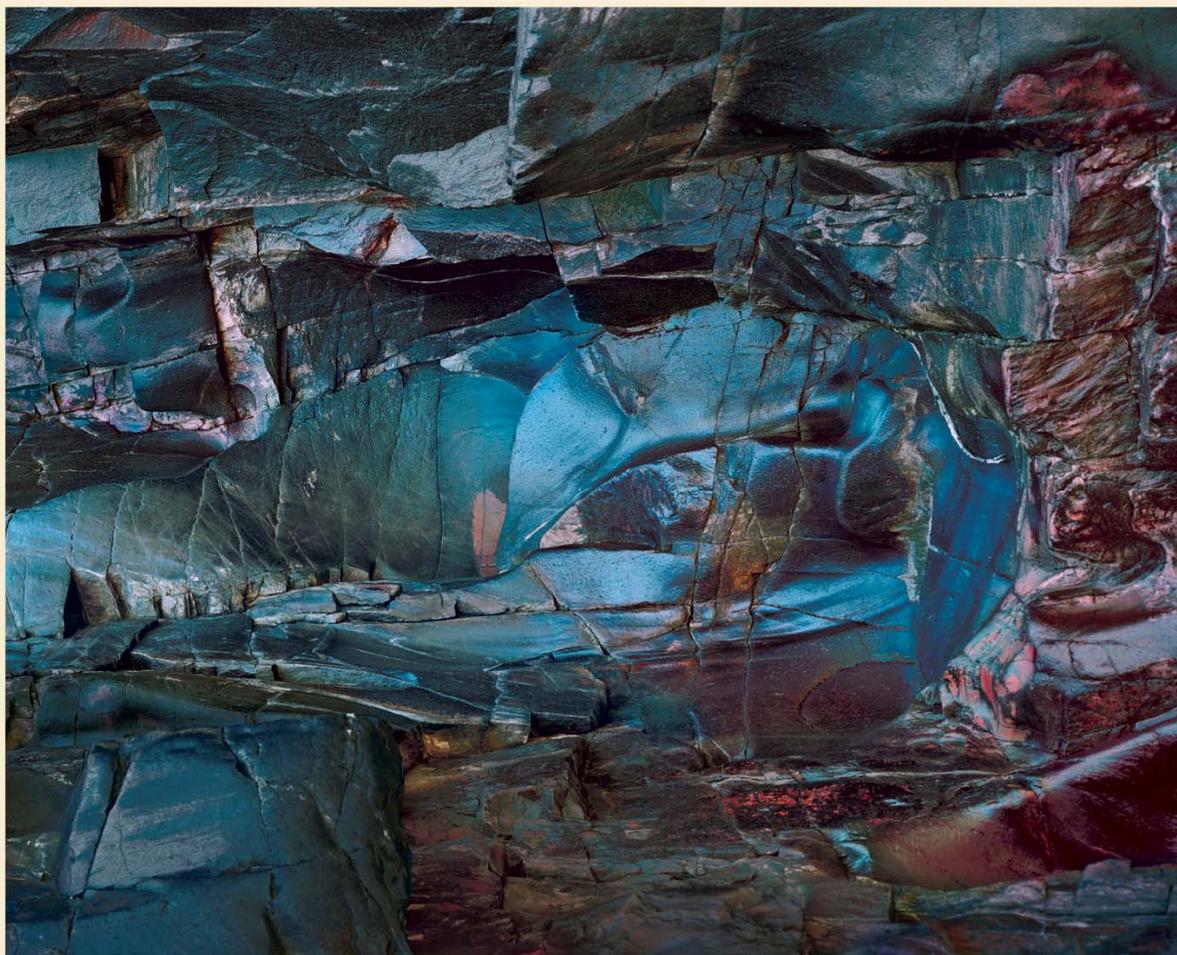


## Making Digital Prints from Large-format Color Negatives and Slides

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Photographers who print from large-format color negatives or slides can greatly improve the flexibility of the process, and the quality of large-format prints, by a hybrid technique that combines conventional silver halide films with digital scanning and editing. The workflow for producing my “*Vishnu*” print is described in detail below.



