Application of Digital Image Enhancement in Rock Art Recording

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Faded pictographs and almost invisible petroglyphs were photographed, digitized, and then enhanced using Adobe Photoshop.™ Use of alternate color spaces, CMYK (cyan, magenta, yellow, black), and Lab (Lightness, and two orthogonal color channels) may permit discrimination of subtle color differences. Each color channel is examined and enhanced separately (sometimes inverted). One or more channels are selected as gray-scale images, or are recombined into enhanced or false-color images. Some enhancements require multiple layers with various blending modes such as soft light or overlay. Depending on color and variability of the rock image as compared with background substrate, results can be astounding. Algorithmically enhanced images should be so identified, and distinguished from any method using interpretive artwork (pen, brush, or selection tools).

Computers have long been useful in rock art site recording and database management. More recently, techniques for stitching overlapping photographs to create panoramas or mosaics of panels or entire sites have been developed for site documentation. This was discussed in detail by Mark and Billo (1999). Current techniques have advanced due to new software packages that add spherical and cubic projections (e.g. REALVIS Stitcher). Digital images can be linked to the site locations with GIS software such as ArcView (Harry et al. 2001:154–156). In order to improve the quality of imagery we have developed digital image enhancement techniques using Photoshop.™ Other researchers have reported on multivariate manipulation of multi-band images using Idris software (Buchner et al. 2000)

The emphasis of this paper will be on describing those digital techniques used to enhance digital or digitized photographs. We rely on the use of Adobe Photoshop, and assume that the reader is generally familiar with this software. Significant information about rock art such as details of elements or pigments can sometimes be obtained from the color information in photographs (Mark and Billo 2001). Photoshop allows for alternate color spaces, CMYK, and Lab in addition to RGB (Red, Green, Blue).

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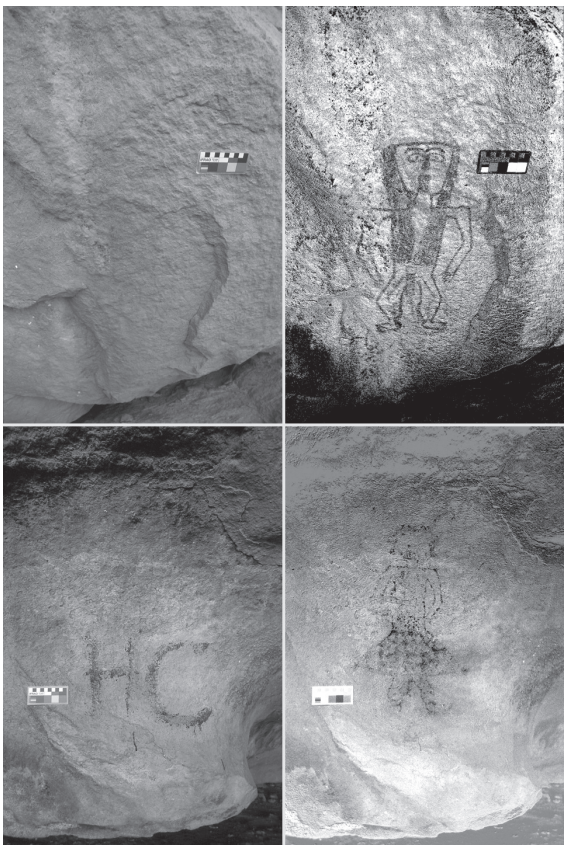

Figure 1. *Two images on the left are as photographed (original in color). Right images are digitally enhanced images: upper right is LAB-red and lower right is CMYK yellow channel. The spray paint initials are in blue and therefore can be separated from the original yellow painted figure.*

Each color channel can be examined and enhanced. One or more channels are selected as grayscale images, or can be recombined into false-color images.

In some cases, elements that were almost invisible in the field can be made visible (Figure 1). In other cases, different pigments can be made to stand out clearly and separately from each other, helping to analyze complex panels (Figure 2). We use grayscale images to illustrate a subset of the Adobe Photoshop techniques useful for image enhancement. Color illustrations are required to show the advantages of enhanced color and false color images.

