Digital Mineral Photography

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Digital photography, the capturing of an image and storing it in an electronic medium rather than on film, is starting to become accessible to the average consumer. Camera prices are falling, and image quality is improving. Compared to conventional 35-mm photography, there are no film or processing costs, and results are immediately viewable so a reshoot can be made quickly if needed. Plus, in an increasing number of applications digital images are more convenient and cost effective. Mineral collectors can create online Web sites of their collections to share with others, send images of minerals via e-mail to potential traders, or print a catalog for their own use. Commercial uses for digital images include advertising, online auctions such as eBay, and e-commerce Web sites.

This article reviews camera selection, techniques specific to digital mineral photography, and the use of image-editing software. It does not address creative or stylistic elements in creating mineral photographs nor fundamental mineral photography techniques. For this information the reader is referred to *Photographing Minerals, Fossils and Lapidary Materials* by Scovil (1996).

Determining Equipment Needs

There are three ways to create digital images: scan a conventional photographic print, scan a 35-mm slide, or capture the image with a digital camera (either digital video camcorder or digital still camera). The final use of the images will determine which method is best. If the images will ever be used to make a presentation to a large group, then 35-mm slides may still be the best way to make the initial image, because they are of much higher resolution. It is true that digital projectors are becoming more prevalent, and it is also possible to create slides from digital images. But it is advisable to start with high-resolution 35-mm slides and then scan to create low-resolution digital images, rather than the other way around.

Digital photography is now accessible to the average consumer. Because more control than ever is directly in the hands of the photographer, the creative potential is enormous. Learn the basics of how to photograph your mineral collection.

If the images will be reproduced in a catalog or book and the final image size will be larger than 3 inches, then 35-mm may also be the best way to make the initial image because of better photographic quality. If you already have a large volume of existing photographs, 4 × 6-inch prints for example, then scanning the images with a flat-bed scanner is the easiest way to transfer the images to digital format. However, if images will be posted to an online auction or e-commerce site, and a high volume of photos is anticipated, then capturing the images with a digital camera is more cost effective and less time consuming.

The bottom line is the trade-off between quality, cost, and convenience. If you anticipate one hundred images per year, then either 35-mm slides or prints will suffice. If you anticipate shooting fifty images a week, then convenience and time savings will be more important than the higher cost of a digital camera. The task of photographing a mineral collection of say one thousand specimens is not insignificant. Obviously, it pays to buy the best equipment for the job. It will save time and effort and ensure image quality. This article focuses on using a digital still camera, the most likely method used by mineral collectors/photographers. Much of what is written also applies to using digital video camcorders.

Camera Resolution

Digital image resolution is measured in pixels (short for Picture Elements). A *pixel* is an individual point of color in an image and is the equivalent to the film grain in conventional photography. The image length in pixels multiplied by the width in pixels yields the total pixel count. Cameras are often sold as *megapixel* cameras, meaning they capture 1 million pixels of information

Pixels vs. DPI

Image pixels are independent of the common specification used in printing known as DPI (for dots per inch) or LPI (for lines per inch). DPI/LPI have no relation to the image quality captured by the camera. They are a control of the printer and of the size of the print image. For example, a 600 × 300-pixel image printed at 300 DPI will result in a 2 × 1-inch image on paper. The same 600 × 300-pixel image printed at 150 DPI will produce a 4 × 2-inch image. *The content captured by the camera (600 × 300 pixels or 180,000 total pixels) and stored as the digital image is exactly the same in both cases—even the file size is the same.* But the print size will be different. A print resolution of 300 DPI is minimum before print quality starts to degrade; 600 DPI is common on laser printers; and 1,200 DPI is readily available.

The pixel count does affect how large an image can be printed before there is apparent degradation. DPI has no effect on the inherent image quality of the digital image. This is a major source of confusion and is important to understand. *The bottom line in the important measure of image quality is pixel count expressed as length × width (i.e., 600 × 300 pixels).* See table 2 for the file- and print-size comparisons.

As a point of reference, a 35-mm Kodachrome slide captures the equivalent of about 1 billion pixels of information, which is why Fuji and Eastman Kodak are not worried that conventional photography will ever disappear.

How Many Pixels Do I Need?

The answer is simple: as many as you can afford. The price of digital cameras is directly related to the resolution and therefore to image quality. But why buy a camera that makes images at 1,280 × 1,024 pixel resolution when a typical image on a Web site or online auction is 300 × 400 pixels? It is because of an artifact of digital image capturing devices called the *edge effect*.

The edge effect (similar to *Mackie Lines* in conventional photography) grew out of the television industry as a way of artificially enhancing the apparent sharpness of a low-resolution image. It creates artificially accentuated edges on areas of contrasting color or brightness (see fig. 1).

By capturing images at high resolution, then reducing the resolution using image-editing software, the final image will look more natural and professional. See figure 2 for a comparison of the same image captured at different resolutions.

Another reason to use a high-resolution camera is to meet unforeseen future needs. The Internet might be faster in the future, allowing larger images to be sent, or you may want to print a catalog of your collection. Therefore, it is highly recommended to purchase a high-pixel-count camera, store images in a high-resolution size for the future, and create image copies at lower resolution for final applications if required.

Camera Requirements

Digital cameras are getting better every day. Any specific camera recommendation made in this article would be obsolete as soon as it is printed because every camera manufacturer has several new digital cameras in the product development pipeline.