Vishnu 2007

## BASIC DIGITAL CONCEPTS

### Color film data capacity

Conventional color films record an enormous amount of information. Kodak estimates that a 35 mm color negative image contains 50 megabytes of information when scanned, which is four times the data recorded by a good digital camera sensor the same size. Based on this estimate, a 4x5 color negative contains more than 600 megabytes of information, depending on the quality of the scan. An important distinction must be drawn between the ultimate resolution of a scan, and the resolution that is required to exhaust the useful information contained in a film medium. Most of the information in a 600 MEG scan from a color 4x5 negative is potentially “useful” in producing a print.

The same 4x5 negative could be scanned to provide over 3.5 gigabytes of information, and still more retrievable information is recorded in a good color negative. This gigantic scan would not provide significantly more useful information than a 600 MEG scan, for the same reason that a 72x90 inch color print made from the same 4x5 negative would not provide a better image than a 20x24 print. The additional information from the scan would resemble a photomicrograph of the grain and dye cloud cluster structure of the original, faithfully reproduced in the print.

Three initial conclusions can be drawn from these assumptions:

- A good 600 MEG scan exhausts the useful information in a 4x5 color negative or slide.
- This is far more information that is required to print an excellent 16x20 image from a 4x5 color slide or negative.
- The amount of *useful* data in the best print cannot approach the amount of *useful* data in a slide or negative original.

### Color paper data capacity

In order to print a fine digital color 16x20 print, the amount of data provided by a digital scan must be sufficient to reproduce an image that is indistinguishable from a superb conventional print made from the same negative or slide.

The minimum size of the digital file used to print the image can be estimated from the size of the print, based on a scan that will provide 300 dots per inch resolution in the print. For a 16x20 print, the minimum resolution in the scanned image should be at least (16x300 d.p.i x 20x300 d.p.i.), or 28.8 megabytes, for each of the three red, green and blue channels, *i.e.*, about 86 megabytes of useful information at 8-bit “depth.” Depending on the inkjet printer, the optimum number of dots per inch in the scanned file may differ. Generally, the final print is made by converting the number of dots per inch in the digital file to a much larger number of actual dots, *e.g.*, 1440 or 2880 actual dots per inch that are printed from a 300 d.p.i. file. If the

optimum printing resolution is 360 d.p.i. (with an Epson printer), the minimum size of the file used to print the image is (16x360 x 20x360) or 33 MEG for each color channel, *i.e.*, about 100 MEG.

Significantly greater resolution, that may reproduce detail such as grain edges or dye cloud clusters, will not be useful, whether the print is made on conventional silver halide color paper, on direct-positive color paper, or by an inkjet process. No more useful information can be recorded in the best 16x20 color print from a file of any size, including an analog negative containing theoretically unlimited data, that could be resolved in a 10G scan.

Based on the maximum useful information that can be conveyed in a 16x20 print made using any medium, the following conclusion can also be drawn:

- A 350 MEG scan of a 4x5 color film image provides about 4 times the information necessary for the best 16x20 print that can be made from the original film image.

This additional information can be used to make a better print, by selecting, adjusting and fitting the information from the film image to the more limited range of the final print, in ways that are not possible when printing directly from the negative or transparency. In printing to a conventional silver halide medium, most if not all of the surplus useful information is simply discarded in the printing process.

### **Matching film data and paper data**

Using any print medium, whether it is black-and-white silver halide paper, color reversal or direct-positive paper, or glossy paper and halftone printing, the essential requirement is to accurately match the density range recorded in the original film to the generally much narrower density range that the print medium can accurately reproduce. Using conventional color films for landscape photography, this is generally a matter of chance and approximation.

Master landscape photographers succeed in recording a density range that either is fully reproduced on color slide film, or that can be manipulated to fit the latitude of color or black and white paper. Making a slide or negative that conveys the luminosity of a landscape generally requires photographing under specific light conditions, to capture the necessary 100 megabytes of useful information, in a range that can be used to make the final print. John Sexton's "quiet" light using Kodak tabular grain negative film and Gary Ladd's luminous slides of Lake Powell using Fuji slide films are wonderful examples.

Black-and-white wet chemistry provides flexibility in manipulating the image, by varying filtration, exposure and development of the negative according to zone system, and in printing by burning, dodging, rubbing, using variable-contrast papers, and bleaching, intensifying or toning the final image.