IMAGES: THE STARTING POINT

We use 35-mm SLR cameras, and various Fuji slide film (ISO 50, 100, and 400) depending on the lighting conditions. In general, it is important to have uniform lighting for pictographs. Noteworthy is the observation that some pictographs are seen better with head-on flash rather than a natural light that illuminates a rough surface from an oblique angle. In one instance, where the pictograph was in deep shadow with only diffuse light from above, the faint painting did not show up in

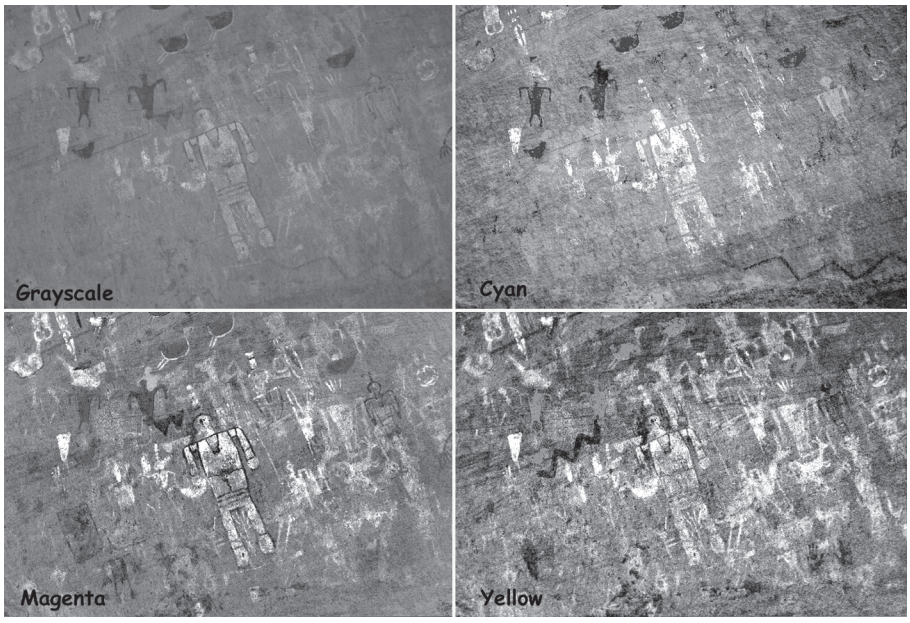

Figure 2. *Grayscale rendition of color image, and three enhanced CMYK color channels. Each channel emphasizes different pigments (and elements).*