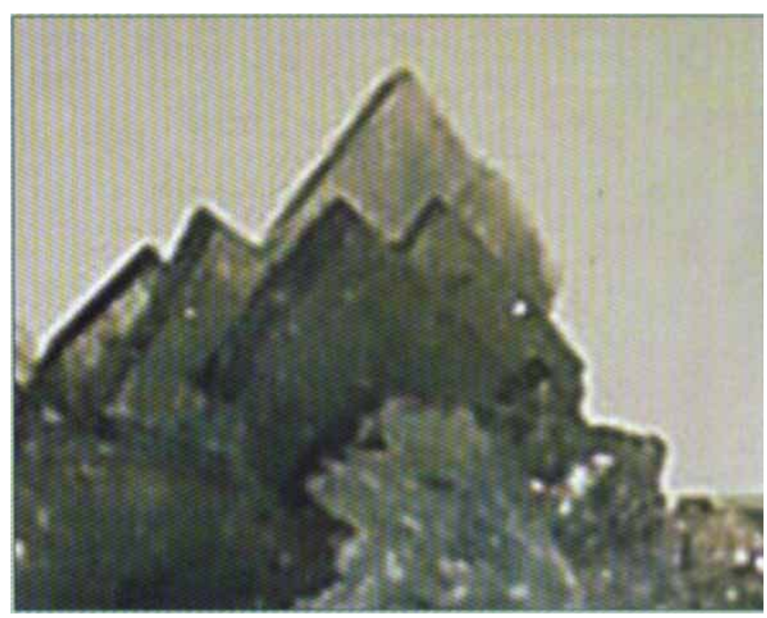

Figure 1. **Enlarged portion of a digital image (barite, Romania). Note the white fringe around the crystals and the exaggerated dark edges of the gray crystals. This is due to the edge effect inherent in digital imaging. Higher-resolution cameras will minimize this effect.**

Table 1. Comparison of methods of capturing digital images.

	Digitally scan 35-mm slide	Digitally scan 35-mm prints	Photograph with digital camera
Step 1	Set up and photograph using 35-mm camera and slide film	Set up and photograph using 35-mm camera and print film	Set up and photograph using digital camera
Step 2	Process the slides (1–3 days)	Process the prints at a 1-hour photo processor (1 hour–1 day)	Transfer digital image to computer (2 minutes)
Step 3	Scan the images with a slide scanner (5 minutes)	Scan the images with a flat-bed scanner (5 minutes)	
Step 4	Transfer digital image to computer (2 minutes)	Transfer digital image to computer (2 minutes)	
Equipment cost	$300 (and up) digital slide scanner plus 35-mm equipment	$100 flat-bed scanner plus 35-mm equipment	$500–$700 for digital camera
Average time per image	15 minutes plus time to get film processed	15 minutes plus time to get film processed	5 minutes

Table 2. Summary of typical image and camera specifications and their equivalents.

Typical image resolutions		Total pixel count		Camera advertised as	Typical JPEG file size	Printed image size at 150 DPI	Printed image size at 300 DPI
640 × 480 pixels	=	307,200 pixels	=	300k pixels	130 kb	4.2 × 3.2 inches	2.1 × 1.6 inches
1,024 × 768 pixels	=	786,432 pixels	=	786k pixels	260 kb	6.8 × 5.2 inches	3.4 × 2.6 inches
1,280 × 1,024 pixels	=	1,310,720 pixels	=	1.3 megapixels	520 kb	8.6 × 6.8 inches	4.3 × 3.4 inches

Instead, discussion will focus on the minimum set of camera features recommended specifically for mineral photography.

Every digital camera has a basic lens, sometimes a zoom lens, built-in flash, automatic focus, automatic exposure meter, and LCD viewfinder. However, when shopping for a digital camera look for the features discussed below.

Macro Photography (Close-Up)

For photographing minerals, the camera should focus to a minimum of 1 inch. This allows photographing thumbnail specimens or individual crystals on larger specimens (see fig. 3). There are many cameras on the market that can focus to 1 cm (0.4 inch) without the need of any attachments.

A poor alternative is using a camera that permits attaching "close-up filters," which are diopter lenses that come in +1, +2, and +4 strengths. By using them alone, or in combination, any

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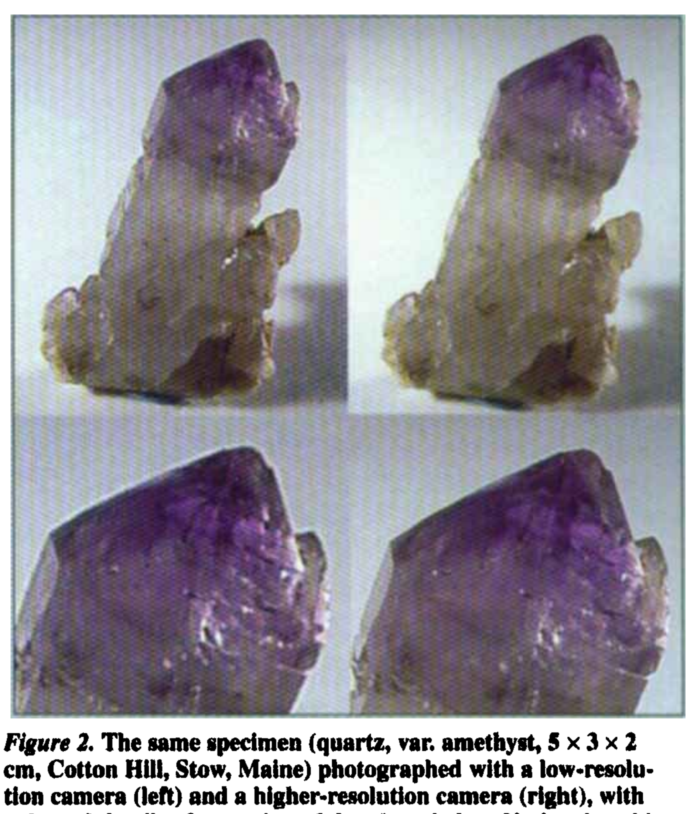


