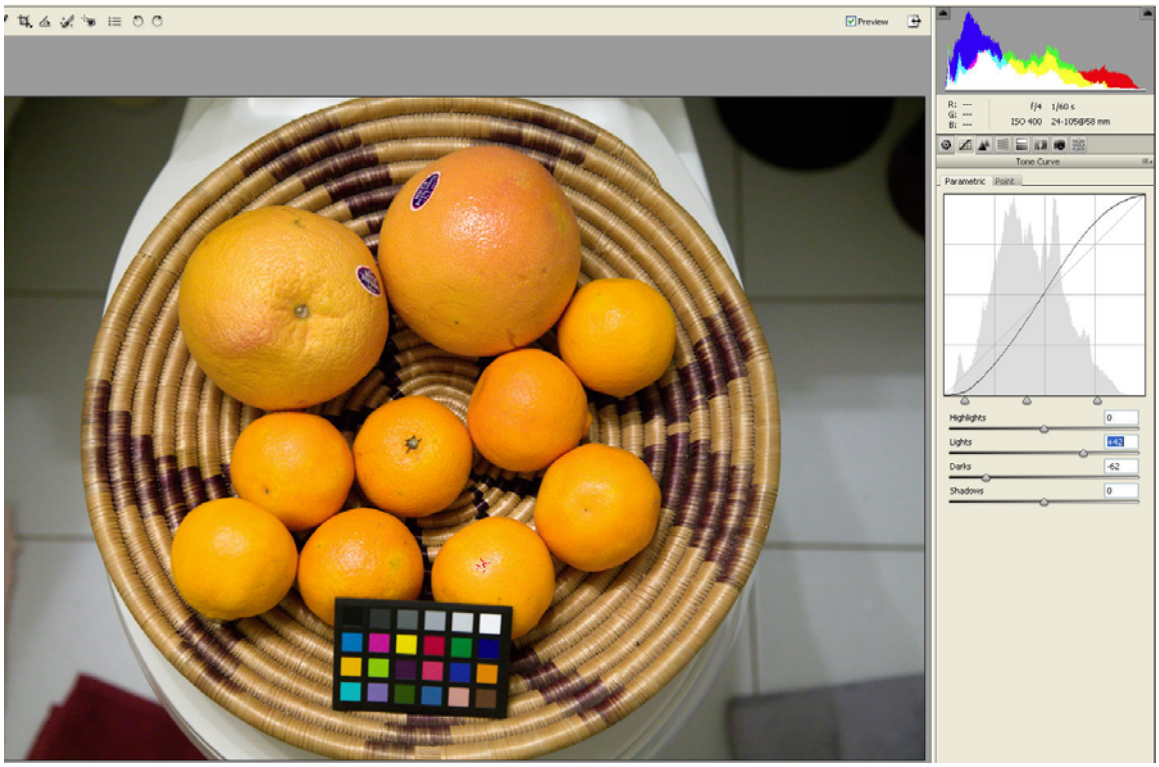


Figure 6. Figure 4 with much deeper CR S Curve

Figure 7. Rendered version of Figure 6

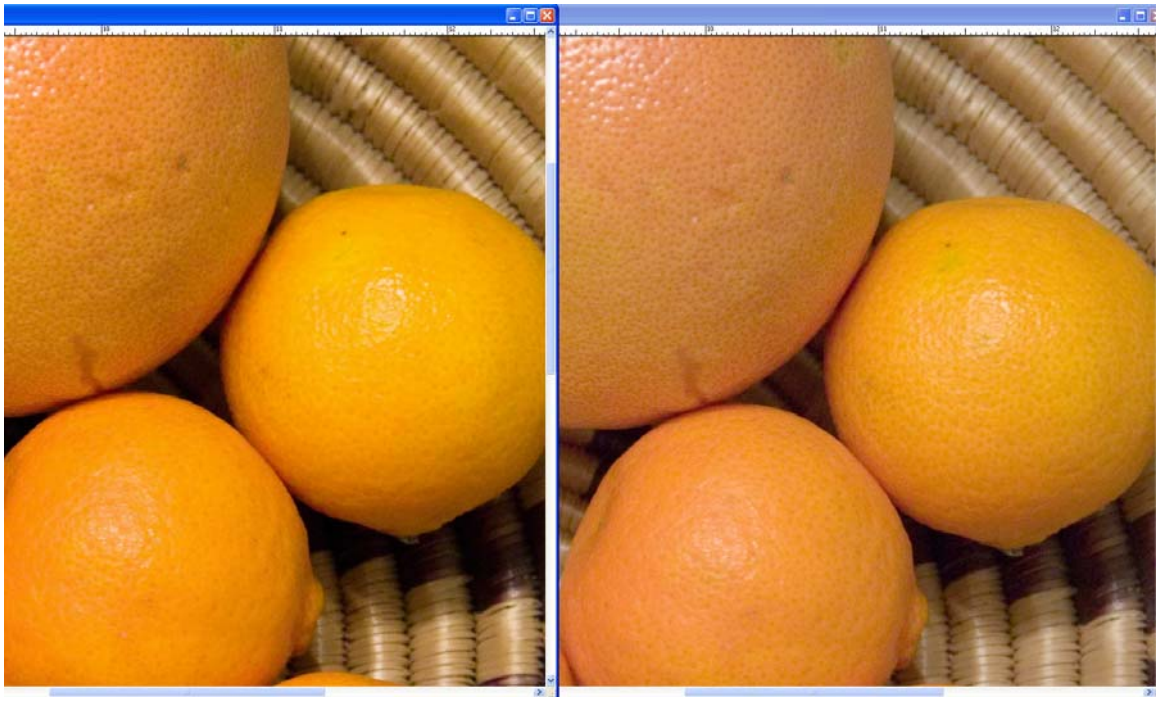


Figure 8. Left: Figure 6 deep “S” Curve; Right: Figure 4 moderate “S” Curve

Figure 8-Left is too saturated, but one may still want the contrast; so can we hold the contrast but reduce the saturation and recover the peel texture in CR 4.x? Two ways of doing this are either to reduce Vibrance (Basic Tab) or reduce saturation of Oranges, Reds or Yellows (HSL Tab). I reduced Vibrance to -20, resulting in Figure 9.

Figure 9. Vibrance -20 on Figure 7

Those who like stronger images may prefer Figure 9 over Figure 5, or perhaps something in-between. At this point, it's a matter of taste. Figure 10 shows that the solution offered in Figure 9 recovers peel texture lost in Figure 8-Left.

Figure 10. Detail from Figure 9

As the discussions have focused on questions of loss and recovery of detail from contrast adjustments in CR, I thought it interesting to dig deeper than Figure 10 above, and examine what happens to detail in individual channels from one image state to the next. While orange and orangey-yellow dominate this image, the most pronounced image detail lives in the blue channel, with image brightness contributed by the red channel (and some by the green channel). I compared red and blue channel behaviour as I moved between various states of the image's contrast and saturation adjustments.

For convenience, I recall the hierarchy of states for these images:

- Figure 2: Initial conditions in CR after White Balance only.
- Figure 3: Figure 2 with CR Exposure correction of 1.75.
- Figure 5: Figure 3 with CR Parametric S contrast boost; Light +12; Dark -35.
- Figure 7: Figure 5 with Parametric S strong contrast boost; Light +42; Dark -62.
- Figure 9: Figure 7 with Vibrance reduced by 20.

Since the main focus of concern here is the impact of curves movements on contrast, saturation and detail, the interesting comparisons are between Figures 3 ~ 5, 5 ~ 7, and 7 ~ 9. In all cases the light and dark grayscale images below are extracts at 100% magnification of the red and blue channels respectively.

Figure 11. Red and Blue Channels from Figure 3 (WB and Exp Adjusted)

Figure 12. Red and Blue Channels from Figure 5 (S Curve on Figure 3 State)

These are best viewed on a monitor with the document view expanded to “page width”, or more, as some of the differences are indeed quite subtle. There are only subtle changes between Figures 11 and 12: red channel detail has become very slightly less and blue channel detail slightly more pronounced, explaining why detail preservation between figures 3 and 5 looks good.