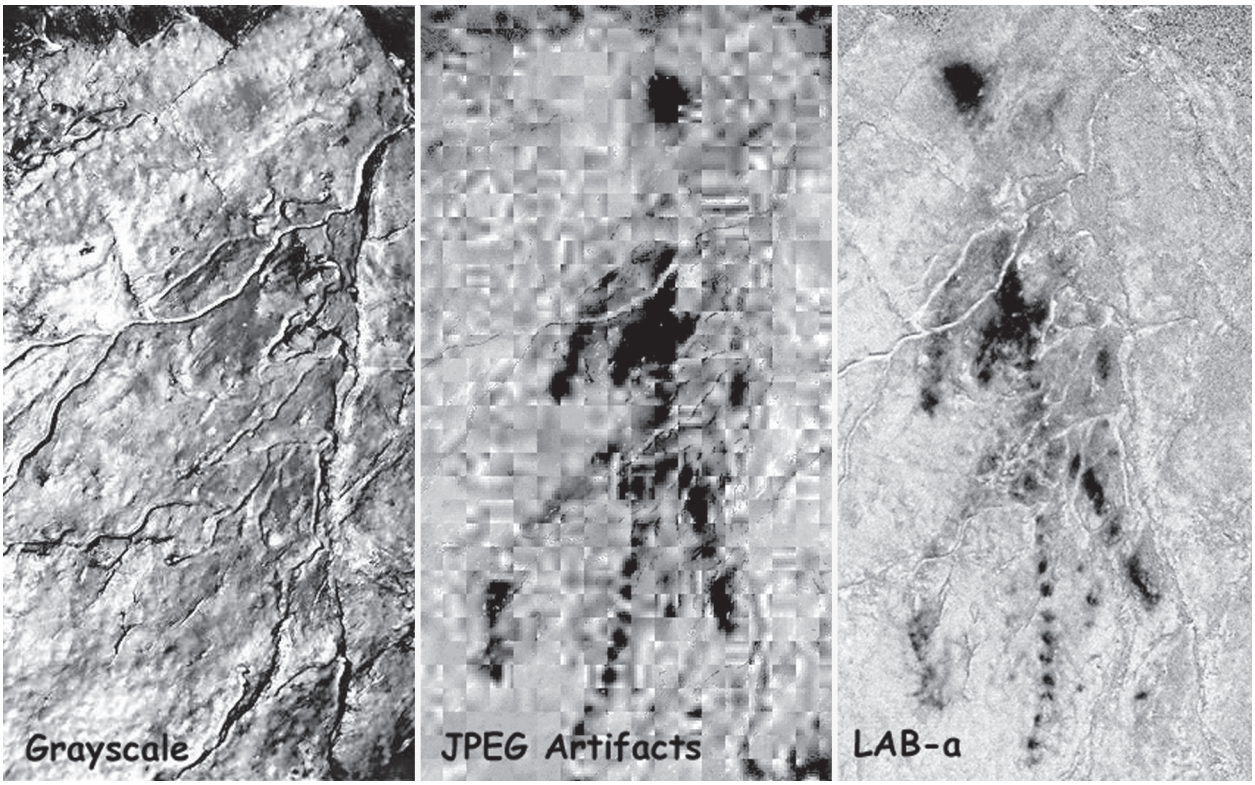

Figure 3. *Grayscale image of highly-compressed (compression ratio of 15) color image, with anthropomorph(?) in faded red. The second panel shows the JPEG artifacts made visible by the enhancement process of the first image. The third panel shows a LAB-a enhancement of a different image that was compressed using a JPEG compression ratio of 3.*

a film time exposure but was visible in the digital flash image. Oblique lighting, whether natural or flash, is usually best for petroglyphs. Sometimes a flash held to the side can bring out fine-line imagery not visible with direct lighting.

We obtain most of our digital images by scanning color slides. We also use digital cameras in the field (Nikon Coolpix 950 and 995). Images can be acquired by scanning photographic prints; however, there is a loss of information when prints are scanned. Negatives can provide high quality scans, but they are more difficult to handle in our automated system (Nikon Coolscan 4000 ED with stack loader).

Significant compression of an image particularly degrades color information. This can be a problem, producing serious artifacts during enhancement (Figure 3). While best-quality JPEG compression in Photoshop is generally not a problem, best-quality JPEG compression from a digital camera can be. By "best-quality" we mean selecting the highest number available in the version of software being used (for Photoshop 6 this number is 12).

FIRST STEPS

After opening an image in Photoshop, the first step is usually to examine the **Levels** histograms (note: use of bold indicates Photoshop entities). Histograms display the range of color information available to work with. They graph the number of pixels (picture elements) at each color intensity level. Adjustments are usually needed in **Levels** (or **Curves).** Eyedroppers in the Levels window can sometimes be used, in conjunction with a

white or gray scale (if one was in the original image), to adjust color balance.

After minimal adjustments, and before image enhancements, a copy should be saved. We recommend that enhanced images be so identified, and that unenhanced images also be preserved. This will enable future researchers to see how the original site looked as photographed, and have the original images to work from as additional techniques and methods of enhancement are developed.

Applying the **Autolevels** command sometimes brings out much detail, but typically produces a "burned-out" image. **Fade Levels** (**Edit** menu in Photoshop 6) can then be used to reduce the effect or change its **mode** to **color** or **luminosity.** Also useful are RGB techniques to adjust **Color Balance, Hue/Saturation,** and **Curves**. For some images these simple steps may be the only ones needed.