Color chemistry is much more restricted, because it is generally not possible to vary development significantly without degrading color balance in a negative or transparency. This problem is acute with transparencies, which record only a restricted luminance range

without blocking shadows or blowing out highlights, leaving no useful image detail for printing. Direct-positive print media, which are not able to reproduce the full density range of a transparency, may require techniques such as masking to produce a fine print.

Color negatives are more forgiving than transparencies. Although it is not possible to alter the density range of a color negative by varying development time (using zone system techniques), a color negative has an inherent advantage because it has significantly greater latitude. In contrast to a color transparency, which may not record a 10-zone luminance range, color negatives will record a 12- or 13-zone useful luminance range. This is an advantage in landscape photography, because of the additional image information that is available for producing a print, and to accommodate fluctuations such as metering the wrong spot, photographing in bright light, or in canyons with the inevitable burning bright spot marring subdued, glowing walls.

Many of my best images were made under difficult conditions—the negatives are flat, the colors are muted, there is an overall color cast, and subtle variations in light are so compressed as to be unreproducible using conventional printing techniques. This scan of the *Vishnu* negative from the Grand Canyon demonstrates each of these flaws, and also includes an unprintable, distracting hole burned into the large rock in the foreground:



The negative was made in deep shadow, with blue light reflected from the schist in a very narrow luminance range; the close shades of blue are compressed even on the negative; the bright rocks at the bottom of the negative are uninteresting and distracting; and the red rock at the right is dulled by the blue incident light.

Only by scanning this negative and using the information to adjust both color and density was it possible to produce a print that conveys the subtle, glowing light of this unearthly scene.

## WORKFLOW

The workflow for producing a conventional color print generally involves: (1) developing the negative or transparency, (2) directly printing the film image on a color reversal or direct positive paper and (3) adjusting the density range of the original, if necessary, by masking

techniques using a “human curve” or more likely, a digitally produced mask. Little, if any, adjustment of the cyan, magenta, and yellow layers in the original is possible, and no individual adjustment of any color can be made, without also affecting the balance of the other colors. I printed 4x5 color negatives for 20 years using wet chemistry, before turning to digital printing techniques.

My workflow for producing the *Vishnu* schist print is briefly described as follows. This negative is a medium-format (60 x 70) image made using Fuji NPS 160 film (or its current incarnation). Fuji NPS is the only color film that I use.

I develop 4x5 negative film using Kodak Flexicolor chemistry, with a development time of 8.5 minutes at 30° C, controlling the development temperature to  $\pm 0.1^\circ$  C, with continuous agitation using a Jobo 10-sheet film drum. The longer development time provides a greater margin of error for filling and emptying times, temperature fluctuations, lapses of attention, and the like, and also produces a flawless image, compared with a shorter development time that led to occasional streaking.

For scanning, I use an Imacon Precision II scanner, and Flexcolor 4.0.3 software, which is the last version that supports the SCSI platform. This scanner has a maximum resolution of 1800 samples per inch for 4x5 negatives, 3200 s.p.i for 6x7 negatives, and 5750 s.p.i for 35 mm negatives. It produces RAW (3f) scans of 4x5 negatives with a file size of about 450 MEG.

For editing the scanned image, I use Photoshop CS on a Windows 2000 professional PC platform, and save the RAW scans and images on a 1-terabyte mirrored RAID drive. I scan and print using a separate dedicated PC, because these operations can take 30 or 45 minutes. For printing, I use an Epson 7600 ultrachrome (six-ink) printer, and a custom ICM profile for Epson’s double-weight glossy fiber-based paper on this printer.

## SCANNING

(1) Decide whether to use any automated adjustments available using the scanning software, and if necessary create a profile that will determine, *e.g.*, whether the scanner performs initial sharpening, whether the scanner increases saturation of colors, the color space that is used by the scanner, the bit depth of the scan, the default gamma of the scan, etc. I do not use automatic adjustments, preferring to make manual adjustments as described below.

