Photographing Minerals, Fossils, & Lapidary Materials

Jeffrey Scovil

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DEDICATION

I dedicate this book to Lee Boltin, a man whom I never had the pleasure of meeting. Lee was the first person to establish high standards for the photography of minerals. His work in Paul Desautels's landmark book, *The Mineral Kingdom,* was a great inspiration to me and many other photographers. I spent many hours studying his photographs in that book, trying to determine what techniques he had used to take them.

We all stand on the shoulders of those who have gone before us, and Lee Boltin's were the foundation of my life's work. Thank you, Lee, for helping me along the path to a career I love.

Acknowledgments

Writing a book is never a one-person job: it requires the work of many. The following people have all been important in the production of this book, and 1 wish to thank them for their contributions.

Dan Behnke, for reviewing the manuscript; Bernice Pettinato, of Beehive Production Services, for copyediting the manuscript; and Meredith Edwards, for the fine line drawings. For the loan of equipment to be photographed: John Lucking, Bob Markow, and Photomark; Bill Hunt; Michael's Creative Jewelry; and C & N Minerals. Ron Stebler, for the loan of fossils. Kevin Downey, for discussions on, and demonstrations of, light painting. Robert Gait, of the Royal Ontario Museum in Toronto, Canada, for his loan of Violet Anderson's photographs; and Caroll Boltin, for the use oí' Lee Boltin's photographs. 1 especially thank all of the photographers who loaned their work for use in this book . 1 hope that 1 have not forgotten to thank anyone, but if 1 have, 1 offer my apologies and thanks.

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Chapter 1

Aesthetic Considerations

Your first step as a photographer is to establish your reasons for photographing minerals (or lapidary materials or fossils): What is the ultimate purpose of your photographs? The answer to this question will influence both your technique and aesthetic considerations. If you are photographing purely as an aid in cataloging, then the process can be a simple, clean, and accurate depiction of the subject. On the other hand, your orientation may be purely artistic, in which case you may have no need for precise definition of form and recognizable species.

Most mineral and gem photographers fall somewhere in between these two extremes, though usually closer toward that of accurate rendition.

Bear in mind that it was most likely the beauty of the mineral and gem kingdom that first caught your eye. The col ors, forms, and incredible, regular geometric shapes are a part of this appeal, and it is their accurate recording that helps us convey that sense of wonder and beauty we find essential to our experience of crystals and gems.

If your orientation is more mineralogical, then accuracy of representation is of prime importance. There should be no ambiguity in the finished image. Specimens should be identifiable and undistorted, but they need not be plain and boring. Even within the constraints of the principles of "scientific illustration," there is a great deal of room for creativity. Background choice, color, and lighting are open to personal taste, as are the choices of the specimen itself, and its orientation.

SPECIMEN CHOICE

The first step in the photographic process is the choice of a specimen. Generally, the qualities that make a specimen a good one to begin with also make it a good photographic subject. These factors are color, freedom from flaws, a pleasing arrangement of crystals, and proportions. Rarity, locality, and size also make for a good specimen but contribute little to the making of a good photograph. The criteria for a good specimen are not enough in themselves to make a specimen

Figure 1-1a Calcite on fluorite from the Denton Mine, Hardin County, Illinois; 9.2 cm wide. (Severance Collection)

photogenic. For instance, the crystals may be so jumbled together that they will be hard to define in the photograph. Specimens with druses of tightly clustered crystals are difficult to photograph and usually come out as a mass of undefinable sparkles. It is better if the crystals are more isolated so that they are distinct and recognizable. Major crystals should also be in roughly the same plane so that when this plane is parallel with the film, depth-of-field problems are minimized.

A photograph of a flat matrix with a sprinkling of crystals will be far less dramatic than a close-up of crystals in pro file. Whenever possible, I try to isolate smaller groups of crystals to photograph instead of shooting the whole specimen. Of course there is good reason to photograph both ways. If I'm photographing for a dealer who is using the photograph to help sell the specimen, then I must include the whole piece in the frame. Then I take a shot that more pleases my aesthetic sensibilities. This way, both the client and I are happy.

It's important to keep in mind that the impression you get of a specimen that you are holding in your hand is a composite of multiple views. A photograph is trying to capture the essence of the specimen from a single angle, and is thus necessarily limited. The photographer is a mediator between you and the specimen. You see it in the photograph as he or she saw it or wants to present it.