OTHER ENHANCEMENTS

Other image enhancements utilize alternate color spaces: **Lab** (**L**uminosity or lightness, and two orthogonal color channels, **a** and **b**) and **CMYK** (**c**yan, **m**agenta, **y**ellow, and blac**k**) (Adobe Systems Inc. 2000:111–112). Both of these color spaces tend to separate color information from luminosity, and thus are useful for amplifying subtle differences in color. We define enhancements in three general classes:

1. Grayscale images: the only class we fully illustrate in this paper, although we discuss the other classes and techniques and illustrate grayscale versions of them. These are single color channels or mathematical combinations of color channels.
2. False color images: the output colors are not similar to the original, but are used when rock art elements are difficult to discriminate in the original color hues. Many false-color enhancements are created in Lab, but occasionally simply taking the **Inverse** (negative) of an RGB image and adjusting **Levels** produces a useful false-color image. This is particularly helpful to bring out the imagery in some low contrast petroglyphs (Figure 4).
3. Enhanced color images: in the case of pictographs, the final product has more saturated colors; these colors are in the general range of hues of the paler pigments found in the original. Most of these are created in CMYK.

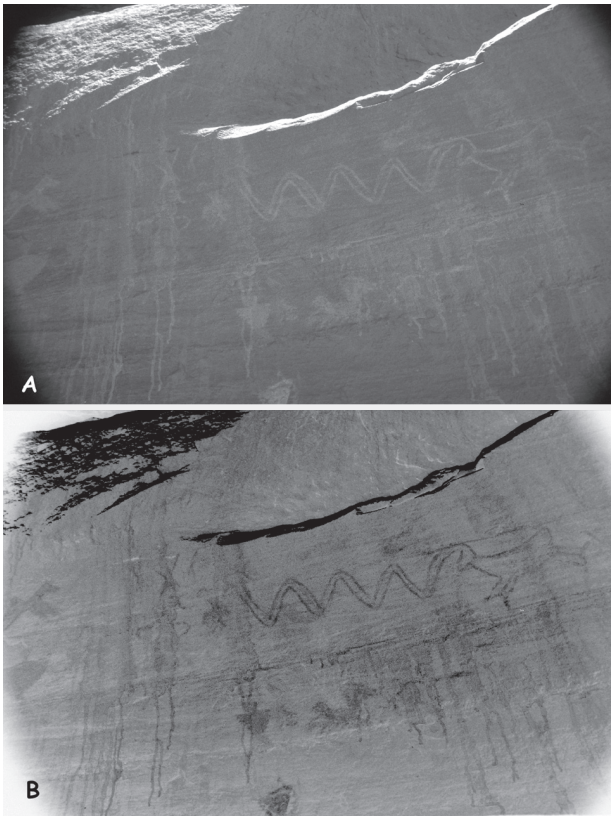

Figure 4. *a) Some difficult-to-see petroglyphs. b) Image* ***Invert****ed and* ***Levels*** *adjusted. Enhancement is better in color.*

Lab Color Space

Adobe defines **L** as lightness with a range of 0 to 100. **L** contains no color information. The **a** component (green-red axis) and the **b** component (blue-yellow axis) range from +120 to –120. While green-red and blue-yellow are not quite accurate descriptions of the color axes, they are close enough for