Figure 13. Red and Blue Channels from Figure 7 (Steeper S Curve on Figure 5 State)

Figure 14. Red and Blue Channels from Figure 9 (Vibrance Reduced on Figure 7 State)

Comparing Figure 13 with Figure 12, there is moderate “bleaching” of detail in the red channel and “muddying” of detail in the blue channel, all told contributing to an appearance of reduced image detail in the composite image. However, comparing Figure 14 with figure 13, the reduction of Vibrance reduces the bleaching in the red channel and brightens the detail in the blue channel, contributing to the appearance of restored detail in the composite image. Because all of these changes are sets of meta-data instructions performed on the raw image data before rendering and the original raw file never gets damaged by these instructions, each state of the image is opened in Photoshop “undamaged” (but the viewer may not like some of the renderings’ appearance – a different matter altogether). One may always revert to the raw image and change the instructions – non-destructively. In this sense the raw converter is the true non-destructive image editor to the extent it can perform these editing functions.

It now remains to report some measurements of hue, saturation and brightness through the stages of this editing process, in order to evaluate how CR 4.0 performs in these respects on this image with a pronounced area of strong, bright colour. The images selected for these measurements are the PSD files of Figures 2, 3, 5, 7 and 9.

Figure 15 shows the image at the Figure 2 stage with the measurement points: (1) the grey tile floor, (2) the grapefruit, (3) an orange, and three measurements of the Color-Checker (Yellow, Orange and Blue). Figure 16 shows where four of these points would sit on a linear curve for Figure 5. Figure 17 is the table of measurements.

Figure 15. Measurement Points

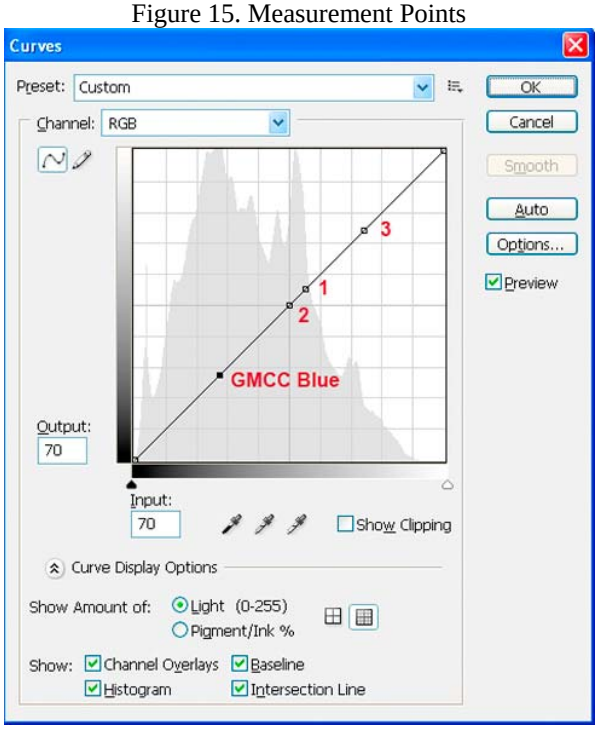


Figure 16: Point Positions on Curve for Figure 5

Figure	Point	H	S	B
2	**1**	91	1	25
	2	29	61	31
	3	32	50	44
	yellow	56	65	34
	orange	35	68	29
	blue	244	45	22
3	**1**	91	1	50
	2	29	60	62
	3	31	50	87
	yellow	56	65	67
	orange	35	69	57
	blue	244	46	44
5	**1**	204	3	56
	2	29	62	67
	3	31	45	90
	yellow	57	66	73
	orange	35	72	63
	blue	244	51	49
7	**1**	205	4	57
	2	31	74	73
	3	32	50	96
	yellow	57	77	80
	orange	37	83	67
	blue	244	64	48
9	**1**	205	3	57
	2	29	65	71
	3	31	43	95
	yellow	57	68	79
	orange	37	76	65
	blue	244	55	46

Figure 17. HSB Measurements

Hue preservation is generally well achieved. However, there is a huge measurement anomaly affecting Point # 1 (the grey tile floor), which switched from 91 degrees in Figures 2 and 3 to 204~205 degrees in Figures 5, 7 and 9. This latter hue value defines a shade of cobalt, but the floor is not cobalt, it doesn't look cobalt in the photographs and the RGB readings indicate it is grey – in Figure 5, for example the RGB values are 139, 141, 142 – just about neutral. So I don't understand why the measurement is incorrect.