You'll find that some fine specimens are just not photogenic. With experience, you will learn to recognize them before wasting a lot of time trying to get a good picture. You will also find that some minerals, such as azurite and dioptase, are notoriously hard to photograph due to the intensity of therr color. Lustrous black minerals can also be quite a challenge because of therr high con-

Figure 1-1b Close-up of left calcite crystal in Figure 1-1a; 3.2 cm high. (Severance Collection)

trast. You'll occasionally encounter colors that are beyond the sensitivity of films, and so will not record accurately. Such problem colors include blue fluorites, emeralds, and the blue barites from Stoneham, Colorado. The blue fluorite will turn a grayish purple; the emeralds will be green, but the wrong shade; and the barites will turn grayish.

ORIENTATION AND FRAMING

The next step in the process, that of orientating the specimen, may seem simple, but there are, in fact, many things of which you need to be aware. The first, and perhaps the most subjective, thing to determine is which side looks the best. Factors to be considered include such things as the pleasing arrangement of crystals, the display of main crystals to their best advantage, the visibility of any defects, and the position of catalogue numbers (which are best to avoid showing).

Turn the specimen around and view it from all sides, keeping in mind the aforementioned factors. At the same time, imag ine the specimen as it will be framed in the photograph. Will it work well with a horizontal or vertical framing? Should you photograph the whole specimen, or just part of it to avoid excess matrix or to emphasize one particularly fine cluster of crystals? *(See Fig. 1-1).* Sometimes it helps to look at the specimen with one eye closed to more closely approximate the two-dimensional view of the camera.

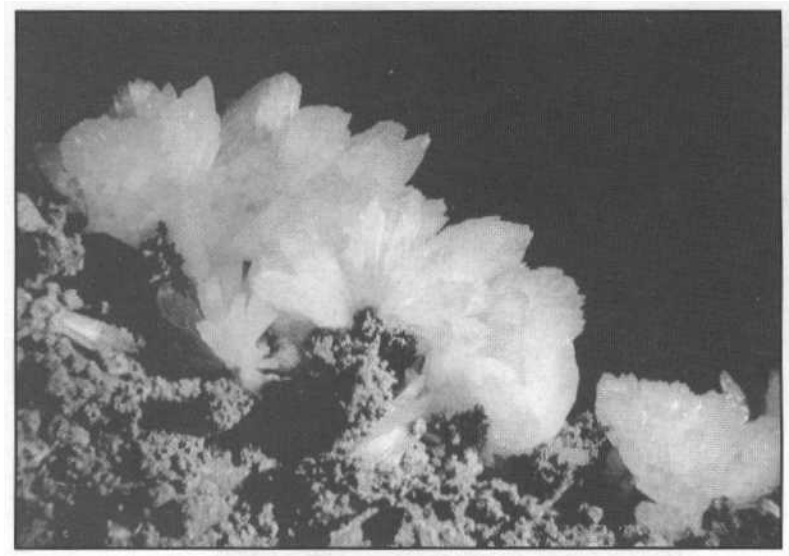


Figure 1-3 A shot of Legrandite (from Mina Ojuela, Mapimi, Durango, Mexico; field, 5.2 cm) showing that a diagonal horizon is more interesting than a leve¡ horizon. (Canadian Museum of Nature)

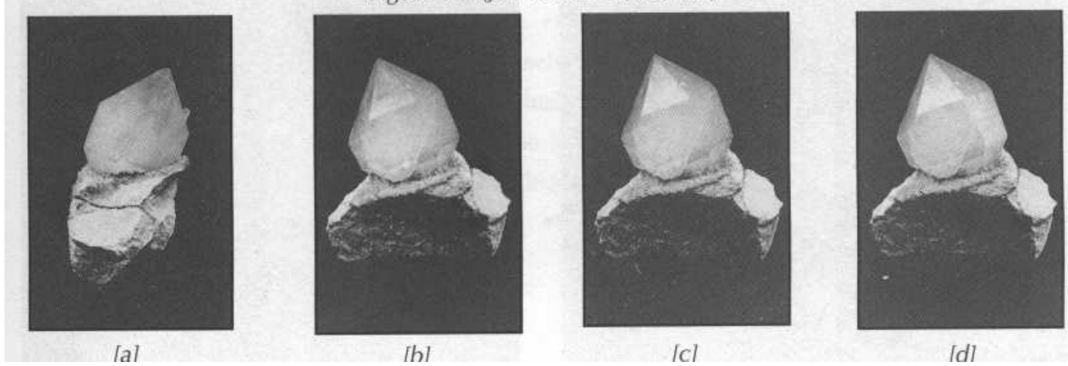
In general, people prefer that objects have their wider portions down and their narrower up, otherwise they look top heavy. An ideal example of this orientation is a pyramid. Columnar objects are always oriented roughly vertical; radiating objects, such as sprays of crystals, should spread upward, or possibly sidewise, but rarely downward.