(2) Scan the image at 3200 samples per inch and at 16-bit depth, to produce a 400 MEG file. If the negative is a larger 4x5, the scan can be made at a lower resolution of 1800 s.p.i., to produce a 350 MEG 16-bit file that provides all of the necessary “useful” information without pointlessly increasing the file size. (A service bureau can do this and deliver the negative file in a RAW format that can be used with Photoshop to make the adjustments described below.)

I save the scan as a RAW file in Imacon’s 3f format, because this enables me to generate any number of images later that can be imported into Photoshop as TIFF files without rescanning

the negative. (The scan could also have been saved as a “digital negative” scan in Photoshop’s .DNG RAW format).

Although a 16-bit scan produces a larger file than an 8-bit scan, this information is essential for later work on the scanned image. It provides additional information that can be discarded to get the best 100 MEG print. “Bit depth” refers to the divisions of density variation in the scanned image file. An 8-bit scan renders each color channel as a “step-wedge” containing 255 steps. In theory, a 16-bit scan renders each color channel as a much more detailed step-wedge containing 65,000 steps. In practice, few scanners reproduce a full 16 bits, and most of this information is useless in producing an 8-bit print, except for the flexibility provided in adjusting the scanned image. A 10- or 12-bit should provide more than enough information for most color work. A 12- or 14-bit scan may be preferable for black-and-white work, to avoid “banding” of fine gradients in the image, when the image is later adjusted.

(3) Open the 3f file in the scanner’s RAW editing mode (or Photoshop’s RAW editing mode), and make initial rough edits to the scanned image, in the following sequence:

(4) Crop to the borders of the full-frame raw scan to eliminate blank areas, and clearly unwanted areas of the original. An initial smaller crop to an important image area containing significant highlights and shadows will provide RGB histograms that are useful in determining the appropriate endpoints in the next step. Pure black and pure white edges included in the histograms will complicate the required adjustment.

(5) Adjust each of the RGB color channels so that the digital file contains all useful RGB image information, using the individual RGB histograms to select the endpoints of each of the RGB channels. By manually adjusting the endpoints of the histograms, all of the useful information in the original scan can be retained, without clipping the image to lose shadow and highlight detail. DO NOT use the “Auto” function of the scanner software, and DO NOT select endpoints based on the image generated by the scanner software—this may lose information that is essential for later work on the image. This step should be performed using only RGB histograms (or the software density “picker”), making sure that the dynamic range of the scan exceeds the density ranges of the original image, *i.e.*, by setting the endpoints of the scan slightly outside the endpoints of the histograms.

This is the critical step in the entire production process. The final print can never contain more information than is recorded in the scan, and all shadow and highlight detail must be included in the original scanned image. The key reason that a good scan is vastly superior to the original film medium for printing is that a good scanner at high bit-depth is able to capture and discriminate subtle image density information, in the thinnest areas of the original (shadow areas of negatives, highlight areas of slides) that are nearly invisible, and that cannot possibly be reproduced using conventional silver print media. You have to see this to believe it—it is amazing.

This is a reason for making a high bit-depth scan, because the information in the thinnest areas of a slide or negative, that may be critical to making a fine print, is recorded and differentiated in the scanned file. The very subtle variations in these areas are recorded as

distinct density “steps” that can be used in producing beautiful, luminous, detailed highlight and shadow areas in the 8-bit final image.

(6) Adjust the color balance of the image to eliminate gross color casts, ideally by selecting a neutral area and using it to adjust each of the RGB channels automatically, so that the selected area appears as a neutral grey. This generally provides an RGB image that roughly approximates the desired color balance. The benefit of roughly balancing the color channels at this stage is that the redistribution of densities in the color channels of the initial scanned file is made using the 16-bit scanned image, and the scanner output will contain more useful information for each color channel. This provides more useful color information for later adjustment.

(7) Make a rough density correction, if needed, using curves or by adjusting gamma, to place quartertones, halftones, and three-quarter tones in the scan that will approximate these tones in the final print. It is best to undercorrect, if at all. Once again, DO NOT alter the shadow or highlight values, and DO NOT adjust the quartertones and halftones to crush the shadow and highlight details in the eighth-tones and the seven-eighth-tones. It is not helpful to try to match the tonality of the final print at the scan stage—the best scan will be a slightly flat image in the mid-tones, with good separation of the highest and lowest tones.