Figure 2. **The same specimen (quartz, var. amethyst, 5 × 3 × 2 cm, Cotton Hill, Stow, Maine) photographed with a low-resolution camera (left) and a higher-resolution camera (right), with enlarged details of a portion of the photo below. Notice the white halo visible around the outside of the crystal on the left due to the edge effect and the sharper detail of the higher-resolution image on the right.**

Figure 3. **Close-up image of 1/16- to 1/8-inch crystals (mimetite on philipsbornite, 5 × 4 × 3 cm, Hat Yai, Thailand). Any camera used for mineral photography should be able to focus to 1 inch minimum to capture this sort of detail, ideally without any additional attachments or filters.**

value up to +7 can be obtained. However, every mineral is unique, and sizes and focus distances vary greatly. The hassle of switching filters for every specimen is tolerable but time consuming. For the last year I have used a camera that focuses continuously down to less than 1 cm, and I find it far preferable to using to my previous camera that required close-up filters. Close-up focus is highly recommended as a fundamental requirement for a digital camera.

Adjustable Exposure

The camera should offer manual exposure compensation of plus or minus 1 stop minimum (plus or minus 1.5 stops is optimum). This allows the photographer to make fine adjustments in exposure. Many shortcomings in an image can be fixed later with image-editing software; however, if the exposure is not correct, the information will never get recorded properly, and digital enhancement may not be successful.

Spot Metering

All digital cameras have built-in exposure meters. These "averaging" meters measure the overall image to determine exposure. A camera with "spot" metering is recommended for mineral photography. This feature allows the photographer to meter a small area of the image to determine the proper exposure rather than averaging the entire image. This is important when photographing a dark specimen on a light background or a light specimen on a dark background. Often the spot metering is a separate "mode" that must be set up before using the camera.

Manual Focus

Manual focus control is especially important for close-up photography where depth of field is shortened. It is also useful when the camera's autofocus misbehaves for some reason and insists on focusing on the matrix or the background rather than on the crystals you are trying to capture. One shortcoming of digital cameras is that the relatively small LCD viewfinder makes it difficult to tell whether the image is in focus. When in doubt, take multiple exposures, varying the focus in each, to make sure there will be one good image.

Flash Control

All digital cameras come with a built-in flash for general photo use. However, lighting control is important with mineral photography. The camera must have the ability to shut off the built-in flash. Simply covering up the flash with tape will not work because the camera's automatic exposure system will likely overcompensate and produce a bad image.

AC Adapter

Digital cameras consume batteries at a very high rate. Invest in an AC adapter if photographing more than twenty specimens at a time. The adapter will pay for itself in savings on batteries.

Self-Timer

All digital cameras have a self-timer. It is recommended to use the self-timer for close-up images to eliminate camera vibration during exposure. Also, there will be times when you need both hands free to hold diffusers or reflectors. The self-timer can be used to take the exposure while you are holding the props.

Accessible Shutter Release When Mounted on a Tripod

This seems obvious, but make sure the shutter release is located where it will be convenient. Imagine photographing a specimen up close—will fingers get in the way of lighting, or is the shutter release on the front where it is not easily located?

Memory Media

Every camera manufacturer uses a different way of storing the images once they have been captured. Some use inexpensive floppy disks, some use memory sticks, some use smart cards. None of these are perfect. Make sure to understand the cost for the media, special hardware required to read the media, and the transfer to computer process. Most importantly, run a trial to see how long it takes to capture an image and transfer it to your computer. All cameras are not equal in this respect. It may be possible to skip storing the image on any media and transfer the image through a cable directly to the computer. Although this may be a time saver, it is not always convenient to locate a computer adjacent to the photo stage.

Features That Are Not Relevant

Digital cameras come with many other features that, although handy for other applications, are not important for mineral photography. They include zoom lens, digital zoom, interpolated high resolution, special-effects modes, and red-eye reduction. For example, although having an optical zoom lens on the camera may seem important, for mineral photography all images will be composed by moving the camera closer to and farther away from the subject. Digital zoom enlarges the image digitally without changing the optics. Digital zoom leads to image degradation and is not advisable to use, even if the camera comes equipped with the feature.

At the time of this writing, both Sony and Nikon offer the best digital cameras that meet the criteria for digital mineral photography.

Other Equipment

In addition to the camera, other equipment is needed, some of which is the same as that used in conventional photography. A sturdy tripod is very important because camera movement is the enemy of a sharp photograph. Tripods have improved greatly in the last twenty years. It might be worth upgrading to a better tripod with more convenient features.