The orientation of the specimen can be fine-tuned while viewed through the camera. The background you use, the lighting, and even magnification will each have its effect in the final orientation of the specimen.

Orientation of the specimen is closely tied to the composition of the photograph as a whole. Once you have determined the optimum orientation, the specimen must be framed pleasingly (Fig. 1-2). Seldom does the subject look good when placed dead center. Preferably, the center of the specimen should be slightly below the center of the photograph, and slightly to one side. If the base of a single crystal shows, it is often best to orient it vertically. If the base does not show, then it might be best to have the crystal run from lower left to upper right.

Make sure your framing is in relation to the shape of the specimen. The length of the format should be roughly parallel to the long dimension of the specimen. If the specimen is on matrix, it is often best to have the "horizon" formed by the matrix on the diagonal. This composition adds a more dynamic element to the picture, while a perfectly horizontal horizon is standard and boring (Fig. 1-3). Remember that, in general, compositions that are perfectly symmetrical, square, or horizontal tend to be static and less interesting Diagonals and asymmetry create more of a feeling of motion and dynamism.

Figure 1-2 (Jeff Scovill Collection)

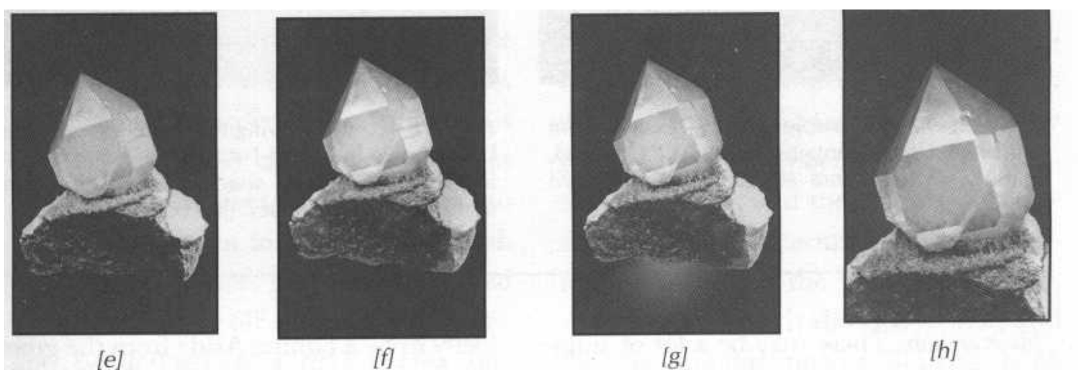


[a] Quartz from New Britain, Connecticut; 5.3 cm high; specimen not oriented.

[b] More pleasing orientation of specimen in [a].

[c] Top front termination face of specimen in [a] highlighted by main lights

[d] Right prism face of specimen in [a] highlighted with reflector to right



[e] Left prism face of specimen in [a] highlighted with reflector to left

[f] Bottom front termination face of specimen in [a] highlighted with reflector in front and below

[g] Background of specimen in [a] spotlighted by fiber-optic source

[h] Close-up of main point of interest-the crystal in [a]-with decreased emphasis on the matrix

An old rule of artistic composition is the "law of thirds." If you divide a photograph into thirds both horizontally and vertically, you get four points of intersection. Critical subjects are best located at these points. If you have a horizontal line in the photograph, such as a matrix horizon, it is best to locate it at one of the one-third division lines. As is the case with all rules, however, they are meant to be broken. Such rules are good starting points that often work, but even such rules when adhered to slavishly become boring.