(8) After all density and color corrections, check to make sure that the darkest areas of the image retain useful shadow and highlight detail, using the color picker or shadow detail features. This is also a critical step, and the term “useful detail” is important. Although the scanned image may contain discernible shadow detail (*e.g.*, lowest density values of 2-5 on a 255 scale) and highlight detail (*e.g.*, highest density values of 250-255), this does not necessarily mean that the shadows and highlights will be “useful” in the final print. Printers are not generally able to carry and distinguish all of the deep shadow and bright highlight detail that is present in the scan. For this reason, the color print made from this file may have an effective color density range of only 245 gradations. It is helpful at the scan stage to make sure that the darkest and lightest areas of the image are within the endpoints of the print density range, and that these values are as well-separated as possible.

(9) Output the adjusted RAW scan to a format that can be used in Photoshop, such as a TIFF file, at the same resolution used to make the original scan (3200 s.p.i), as a 16-bit file. In outputting the file, convert the ICM profile used by the scanner to the color space used in Photoshop, which in my case is ADOBE RGB 1998.

With practice, these scan adjustment steps may take 5 or 10 minutes, and the actual scanning may take 20 minutes (depending on the image size and resolution selected).

## **EDITING THE SCANNED IMAGE**

The RGB image that is initially opened in Photoshop should approximate the image displayed by the scanner software, assuming that the conversion from the scanner profile to the working space is correct, and that the monitor is calibrated. If your monitor is not correctly

calibrated, you can give up the idea of making a fine print, and proceed to print the final image without the annoyance of further editing, adjusting the color and density by trial and error using proof prints, as necessary (go to step 17).

The imported image should be slightly flat, with clearly visible highlight and shadow detail, and somewhat muted colors. If the deepest shadows approach an inky black, or the brightest highlights approach a chalky white, re-curve and re-import the RAW file to provide more usable information. The *Vishnu* image reproduced above is a good scan of the original negative, illustrating these qualities, obtained by following the scanning protocol described above.

The present brief sketch is not a tutorial in Photoshop techniques, and assumes familiarity with the editing tools described. There are excellent books on advanced Photoshop editing techniques\* and color balancing images in RGB and LAB colorspaces.\*\*

I use few editing tools in Photoshop except for selection tools, layers, channels, masks and curves, and the desaturation tool, always applying the curves in adjustment layers. It is not uncommon to use 10 or 15 adjustment layers, in the course of editing and balancing a print, always by modifying individual adjustment layers. This involves working with gigantic files (e.g., 2-4 GIG files for 16-bit scans), which can proceed at a snail's pace. More or less repair of the landscape may be necessary using cloning tools and blend modes.

These tools provide enormous flexibility in adjusting the original image. Typically, editing the original image to produce a final print takes 8-15 hours, in which I repeatedly alter the individual adjustment layers, to obtain the desired color and tonality.

I use the following workflow to edit the imported scan in Photoshop.

- (1) Copy the image layer to provide a working layer on top of the original background layer, in case serious backtracking later becomes necessary to repair or replace a damaged or lost area.
- (2) Curve the overall image to more closely approximate the desired quarter-, half- and three-quarter tones. In *Vishnu*, I increased contrast between the half- and quarter tones, while preserving shadow detail, without losing detail in the hot spot. Save the image (STI) as a working copy of the original TIFF file (e.g., "Vishnu working 3200.TIF"). If there is a pronounced color cast, adjust the RGB curves to eliminate it before proceeding. (STI). At this point, the image has the overall tonal distribution of the final print, from detail in the darkest shadows to subdued highlights. The shadows and halftones are still drab, although they preserve all of the useful 16-bit detail from the scan.

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\* John Paul Caponigro's *Adobe Photoshop Master Class* provides an excellent discussion of useful techniques, and is the best book I have found not only on Photoshop, but on the art of photography in general.

\*\* The irrepressible Dan Margulis has exhaustively described color correction theory and techniques, in separate books for RGB and LAB colorspaces: *Professional Photoshop-The Classic Guide to Color Correction* (in its current incarnation) and *Photoshop Lab Color-The Canyon Conundrum*.