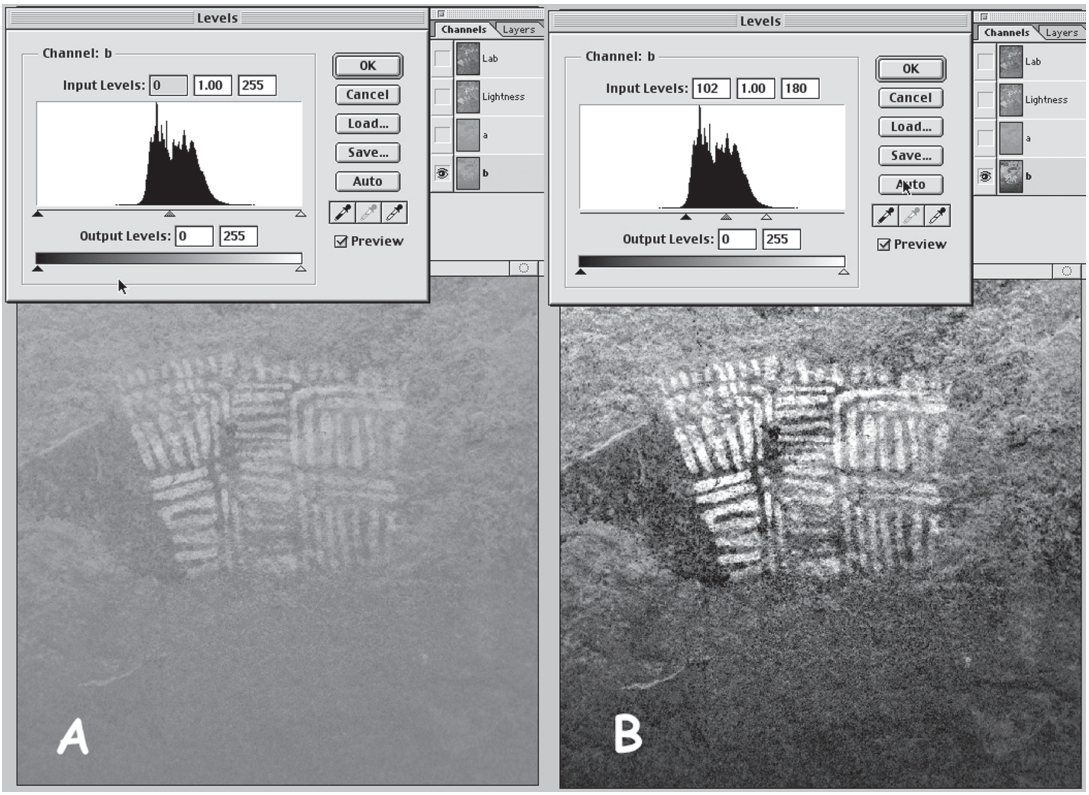

Figure 5. *Photoshop screen images of: a) LAB-b channel before adjustment. b) after* ***Levels*** *adjustment to increase contrast.*

discussion. After conversion to Lab color space (**Mode Lab**), the individual channels are examined (**Levels**) using the **Channels Palette**. Both color channels start with very low contrast (Figure 5a). Their contrast is substantially increased (**Levels**) in the enhancement process (Figure 5b). Any of the enhanced channels (**L**, **a**, and/or **b**) can be saved as grayscale images (**Mode Gray** or by **Split Channels**, Figure 6). The Lab image, after increasing the contrast of the a and/or b channels, is a false-color image. It can be converted back to RGB (**Mode RGB**) and saved. Alternatively, an individual channel (R, G, or B) can then be saved as a grayscale image.

Figure 6. *Enhanced LAB-b channel, converted to* ***Mode*** *grayscale, and* ***Invert****ed.*

CMYK Color Space

CMYK color space (usually used for printing) is used by us for color enhancement. After converting to CMYK (**Mode CMYK**), the individual channels are examined (**Channels**