Don't be afraid to get in close to the crystal. A common mistake by beginners is to lose the specimen in too much background. On the other hand, don't frame it so tightly that the picture looks cramped (Fig. 1-4). Keep in mind also that no law says the whole specimen must be in the

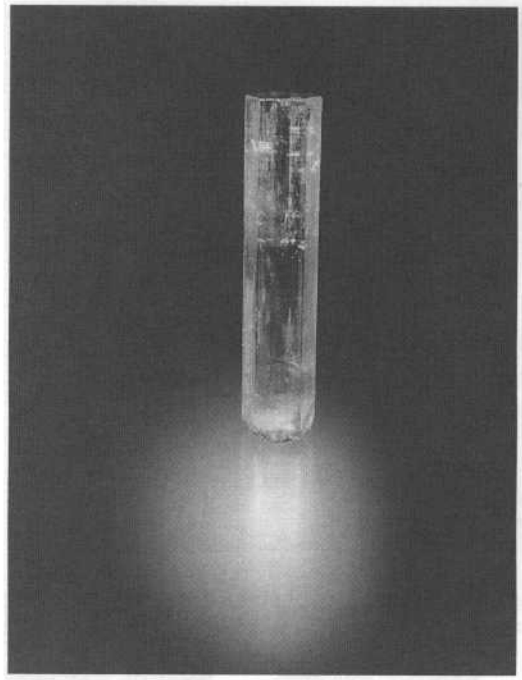


Figure 1-4a The subject here, beryl (from Mursinka, Ural Mountains, Russia; 4.8 cm long), doesn't fill the Trame adequately. (jeff Scovil Collection)

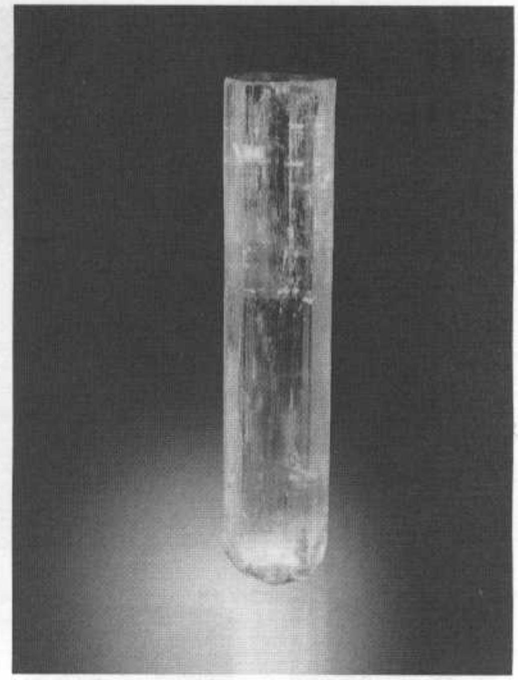


Figure 1-4b After moving the camera closer, the beryl shown in *Figure 1-4a* fills the Trame better, leaving less empty space and resulting in increased image impact. (Jeff Scovil Collection)

photograph. There may be a lot of uninteresting matrix that can be cut off, or one group of crystals on the matrix will show to best advantage with tighter framing.

BACKGROUND CHOICE

Backgrounds are discussed in greater detail in *Chapter* 11. They are obviously of critical importance in the aesthetics and composition of a photograph. Specimen choice, orientation, and framing may all be immaculate, but if the background does not work, then the photograph is likely to be a failure. Aside from the gross aspects of the subject itself, the background is usually one of the first things to strike the viewer. In *Chapter* 11, read especially the sections on color choice and lighting of the background.

SPECIMEN VERSUS MINERAL PHOTOGRAPHY

The topic of backgrounds leads us to consider "specimen" versus "mineral" photography. The latter is the more or less purist point of view that a mineral should stand on its own merits and not need any fancy backgrounds to set it off. Ideally, then, the matrix would be the

Shape and color are not enough in themselves to allow a viewer to appreciate or even to identify a mineral. The individual faces must be highlighted by light reflecting off of them. Faces may also be defined as a darker area surrounded by adjacent highlighted faces.

background, which is seldom the case except in micromounts. In specimen photography, the background enhances the subject and is quite necessary for specimens having little or no matrix. How far you're willing to go to enhance the specimen by means of a background is a matter of personal taste.

Assuming you are striving for some accuracy in your mineral photography, definition of the individual crystal faces is important. Shape and color are not enough in themselves to allow a viewer to appreciate or even to identify a mineral. The individual faces must be highlighted by light reflecting off of them. Faces may also be defined as a darker arca surrounded by adjacent highlighted faces. A good rule of thumb is either not to have adjacent faces highlighted, or to highlight them to different degrees (Fig. 1-2, *page 5).*

When carefully maneuvering your lights and specimen to highlight the faces, be careful not to get too bright a reflec tion. Too strong a highlight will create a burned-out white face with no detail and will be distracting. It's best to use diffused light that will produce soft highlights to retain detail. This detail, such as growth hillocks and etch pits, gives the specimen more character and conveys more information about the crystal to the viewer. See *Chapter* 8 for more details about highlighting.