(3) Convert the TIFF image from RGB to LAB color. (STI as a separate working LAB copy.). The brightness range and color tonal range of the scanned image are very narrow, and the image essentially has only a spectrum of blues from near-black to the middle-brightest central turquoise area, with far less tonal and color variation in the dull red detail at the right. By using the LAB colorspace, it is possible to independently adjust the red-green balance (in the A channel) and the blue-yellow balance (in the B channel). Working in LAB, it is also possible to adjust the luminosity values, and thus the overall tonal range and balance of the print, without altering the two color channels. These operations are much more difficult, if they can be done at all, in the original RGB colorspace.

(4) Block out rough selections of important image areas that need to be separately adjusted, and make separate alpha channels for each. In *Vishnu*, I made separate alpha channels for: (1) the horizontal cone-shaped blue area (green), (2) the central circular area, which dominates the image like an eye (four sub-selections for different parts, following the rock contours) (purple), (3) the red granite area at the right (red), (4) the foreground bright rocks (purple), (5) the rock shelf at the top (mustard), (6) the rock shelf above the cone at the left (red), and (7) the distracting left foreground rock with the hideous bright spots (purple).



(5) Make gross repairs to the image. I copied small areas of intact rocks into separate layers, to fill the hideous hole in the foreground and to repair the damage to the top area of the central eye. (STI). Placing these layers under the working layer, I masked the working layer (STI), and blended the repair layers to fill in the necessary color and texture, while preserving the interesting crack structure of the original image. (multiple adjustments to each). (STI). I carefully retouched the mask layers brushing in the edges with a small soft brush, to smooth the edges of the repaired areas. (multiple adjustments, STI after each improvement). I added adjustment layers to each of the two new repair layers, (STI) and curved them to match the tonality of surrounding areas in the patched image. (STI). To reduce inevitable confusion in the following step, I merged the working and repair layers, to provide a single repaired working layer, which also reduced the file size.

(6) Using LAB channels, independently adjust the tonality and color of each selection. (STI after each adjustment). This requires at least one separate LAB adjustment layer curve for each of the selected areas. In *Vishnu*, using these curves, I raised the brightness and increased the contrast of the red rock, intensified the separate colors of the central eye; intensified color and raised both contrast and brightness in the cone; darkened the distracting foreground rock and intensified its color; subdued the bright foreground rocks at the right, and separated their colors; lowered the saturation and darkened the top rock shelf and the hideous spot; and raised the brightness of the interesting snakelike feature at the top of the cone on the left. (STI after each adjustment).

In making these adjustments, I use only curves, rather than less precise adjustment tools like “brightness” or “levels” or “color” or “burn” or “dodge.” As adjustment layer curves, I generally use a normal curve, a multiply curve to intensify areas, and an overlay or screen curve to selectively “bleach” areas. It can be helpful initially to “over-adjust” the image areas, and then to reduce the effect of the curves using the adjustment layer opacity sliders, which permits infinite variation of the effects, without altering a curve that generally provides the desired correction.

(7) After these operations, some of the areas will have adjustment curves that increase the tonal values of the selection; some will have adjustment curves that lower the tones; some will have layers that change the color of the selected area, or that separate and intensify specific colors; some will have layers that desaturate colors; some will have layers that increase contrast; some will have layers that reduce contrast. The working image is complex, consisting of the repaired original layer and multiple, separate or overlapping adjustment layers.

These additional channels vastly increase the size of the 16-bit working file, in the case of *Vishnu*, to about 3.5 GIG, slowing the process considerably. I generally try to make individual adjustments to the selected areas using curves in separate adjustment layers, before converting the image to an 8-bit file. This preserves the maximum tonal range for each separate area.

At this stage, most of the gross and fine adjustments are substantially complete, and in each selected area, the full range of data from the original 16-bit scan has been effectively stretched, curved, compressed, separated, intensified, desaturated or otherwise altered. Each of these modifications inevitably reduces the amount of information present in the original 16-bit file from the scan. The goal is to retain as much fine detail and tonal distinction as possible in the final 8-bit image for printing. The rest can now be discarded by converting the edited image to an 8-bit image.

(8) Convert the image to an 8-bit LAB file, and save it as a Photoshop PDF file. By keeping the image as a TIFF file until this step, it is possible to work on a 16-bit image in a file that is larger than the 2 GIG maximum file size in Photoshop.