The same backgrounds, reflectors, and diffusers as conventional photography will be needed. I prefer photographing on black glass or Plexiglas because of their resistance to scratches and the relative ease of keeping them clean. An assortment of small Mylar reflectors, mirrors, and diffusers are used to create controlled reflections off crystal faces to define the crystal shape.

Lighting

Probably as important as camera selection is lighting. Digital cameras have built-in white balance to compensate for the color temperature of the light source. It is relatively easy to compensate for the color of a specimen illuminated under incandescent light, something not easily accomplished with conventional photography. However, it is important to use a full-spectrum light source. For example, a 60-watt incandescent bulb has very little blue/purple in the spectrum of the light it emits. A mineral specimen with dark blue (i.e., azurite) on a black matrix that is illuminated under incandescent light will render both colors as black. No amount of photo manipulation on the computer will ever differentiate the two colors. By using a full-spectrum light source, that problem can be minimized.

Also, the light sources should be small, adjustable/moveable lights that produce broad illumination without strong hot spots; this can be accomplished by using frosted bulbs or an additional diffuser. Either will control the reflections off individual crystal surfaces and eliminate harsh hot spots—very important in mineral photography.

The one light source that meets all these needs is the new SoLux halogen bulb. This is a new-technology lamp based on MR-16, 50-watt halogen bulbs but with proprietary technology to produce a full-spectrum light output. SoLux bulbs have been so successful they have been adopted by several museums as the standard light source for their paintings and exhibits. The bulbs are available in several different color temperatures. The SoLux bulb best for photography is the 4,700°K version, which is the equivalent to daylight at 10 A.M. and very close to 5,000°K or daylight at noon. (It should be noted that 35-mm photographers can use an 80D filter to convert SoLux illumination to conventional daylight film.) For digital photography, SoLux bulbs are perfect, yielding accurate rendition of difficult-to-photograph minerals such as dioptase and azurite. They are 12-volt bulbs and fit in any light fixture that can accept an MR-16 bulb. SoLux also manufactures a task light to hold SoLux bulbs that has an adjustable swivel arm that works well in photography, displays, or even illumination of specimens under a microscope.

Image Editing

It is a mistaken assumption that a photograph can be used "straight" or not retouched. Even in conventional 35-mm photography, color balance, exposure adjustments, and contrast control are manipulated to produce a satisfactory image by the photo processor.

Image exposure (lightness and darkness) is the most commonly manipulated variable. Digital camera built-in exposure meters try to balance the image exposure to produce a medium value. This works well when the subject is a medium value—such as skin tones. But if you are photographing a dark mineral such as azurite, the camera will lighten the exposure in an attempt to yield a medium value, making the image overexposed. If you are shooting a bright white subject such as okenite, the camera will attempt to darken the exposure to yield a medium value, making the image underexposed.

Similar problems occur with color balance. Digital cameras have an automatic "white level" control to achieve normal color balance. This works well with a normal subject. But if the subject is a specimen of etched green prehnite with no brilliant highlights, the camera will not see any white highlight pixels in the image and will think color correction is necessary. The camera in this instance will shift the color from green toward white (usually by adding red/pink/magenta) and fail to accurately capture the green prehnite.

Author's Equipment

- Sony MVC FD-83 digital camera. Captures 1,024 × 768 pixel images in native mode; focuses to 1 cm; stores images on common floppy disks, 8–12 images per disk depending on image/subject.
- Two 50-watt/flood SoLux 4,700°K halogen bulbs for illumination, with frosted mylar diffusers over the bulbs.
- Black glass or white backgrounds for mineral photography.
- Adobe Photoshop 5.0 for cropping, cleaning up, and optimizing images.
- Computer: Dell XPi CD 166 MHz with 48 MB RAM.
- Iomega Zipdrive for storing images; each disk is capable of storing 100 MB of images.
- Epson Stylus 800 color inkjet printer prints at 1,440, though regularly used at 720 DPI.

Lastly, images need to be adjusted because digital sensors may artificially enhance one particular color. This is common with 35-mm slide films too: Kodachrome has exaggerated reds, Fujichrome has exaggerated greens, Ektachrome has subdued neutrals, and so on. So the image may need adjusting to accurately represent the subject. My camera overly saturates reds, probably because camera manufacturers artificially enhance the reds to produce better skin tones.

Image retouching varies from simple to extreme. Following are some typical operations:

- **Simple:** Crop image and adjust for any tilt, adjust lightness/darkness, correct color
- **Moderate:** Retouch dust or lint on subject, clean up background, remove digital artifacts
- **Radical:** Sharpen focus, add airbrushed background, combine multiple exposures

Retouching can improve an image only to a limited extent. The beginning image, before adjustments and retouching, must still have a good pose, sharp focus, good exposure, and descriptive shadows and reflections. These cannot be faked or added later.

Software

There are many software packages available for editing images after they have been captured by the camera or scanner. Many come bundled with the camera or scanner, and all are about equal. The industry standard is Adobe Photoshop. All other software is attempting to emulate Photoshop and make it easier for novices. If you are creating a large quantity of images, it pays to invest in Photoshop and learn to use it.