WORDS OF ENCOURAGEMENT

The material covered here, such as composition and aesthetics, is subjective and can be difficult to learn. To stimulate inspiration and to help you learn, carefully examine the mineral photographs in mineral books and magazines. Study the photographer's specimen and background choice, and the picture's composition. Try to determine lighting techniques, including the number of lights, whether the light is diffused or not, and the type and direction of fill lights. Look for the same things in good advertising product photography, and, finally, look at fine art and other types of photography to gain a greater understanding of composition.

Every one of us starts out copying someone else's style. That is how we learn. As time goes on, we develop our own personal way of seeing and portraying our subjects. Style develops with experience while constantly striving for growth, new perspectives, and trying to do the best you can do. Style and skill development is a constant, never-ending process. It is a Zen-like process-you are never there, but always growing and learning. If you think you Nave reached mastery, you are either deluded or stagnant. That there is always something new to learn is part of the joy of photography and what we photograph.

CHAPTER 2

Specimen Considerations

PREPARATION AND HANDLING

The proper preparation and handling of specimens is critical to the success of your photography. The first consideration is that of cleanliness. Dirt, rust and various coatings are not only unsightly, but hide important features of the subject. Even specimens that appear clean may have a film of dust from sitting on a display case shelf and will benefit from a rinse or quick dip in the ultrasonic cleaner. lf the specimen is not your own, you are not always at liberty to clean it, and you should have the owner clean it if necessary. If more than a simple cleaning is needed, involved techniques may be required. Such methods are not within the scope of this book. For details on mineral cleaning, see Sinkankas (1972) and Pearl (1973).

If the specimen has been stored in a cotton-lined box, examine it carefully for cotton lint. The best way to do this is to hold it under a strong light against a dark background. Rotate the specimen and look for lint profiled against the background. Have a pair of good tweezers on hand to remove the lint. A safer method is to touch the lint with a bit of sticky putty you have formed into a pointed shape. For fine lint, you can use an air bulb to blow it off or to get finto crevices. lf an air bulb is not strong enough, you can use canned air as is sold for cleaning camera equipment and negatives in the darkroom (Fig. 2-1). Another option, if available, is the use of a compressor. When using one, be careful that the air pressure is not so high as to damage the specimen.

After the specimen has been cleaned and dusted, it must be handled carefully. Wash your hands before touching speci mens and be careful not to touch crystal faces, polished metal on jewelry, or faceted stones. It helps to do a final cleaning of crystal faces with a piece of lens tissue (but not if it is a very soft mineral). Be sure the lens tissue does not leave any lint. For jewelry, a jeweler's polishing cloth is handy. Be careful that the jewelry

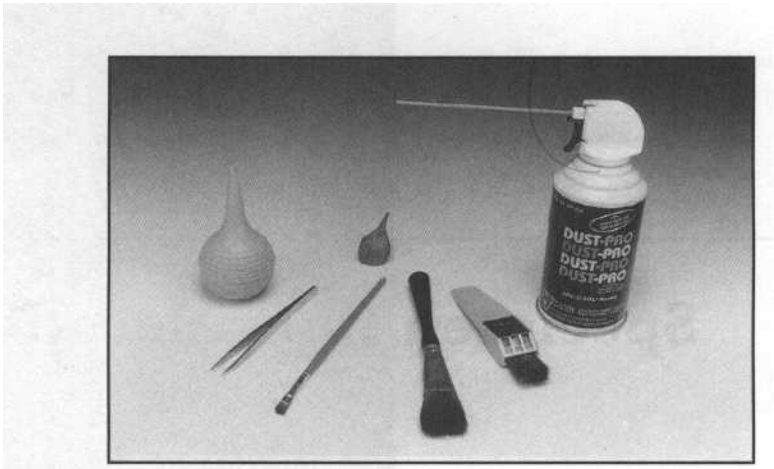


Figure 2-1 Tools for dust control. *Left to right:* air bulb, tweezers, putty, fine brushes, antistatic brush, and canned air.