More often than not, saturation increases with brightness, but the relationships are not simply correlated, and this does not always happen; very often the saturation changes are modest in comparison to the brightness changes. Care is needed making comparisons. Figures 3 to 5 and 5 to 7 compare curve shifts, while 2 to 3 involve Exposure and 9 - Vibrance. Also there may be issues under the hood with the HSB measurement in Photoshop.

As a final photographic comment on the citrus example, one could largely avoid hue and saturation effects by adjusting this image using a PS-RGBc Curve in Luminosity Mode. Figures 19 and 20 show what the results look like under two sets of rendering conditions:

(a) After WB in CR, Exposure in CR is increased to 1.75, the image is rendered in PS and a PS-RGBc “S” Curve (Figure 18a) is applied in Luminosity mode resulting in Figure 19. (b) Only WB is adjusted in CR, the image is rendered in PS and brightness and contrast are both adjusted using Levels (Figure 18b) for a brightness/contrast boost and the “Figure 18a” PS-RGBc “S” curve for a contrast boost, both in Luminosity Mode, resulting in Figure 20. While Figure 19 has satisfactory contrast and saturation, it is clear comparing contrast and saturation in Figure 19 (or 9 or 5) with that of the under-saturated result in Figure 20 why the Adobe programmers created a default relationship between Contrast and Saturation.

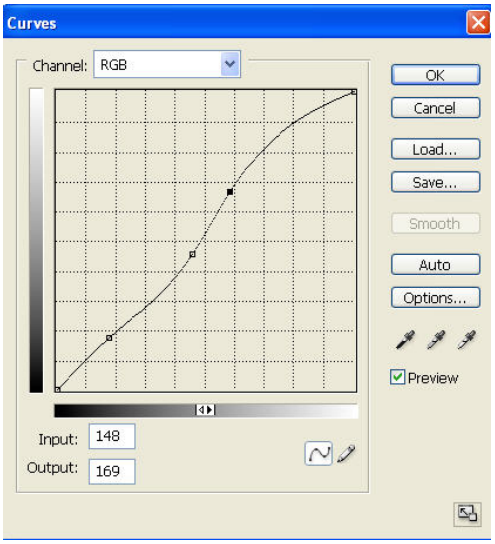


Figure 18a “S” Curve in Luminosity Mode

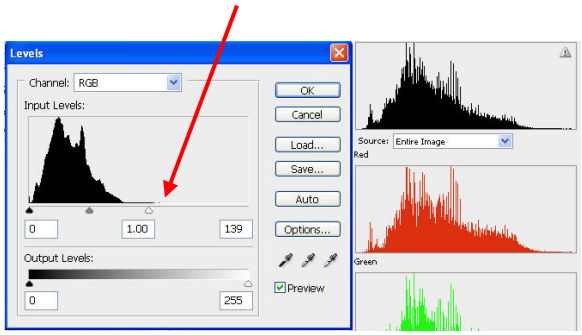


Figure 18b – Levels Shift for Figure 20

Figure 19: WB and Exp in CR + PS-RGBc “S” Curve in Luminosity Mode

Figure 20. WB only in CR; All luminosity edits in Luminosity Mode

To conclude this discussion, because red flowers with detail re-emerge as a compelling issue (ref. Chapter 16 of Dan Margulis "Professional Photoshop 5th Edition and recent related discussion on ACTL), and given what I've said before about possible issues with reds, I shall now touch upon reds. I shall not delve into the extensive kind of analysis I did with the citrus case above; my objective is simply to show whether CR can achieve satisfactory colour, contrast and detail retention for red-dominated images. Unfortunately, at this time I cannot use the same images that Dan used, because the images on the CD-ROM accompanying Dan's book are protected by a Terms of Use Agreement which need interpretation relative to the purpose at hand. No matter, other images serve as well.