(9) The image still has all of the individual adjustment layers, that can be further altered to produce subtle variations in the final print, which is now luminous, balanced, glowing, and harmonious, conveying the mystery of the original fractured dark blue schist, meeting the sinuous flow of red Zoroaster granite.

(10) Survey the image, to see whether additional local tonal adjustments will enhance the image. Will the image be improved by bleaching or intensifying details, such as the fracture lines in the rock, or the red spots or streaks in the blue and green rocks? Can small shadow areas or details be darkened to increase local contrast? Should some of the contours be emphasized by slightly increasing only the highlight values, leaving the rest unchanged (“bleached”). Can less important, or distracting areas, like the rock shelf at the top or the foreground boulder, be de-emphasized by burning or selective color desaturation?

(11) Make any desired local corrections, using the saved adjustment layer masks. For example, in order to retouch the image by emphasizing the crack structure of the rocks, open the adjustment layer mask channel for a selection that has been intensified and darkened using a multiply curve. The corrected area will appear just as in the selection, but the unaffected area will be covered with a red mask, indicating the area in which the darkening adjustment curve has not been applied. The smallest detail in the masked area can now be darkened, using the brush tool to selectively remove the mask, or to selectively reduce the density of the mask. (STI after each alteration). The “unmasked” detail will now be darkened by the existing adjustment layer. This technique of painting on the original adjustment layer masks provides limitless subtle adjustment and enhancement of any fine (or large) detail in the image. It is an incredibly powerful tool for producing a fine print.

(12) Spot the image. Make a copy of the working layer and rename it “spot.” (STI). Increase the image size on-screen to view “actual pixels,” and scroll through the entire image, reviewing each of the 200 megapixels that remain in the 8-bit image. Clone detail into dust spots, specks on the rocks, plants, gravel, cracks or anything else that detracts from the image, on this new layer. Repair small imperfections in the important image areas. (STI after each few corrections).

(13) Make a proof print. Save the image as a new .PSD file, *e.g.*, “Vishnu proof.PSD,” and close your original image without saving it. (Saving the small version as a separate, clearly named file will prevent you from overwriting your original file with the proof version, thereby losing 10-15 hours of work.) Convert the proof image from LAB to RGB mode, flatten the image to remove the separate layers, and reduce the image size to a convenient but sufficiently detailed proof, *e.g.*, an 8x10. Print the proof, and review all of the adjusted areas, to evaluate the tonality of the proof print.

(14) Make any additional adjustments in the original LAB file, using the existing adjustment layers. If the proof print carries all of the shadow detail in the final image file, it is possible to add an “overall” curve lowering the darkest image areas closer to the absolute black limit of the printer. Print another 8-bit proof.

(15) The corrected 200 MEG final image is large enough to print an excellent 20x24 inch print. Rename it (*e.g.* "Vishnu final LAB.PSD") and save it at full size, with all of the adjustment layers. Backup this file.

(16) To make the final 16x20 print, save the image as a separate file, *e.g.*, "Vishnu final RGB.PDF." Close the original LAB image without saving it. Flatten the print file to remove the adjustment layers, and convert it from LAB to RGB mode. Reduce the image size to 16x20, but be sure that the number of dots per inch in this file matches the native resolution of the printer that will be used. Although a 300 d.p.i. print should provide excellent quality, the native resolution of Epson printers is multiples of 90, so I save the image as a 16x20 image at 360 d.p.i. I then print the 360 d.p.i. image at the printer's 1440 d.p.i. setting.

(17) Print the image on a calibrated printer, using a custom ICM profile for the specific ink and paper that you will use. If you do not use a custom ICM printer profile, you have wasted your time so far in making this image.

(18) Ha ha! that's a joke. Epson has beautiful printer profiles for its wide-format printers, for each combination of its papers and inks, that can be downloaded from the support website. The quality of the print can be further enhanced by using a custom printer profile made using a specific printer, paper and ink combination.

The final *Vishnu* image reproduced above is reduced to 1000x1216 p.p.i., and crushed from 120 MEG to 430 KB in JPEG-6 format for web reproduction, then inserted into a Word document and converted to a PDF, with further loss of detail.