It is possible to avoid paying the full cost of the latest version of Photoshop if you have an older version that came bundled with a scanner or other peripheral equipment (this was very common a few years ago). You can purchase the latest upgrade version of Photoshop at a fraction of the regular retail price. Also, Adobe makes an introductory version called Photoshop LE that is an excellent way to get started and learn the basic tools without paying the full price for Photoshop.

Commonly, very few commands in Photoshop are actually used when regularly editing images: cropping, adjusting exposure, retouching flaws, and resizing. However, Photoshop also has productivity features built in that make it much more convenient. One convenience is it retains the history of the last twenty changes and can selectively go back and undo any changes you have made along the way. Photoshop also allows the recording of any sequence of actions to be saved and used on other images (e.g., resizing images to create the small preview images known as "thumbnail" views).

Best of all, Photoshop allows batch processing of multiple images. This is a real time saver if you need to perform the same command on many images (e.g., resizing images to a particular size or adding a company logo to the image). Using Photoshop's batch command it is possible to perform a command or series of commands to a group of images without any user interaction. Simply select the images to process and the commands to perform, and let Photoshop do the work while you get a cup of coffee.

Typical Process

There are two parts to creating digital mineral photographs: capturing the image with the camera and processing the image on the computer with image-editing software. Capturing the image is much the same as conventional photography. Image editing is where much of the work is done.

Setting Up the Camera

Before starting a session, you will need to set up your camera. This is done once, when first using the camera, then never has to be done again. For almost all applications the camera should be set to save images in *JPEG* format, which is short for *Joint Photographic Experts Group*. This is a method of saving the image pixels by compressing the data. Some cameras also allow the selection of high resolution (large file size) or low resolution (small file size), allowing more images to be stored in the camera. For mineral photography select the highest resolution option.

Newer digital cameras may have a *digital zoom* feature, which magnifies the image electronically (independent of zoom optics) to create the illusion of a telephoto image. In fact, the camera is enlarging the same basic pixel data, and image quality is not actually improved. Set the camera to turn off the digital zoom.

Some cameras have a high-resolution interpolation feature that takes a standard pixel count and expands it to a higher resolution. For example, a standard camera resolution (native resolution) may be 1,024 × 786 pixels, but with interpolated enhancement the camera will boost the pixel count to 1,280 × 1,024 pixels. This feature is solely for marketing and advertising purposes, to boost the pixel count, and does not actually enhance the picture quality. Set the camera to disable this feature.

Finally, turn off the built-in flash and set the camera to the macro mode. Now everything is set to go.

Making the Image

The basic steps are as follows:

1. **Clean the visible area.** Eliminating any dust now will save time spent retouching later. Carefully clean all visible dust on the backdrop or lint on the specimen.
2. **Pose the specimen.** No amount of image editing can adjust for a poorly posed specimen. Support the specimen securely on a stand or use nonstaining putty. Posing the specimen to conceal the support reduces time and effort later spent retouching the image. One advantage of a digital camera is the convenient LCD viewfinder that facilitates rotating the specimen while simultaneously previewing the image.
3. **Adjust the camera angle to capture the image.** Though it is possible to handhold the camera, it is definitely not advisable. Camera motion is the single biggest contributor to blurry images. Set the camera on a sturdy tripod and compose the image by adjusting the tripod. It is best to fill the image as completely as possible with the mineral specimen.

Digital cameras have an LCD screen as the viewfinder. This provides the exact view the camera is seeing, similar to a conventional SLR camera.

4. **Adjust the lights and add reflectors for reflections and shadows.** Reflections off crystal faces and shadows cannot be added later during image editing. Arrange the lights to describe the form and crystal luster of the specimen. This usually involves primary and secondary reflections but is a matter of the photographer's personal taste. See Jeff Scovil's book (1996) for further discussion on how to illuminate a specimen for photography.
5. **Adjust the exposure.** With the LCD viewfinder, preview the image to adjust the lightness and darkness using the camera's exposure control. It is important to get the exposure as close as possible at this time to capture all the information in the image. If the exposure is too dark, the shadows will merge into a big, dark mass. Similarly, the highlights will wash out if overexposed. Fortunately, the LCD viewfinder makes previewing and adjusting easy. Be aware that the image on the LCD viewfinder can vary as the viewing angle changes. This may lead to the mistaken belief that exposure is correct. To avoid this problem it is best to make sure you are looking straight at the viewfinder screen.
6. **Prefocus or manually focus.** The shutter release is a two-stage switch. Depressing the shutter release halfway will focus the camera. Depressing the shutter release fully will capture the image and record it. The user should closely inspect the image after focusing the camera. If the image is not properly focused, switching to manual focus may be necessary.
7. **Make exposure.** Finally, depress the shutter release fully. The camera will capture the image and record it to memory. An image 1,024 × 768 pixels will vary in size from 50k to 280k bytes of memory, depending on the image detail. An image with lots of small detail, such as drusy crystals, will create a larger file than an image with soft contours and little detail, such as botryoidal malachite.