Figure 21 is a CR view of a reddish flower with fine line detail in the leaves, taken outdoors in normal mid-afternoon daylight with a Canon 1Ds, 1/250th at f/6.3. In Figure 22 I imposed a CR Parametric "S" Curve strong enough to increase saturation to the point of suppressing some of the fine detail. In Figure 23 I recovered the detail by de-saturating the Reds 12 points in the CR HSL Folder, Saturation Tab.

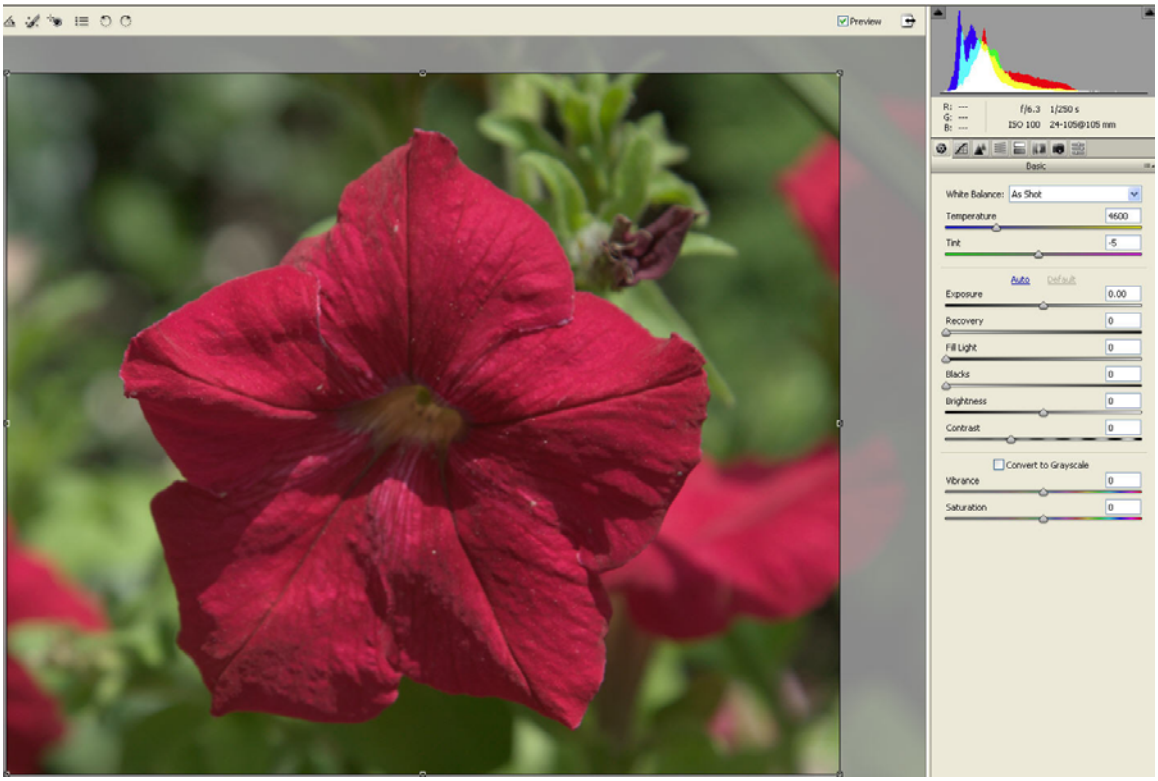


Figure 21. Red Flower 5158 Initial Conditions

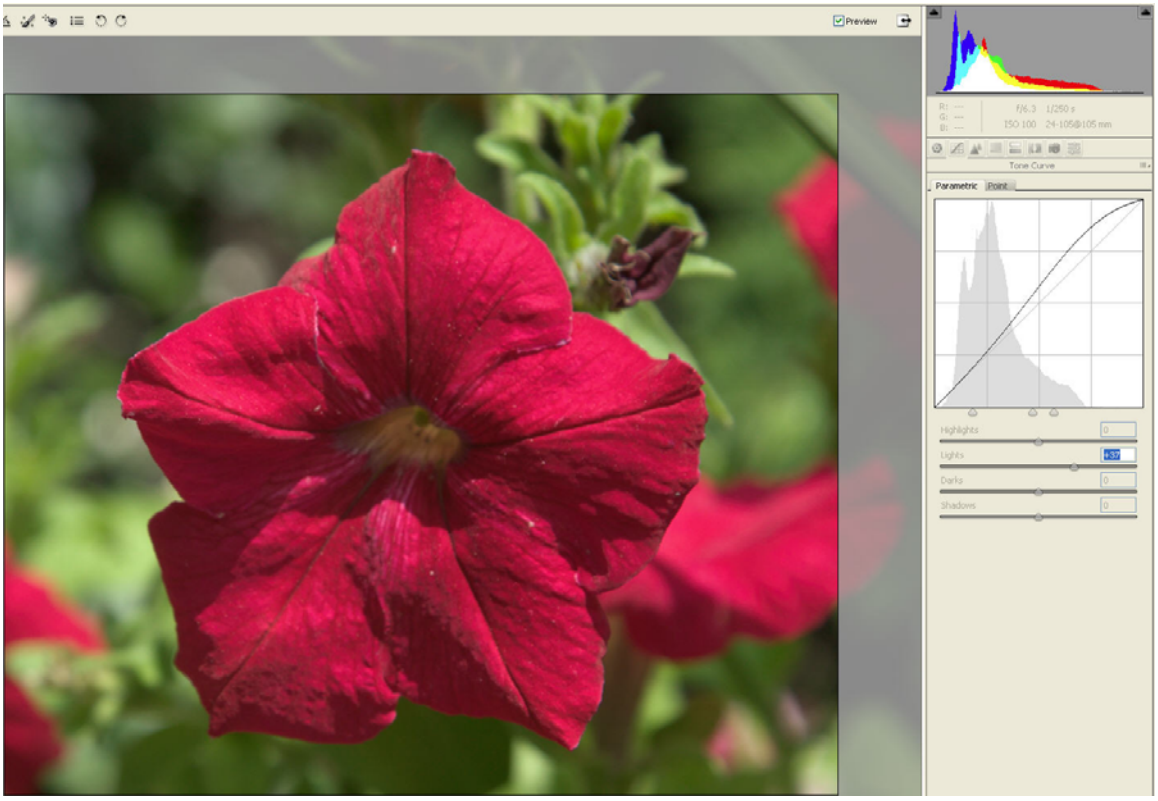


Figure 22. Red Flower with Apparent Suppression of Fine Detail from “S” Curve Contrast Boost