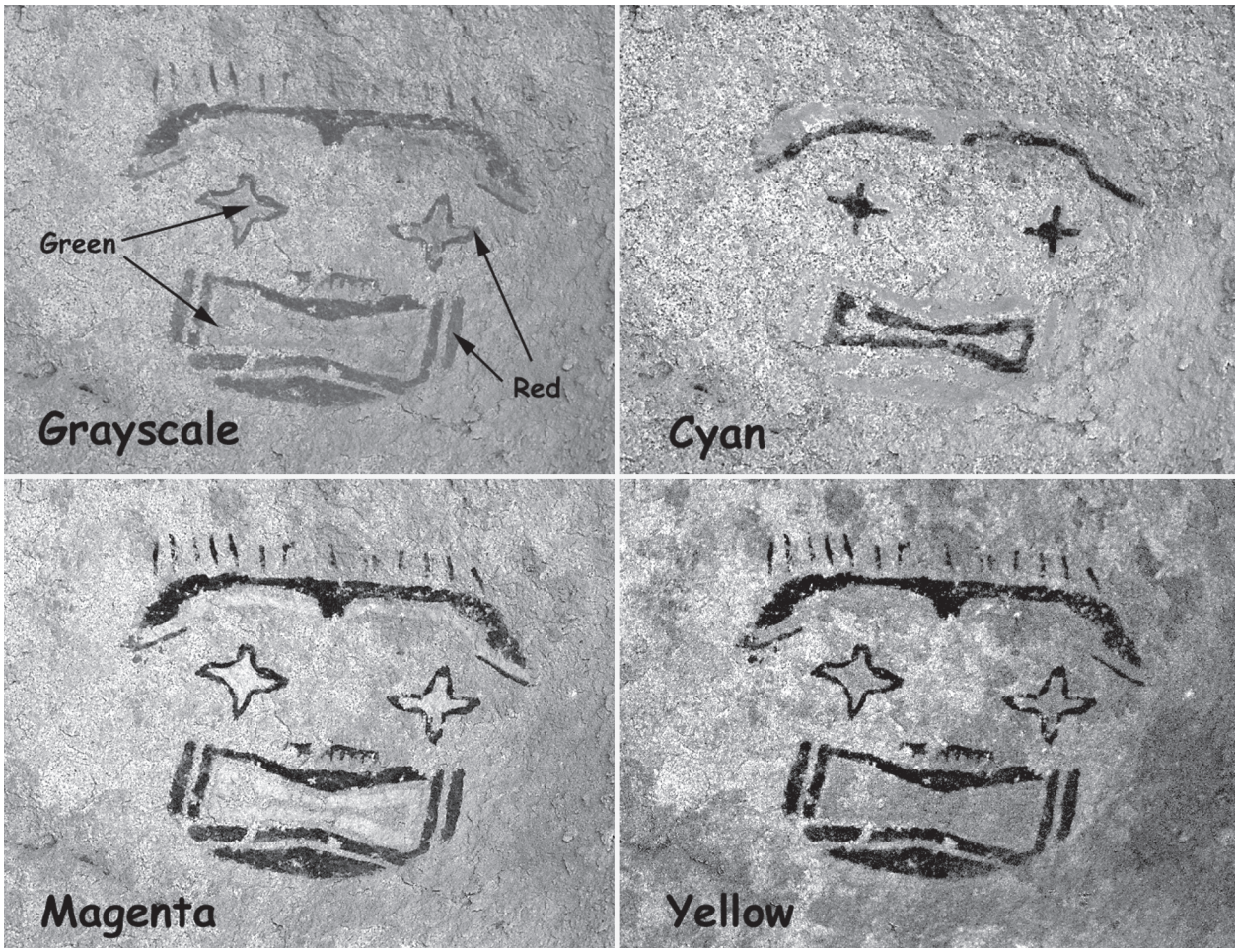

Figure 7. *Grayscale rendition of color image with red and green pigments, and three CMYK enhanced color channels.*

Palette, Levels). Contrast is usually increased in each of the three color channels (Figure 7), and appropriate channels saved as grayscale images (**Mode Gray** or **Split Channels**). The enhanced CMYK image usually shows vivid but generally realistic colors. The image is converted back to RGB (**Mode RGB**) and saved as an enhanced image. It should be noted that the choice of CMYK working color space (**Color Preferences**) will affect the results of this method. In Photoshop 6, we use SWOP v2.

COMPLEX METHODS

There are many possible variations on this process that may prove useful in photo enhancement. These include **Inverting** one or more channels, using the **High Pass** filter, combining grayscale images (**Apply Image** or **Calculate**), or blending a grayscale image over a color image (**Layers Palette**, **Blending Mode**). Particularly useful is blending an enhanced color channel over the original or CMYK-enhanced color image, using multiply, overlay, soft light or hard light blending modes (Figure 8). Sometimes the color channel image needs to be inverted. Other complex methods include using **adjustment layers** with color-channel images as layer masks. The images are usually **flattened** (layers merged) before saving. If they are not flattened, they must be saved in Photoshop format.