Image Editing on the Computer

1. **Transfer the image to the computer.** After all the images in a session are captured in the camera, transfer them to the computer. Every camera/computer combination is different, so the process will vary. Basically, copy the images from the memory of the camera into a directory/folder on the computer.
2. **Make sure the computer monitor is properly adjusted.** When image-editing software is first installed, there will be a routine to calibrate the computer monitor; often this is referred to as the *Gamma. Make sure to go through this process.* If you don't, images may look great on your computer but not on anybody else's. If the monitor is set too dark, adjusted images will look good on your monitor, but they will be washed out on a "normal" monitor. If Photoshop is used for image editing, it has an excellent Gamma calibration built in, as do most Macintosh computers. Unfortunately, not everyone calibrates their monitors, so there is no control over what the viewer actually sees. In instances where color balance is critical the best alternative is to create a color print to send.
3. **Open the image.** This involves opening the directory/folder where the images are saved on the computer. Each image will be listed with a name, such as "MV1607.jpg." The characters before the dot are the file name. The "jpg" after the dot refers to JPEG file format. If the image-editing software is properly installed, double-clicking on a file will open the program and open the image.
4. **Crop the photo.** The very first step is to closely approximate the final cropping of the image. A window is made around the image; after adjusting the boundaries to final position hit "enter" to complete the crop. Recropping can be done later, but eliminating extraneous background is an important first step. Also at this time the image can be rotated if the camera was set for a vertical image. Photoshop has a great cropping feature: the cropping window can be rotated to correct for camera misalignment, saving an additional step.
5. **Adjust levels.** A very powerful tool in Photoshop is the image-adjustment command called Levels. This command expands the dynamic range of the image to cover the full span of light to dark, which results in the best combination of brightness and contrast for most subjects. Basically, it modifies the image so there is at least one black pixel in the image and one white pixel, with all other pixels somewhere in between. Most images can benefit from letting Photoshop automatically adjust the levels using the Auto Levels command. Sometimes, though, the Auto Levels command will cause an unsatisfactory color shift. When this happens, simply undo and manually adjust the levels. The command cannot be fully covered in an introductory article such as this, but it is an important tool whose use should be learned and understood.
6. **Adjust the color balance.** Now is the time to make any necessary adjustments in the color balance. Photoshop has a large selection of image-adjustment tools or commands. For beginners, there is a nifty tool called Variations that displays the current image surrounded by variations on the image. Each variation changes the color balance in one direction (i.e., more blue, more green, more magenta, and so on). Also there is a lighter version and a darker version of the image to choose from. The variations can be further controlled to make fine or coarse (lesser or greater) changes. It is a great tool for making any changes to the color balance, especially for novices.
7. **Save the image.** At this point the image is in useable condition. Go to the command bar, click on File, then Save As, and type in a file name. Make sure the file type is set to JPEG format, then click OK. The software will usually prompt for selecting an image quality value—a higher number means higher quality but also larger file size. A value of 7 or 8 is best for master image files, which should be kept at the high resolution in anticipation of any future use. For maximum image quality, save the image in TIFF format instead of JPEG. TIFF is an uncompressed file format, and

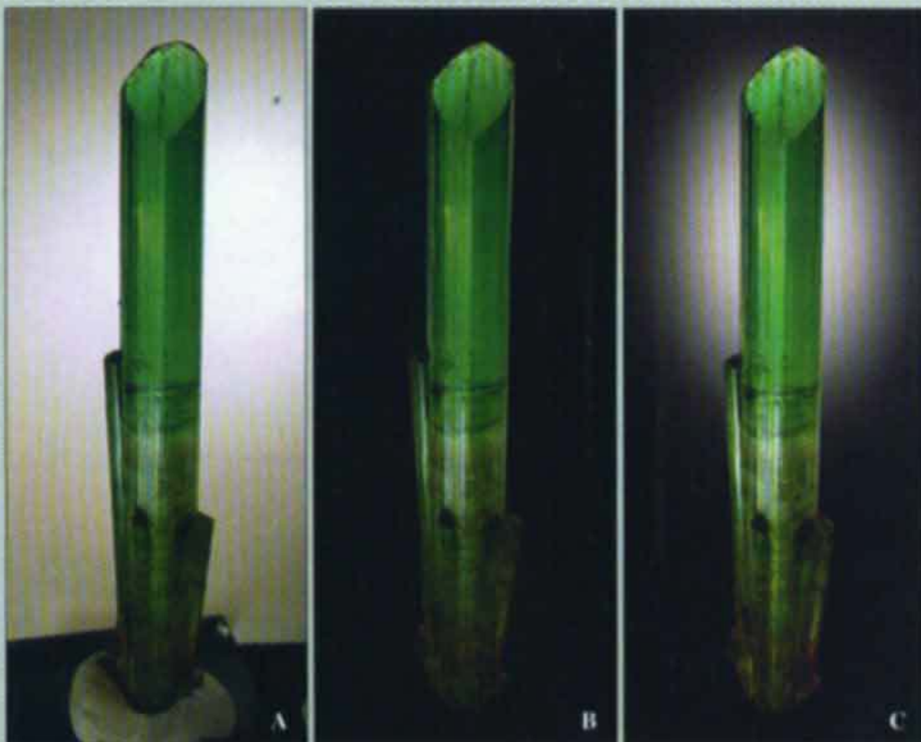
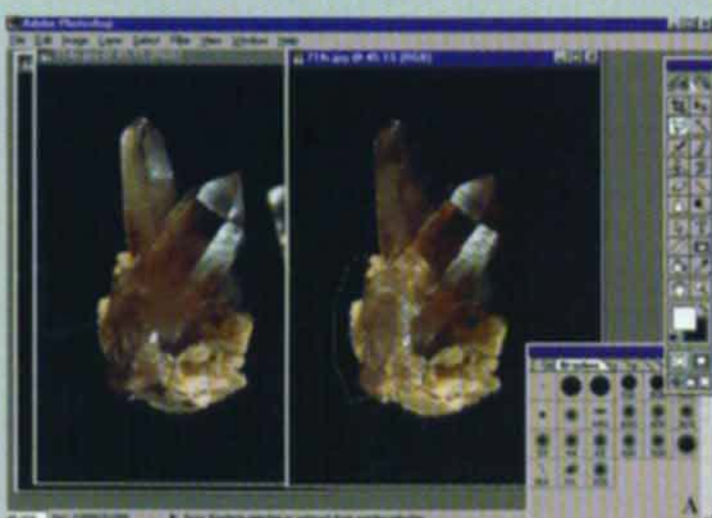