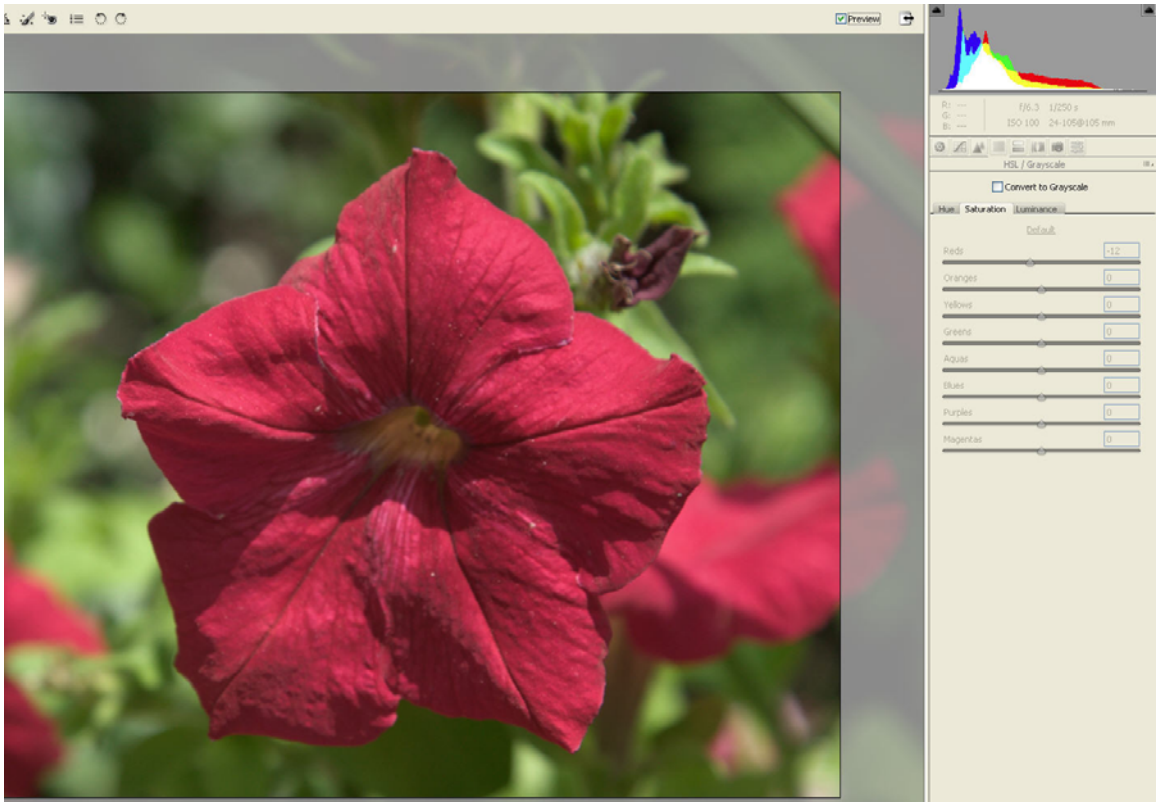


Figure 23. Red Flower with Fine Detail Recovered in CR

Figure 23 is brighter with more contrast than is Figure 21, while image detail is retained.

Andre Dumas kindly loaned me another red flower image which I thought useful in this context. It demonstrates that CR4 can process strong red tones retaining detail while allowing a range of saturation settings to taste. Figure 24 shows the initial conditions of this raw image brought into CR4 with all luminosity settings at zero and the tone curves linear. Figure 25 shows the effect of increasing Exposure by 0.75 and introducing a parametric “S” curve to slightly boost contrast and strengthen the colours. Figure 26 is a comparison of how three Vibrance settings (0, -15 and + 15) affect fine detail. In evaluating this comparison, it is useful to bear in mind that this is an enlargement of a small section of the image, it has not been sharpened, not treated for noise, and is a pre-rendered capture of the raw image section converted to JPEG for pasting into this document. All this considered, these captures indicate that the detail which would be visible in a sharpened and noise-reduced A3 print of the whole image would be largely retained with all three Vibrance settings.

My overall impression is that CR4 handles delicate details in bright reds well, while providing high image quality in terms of brightness, contrast and colour rendition. Furthermore, working intelligently with this module, one retains sufficient “headroom” to perform additional satisfactory edits in Photoshop, for example as I find always necessary once in Softproof mode. (Highest on my “wish-list” for CR is the ability to make all these luminosity and colour adjustments using my printer profile as a softproof.)