NOMENCLATURE

We save files in RGB or gray modes, and try to name them in such a way as to describe the enhancement used. Images are usually saved in best-quality JPEG, TIFF, or Photoshop formats. For an original file named *subject.jpg*, an enhanced color image would be named *subjectLAB.jpg* when Lab color space was used or *subjectCMYK.jpg* when the results of CMYK work are saved. Individual color-channel (grayscale) images for example, would be named:

subjectCyan.jpg
subjectMagenta.jpg
subjectYellow.jpg
subjectLABl.jpg
subjectLABa.jpg
subjectLABb.jpg
subjectLABred.jpg.
etc.

A complex image with overlays might be named:

subject_ovYellow.jpg (overlay mode)
subjectCMYKslLABb.jpg (soft light mode).

In all cases enhanced images are identified as enhanced, and unenhanced images are saved for reference, comparison, and future enhancements. We do not use paint or eraser tools, or drawn selections to alter images. It may be desirable to place enhancement-information text into the image to prevent future misinterpretations.

CONCLUSIONS

Algorithmic digital image enhancement is a powerful tool in rock art recording and analysis. It in effect extends our senses and makes additional data available for study. Adobe Photoshop™ can be used to implement

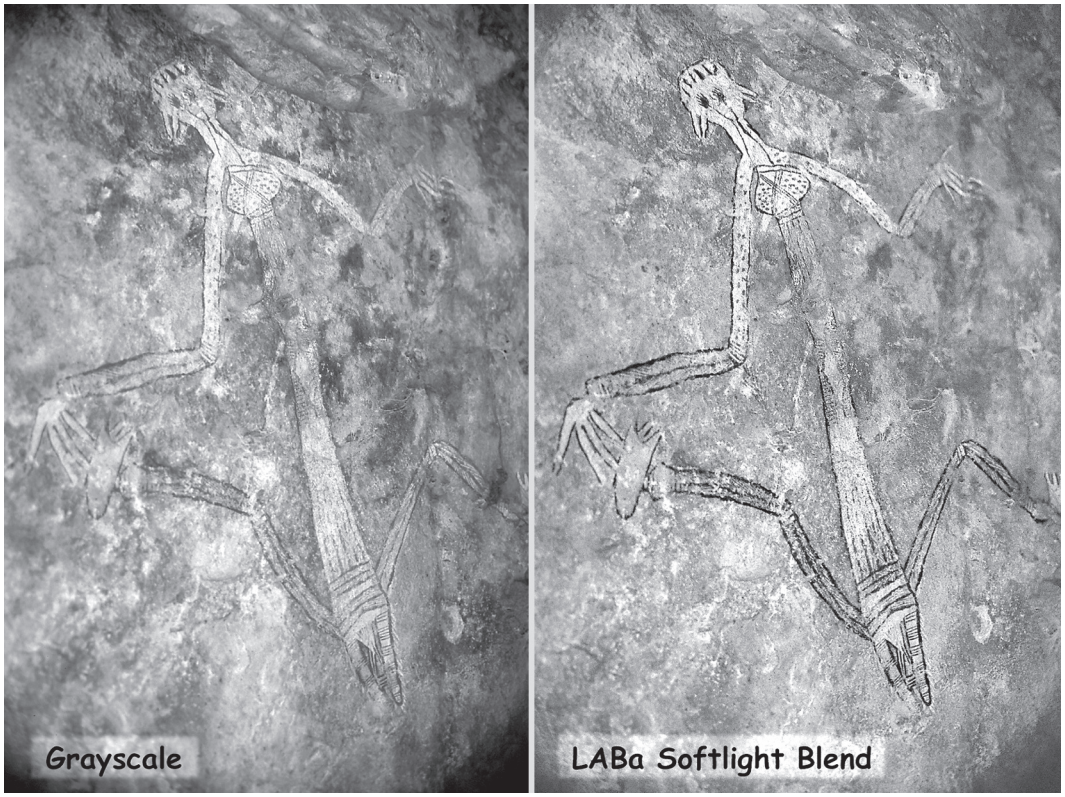

Figure 8. *Grayscale renditions of two color images. The second image is generated by pasting the LABa enhanced (grayscale) image over the original color image, with a* ***Soft Light*** *blending mode in the* ***Layers*** *palette.*

many different methods of manipulating images in different color spaces, which are applicable in various situations. Color illustrations would further demonstrate enhancement techniques available in this program.

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