Figure 4. **Sequence of retouching an image (elbaite, 7 × 1 × 1 cm, Paprok, Kunar, Afghanistan). A: Original image cropped with all extraneous lighting and photo props visible. B: The background dropped out in black. C: Diffuse halo added to the background.**

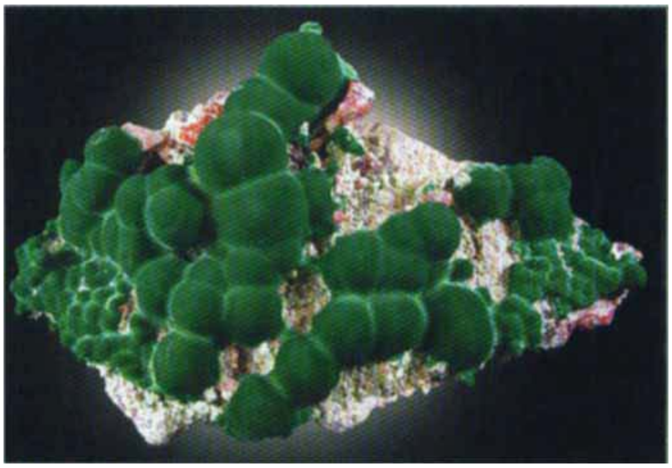
Figure 5. **A: Two different images of the same specimen (quartz, var. smoky, and albite, 4 × 2 × 2 cm, Moat Mountain, New Hampshire) as seen in Photoshop. The left version has good reflections on the termination and the rear crystal. The right version has a better reflection off the central face of the front crystal. Using Photoshop's editing tools, the central face on the right crystal is selected (dotted line) and copied onto the left photo. B: The composite image after copying the reflection onto the image. C: The final photo after retouching.**



unlike JPEGS, there is no image loss or degradation in quality due to compression.

8. **Reduce resolution to useable size and save**. A smaller, lower resolution copy is needed of the master image if sending via e-mail or posting to an online auction or e-commerce Web site. In Photoshop, go to the command bar at the top, click on Image, then click on Image Size. A dialog box will come up. There are two sections: Pixel Dimensions and Print Size. As already discussed, the Print Section is not important to image quality or file size; what matters is the length × width pixel count. Select "pixels" as units of measurement in the Pixel Dimensions section (this only has to be done once; after that Photoshop will use the same settings). A typical full-sized image may be 850 × 650 pixels, depending on how the image was cropped and the quality of the camera. A good target size for e-mailing or Internet use is 400 × 300 pixels. Simply type in new values. Make sure the "Constrain Proportions" box at the bottom is checked. This will automatically adjust the width as the height is changed and vice versa to keep the proportions constant and prevent distortion. Then repeat step 8 to save the newly sized image. Remember to keep a master file at high resolution. Reducing resolution is irreversible—you cannot satisfactorily increase resolution from a low-resolution image.

Figure 6. Other examples of the author's mineral photographs.

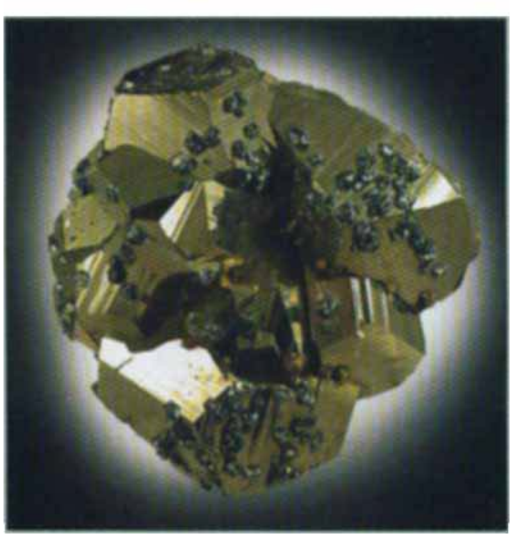


Malachite, 6 × 4 × 3 cm, Morenci mine, Morenci, Arizona.

Vanadinite, 6 × 5 × 1.5 cm, Mibladen, Morocco.