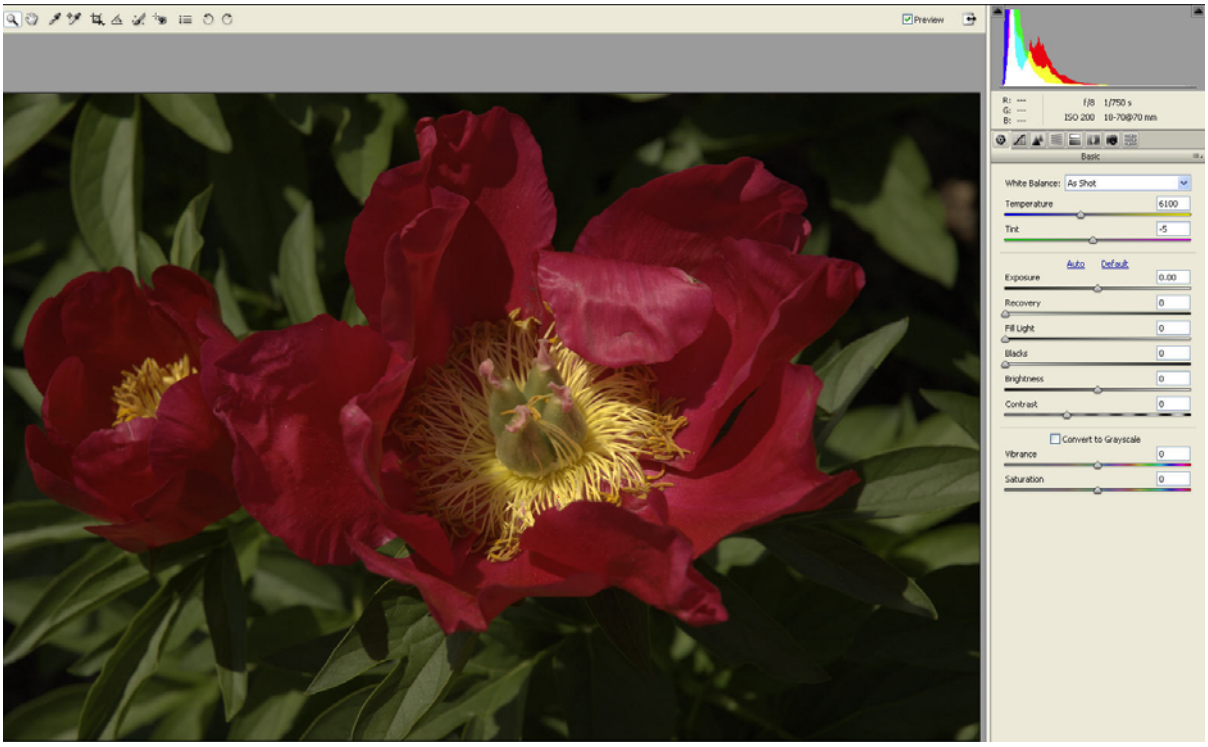


Figure 24 A.D. 2007-06-10.NEF Initial Conditions

Figure 25. A.D.2007-06-10.NEF Exposure +0.75 and Parametric S Curve

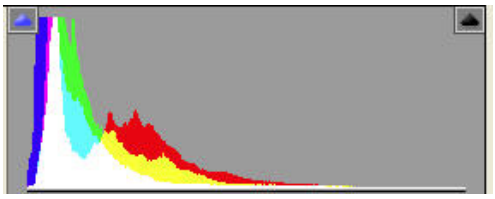


Figure 26. AD1 Detail; Vibrance -15

Vibrance 0

Vibrance +15

Conclusions

Near the beginning of this essay, I said that the object of the exercise is to see whether in CR, for images with areas of pronounced bright colour, we can neutralize a single cast and produce satisfactory contrast without blown highlights, plugged shadows, excessive saturation and sacrificed detail.

I conclude from the foregoing that we can do so – in a highly satisfactory manner. The set of tools in CR 4.0/4.1 is varied and powerful enough to achieve this. Generally speaking, these tools do not duplicate each other –some may seem to do similarly labeled things, but they do so in different ways to different effect. Combining the use of these tools in a logical manner creates many possible sets of adjustments which help achieve the objectives for the image at hand, be it for dynamic range, local contrast, brightness, hue and saturation, without sacrificing necessary image detail.

That said, it is possible to create unsatisfactory renditions (say in terms of saturation and loss of detail) by pushing adjustments in CR beyond what is reasonable or appropriate for the image. Most important, however, within CR all of these changes are sets of meta-data instructions performed on the raw image data before rendering and the original raw file never gets damaged by these instructions. Each state of the image is opened in Photoshop "undamaged" (but the viewer may not like some of the renderings' appearance – a different matter altogether). One may always revert to the raw image and change the

instructions – non-destructively. In this sense the raw converter is the true non-destructive image editor to the extent it can perform these editing functions.

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