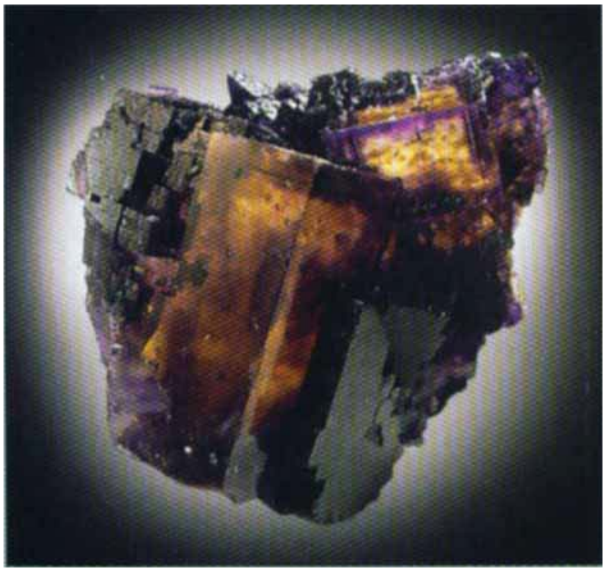
Copper, 4.5 × 2 × 0.5 cm, Champion mine, Painesdale, Michigan.

Azurite, 6 × 5 × 5 cm, Yang Chweng mine, Guangdong Province, China.



Pyrite, 7 × 7 × 7 cm, Huanzala, Peru.

Wulfenite, 4 × 3 × 2 cm, Red Cloud mine, Yuma, Arizona.



Fluorite, 6 × 6 × 3 cm, Minerva No. 1 mine, Cave-in-Rock, Hardin County, Illinois.

Advanced Techniques

Photoshop has many sophisticated image-editing tools to improve poor images or overcome difficult photographic situations. Many operations are very easy to do, including retouching out dust or lint, improving focus, selectively adjusting brightness, retouching backgrounds, and removing artifacts of digital imaging such as the edge effect. Few commands must be learned to perform these tasks. These include Image Adjustments, Magic Wand, Lasso, Dodge & Burn, Rubber Stamp, and Filters. Fortunately, the Photoshop users' manual has an excellent tutorial on each of these tools, and it is possible to learn all of them in twenty to forty hours of practice. It is not within the scope of this article to explain these operations in detail. However, some commonly performed techniques will be discussed.

Quartz, var. amethyst, 14 × 7 × 3 cm, Saltman prospect, Sweden, Maine.

Retouching Backgrounds

Through the years I have grown tired of retouching dust out of the background or scratches on the black glass that supports the mineral. As a result, my process ignores background completely and instead adds the background later during image editing (see fig. 4).

The specimen is posed and lighted, and the image is captured as described previously. After cropping the image and adjusting the levels, the part of the image surrounding the specimen is selected using various Photoshop tools. Most handy is the Magic Wand, which selects similar pixels all at once. Also the Lasso tool can be used to manually grab the background part of the image. Once all the background has been selected, any operations performed in Photoshop will only affect the background pixels, not those on the mineral part of the image. Next, using the Fill command, the background area is filled with a solid background color, in this instance black. It is possible to stop at this point if the image looks acceptable. However, in the example here, the translucency in the crystal, resulting from the white background used when it was photographed, looks unnatural. By airbrushing in a white glow around the crystal, the translucency looks more natural. Again, this is done with only the background pixels selected, so nothing is enhanced on the mineral portion of the image.

Calcite, 7 × 5 × 4 cm, Shullsburg, Wisconsin.

It is important to have the final image in mind when creating the initial image with the camera. If translucency of the crystals is the goal, it is best to use a white background. If the specimen is opaque and the final image will have a dark background with only a colored "glow," then it is best to shoot on black or some other solid color.

Combining Multiple Exposures

Good images can be made of difficult-to-photograph specimens by using multiple images and combining them using Photoshop. An example is a close-up image where the depth of field is shallow. Two images can be captured, one where the matrix is in focus, the other where the crystals are in focus. By combining the focused parts of each image into one

Figure 7. **The author's photography setup. Flexible-arm lights were adapted from track-lighting fixtures and mounted to a small chest of drawers. This elevates the specimen off the table to a good working height to avoid back discomfort during prolonged photo sessions. Each SoLux bulb is covered with frosted Mylar diffusers. The top drawer contains the transformer for the lights. The middle drawer is for the AC power adapter and camera storage. The bottom drawer holds props, diffusers, and computer disks. The top of the case is covered with glossy black laminate. Note that the typical tripod pan head has been replaced with a universal ball mount to simplify camera angle adjustment.**

image, a satisfactory final image can be created. The combining of various parts of images is extremely easy with image-editing software.

An area from one photo is selected using the Lasso tool, then it is copied onto the other image; finally the two are merged (see fig. 5). The Photoshop manual has an excellent tutorial on this common technique.

Another common problem when photographing minerals is getting adequate reflections off all desired crystals. Taking several images with various light positions will give a variety of reflections. Combining various parts of these images into a single image will give a final effect that better describes the specimen. This is not artificially enhancing the specimen image; it is overcoming lighting limitations to capture an honest description.

Conclusion

Digital photography is not very difficult, in spite of the intimidating nomenclature and unfamiliar tools. More control than ever is directly in the hands of the photographer, and the creative potential is enormous. When learning to use digital cameras and software, start with your best specimen, and shoot it twenty different ways. (It is easier to take a great photograph if you use a good specimen.) Try to copy the style of an image used in a magazine or on the Web for the lighting or background.

No single article can teach all the steps of making digital mineral photographs. Similarly, observing an expert only illuminates the techniques used; it does not teach an individual to make good images. Only practice can teach when and how to use various techniques.

ACKNOWLEDGMENTS

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