To handle loose crystals, jewelry, and cut stones, wear the thin cotton gloves used for handling film in processing labs. Such gloves can be bought in a good photo supply store. Synthetie gloves are actually a little better because they are more lint free than cotton, especially after they are used a few times. Cotton gloves tend to get a little fuzzy as they wear.

is not damaged by the cloth. Some of the finishes are very delicate, such as the multicolored oxidized finishes popular today. When in doubt, ask the maker if possible. To handle loose crystals, jewelry, and cut stones, wear the thin cotton gloves used for handling film in processing labs. Such gloves can be bought in a good photo supply store. Synthetic gloves are actually a little better because they are more lint free than cotton, especially after they are used a few times. Cotton gloves tend to get a little fuzzy as they wear. To guard against this, don't reuse the gloves too many times (Fig. 2-2).

After setting up the shot on the well-cleaned background, make a final check for lint and dust. An air bulb, putty, or a fine sable brush is handy for removing dust at this point. A delicate touch is needed here so as not to move the subject you have carefully positioned. Cut stones can do pirouettes across the background with the slightest touch. When setting the specimen on the background be careful if it has crumbly matrix. Check around the base of the specimen to be sure there are no crumbs on the background.

SUPPORT

lt's seldom that a specimen sits in the position we wish it to for photography, and so it needs some sort of support. This support may be provided by something as simple as a block of wood to lean

Figure 2-2 Items for handling and cleaning specimens. Left to right: tweezers, lens cleaning tissue, jewelry polishing cloth, and cotton glove.

against. Found objects, or items from your camera bag, such as film canister caps, erasers, and bent paperclips can be useful.

The best material for propping is a nonoily, nonsticky, nondrying putty. These characteristics are important so that specimens or backgrounds are not damaged. A popular putty with mineral collectors for mounting specimens is called Mineral Tack and it is quite suitable for photography too. Its light blue color is not appealing, but as long as it does not show in the photography, that's not a problem. Another useful putty is Hold-It by Eberhard Faber, and it can be bought in office supply stores. It is white in color and not as sticky as Mineral Tack. I keep several types of putty on hand depending on my propping requirements.

The propping of a specimen can be a difficult and trying experience. The specimen's welfare should take precedence during the shoot, especially if it belongs to someone else. To have a specimen fall over and break is not an experience you should ever have. When applying the putty to the back and/or bottom of the specimen, be sure that there is enough to do the job. Place your head about where the camera will be for the shot. Manipulate the putty so that it holds the specimen in the proper position, but does not show. Be sure the putty is well attached to both the specimen and the background before letting go. When you do let go, do so slowly and watch the specimen carefully. If there are no signs of movement, continue setting up the camera and lighting. Once the camera is set up and the shot is framed, check once again that the putty does not show. Some specimens may very slowly tilt, and then suddenly fall over. The worst offenders are tall, thin crystals that afford very little surface to attach putty to, and little to hide it behind. Extremely gemmy, clear crystals are a problem too, as you can see right through them to the putty.

Because of the shape of some minerals, you can't use putty to prop them up.

The surface of the specimen on which it will rest may be irregular and not provide anything to hide the putty. In such a case, you may be able to make a "kickstand" out of a toothpick or something similar (Fig. 2-3). Take a toothpick, or piece of one, and put a dab of putty on both ends. Attach one end to the back of the specimen, and the other to the background material so that the specimen is leaning on it like a bicycle on a kickstand. Be sure that from the camera position it does not show. Sometimes, more than one toothpick is needed for stability. A paperclip bent in the shape of a V can make a stable support. The two legs of the V are in contact with the background material, and the point of the V contacts the specimen. If you are shooting on glass or Plexiglass, be sure that the base of the specimen does not slide out from under itself. You may have to put little dabs of putty under it to prevent slippage.

One way to deal with long, thin crystals is to photograph them on a paper background. Glue a need1e to the back of the crystal so that its sharp end projects below the bottom of the specimen. The needle is then pushed through the paper background and finto a soft material underneath such as styrofoam or cork. Be sure to use a glue that is easily soluble for case of removal. Model cement is good as it is quickly removed with acetone (nail polish remover). You may find that if the crystal has very smooth, lustrous faces, the glue will peel right off.

Another way to deal with the problem is with a hot-glue gun. This should only be used with nonporous crystals because the glue can only be peeled off. You should also be careful not to use hot glue with heat-sensitive crystals. Besides holding the crystal securely, the hot glue is nearly transparent and colorless, making it less visible through gemmy crystals.

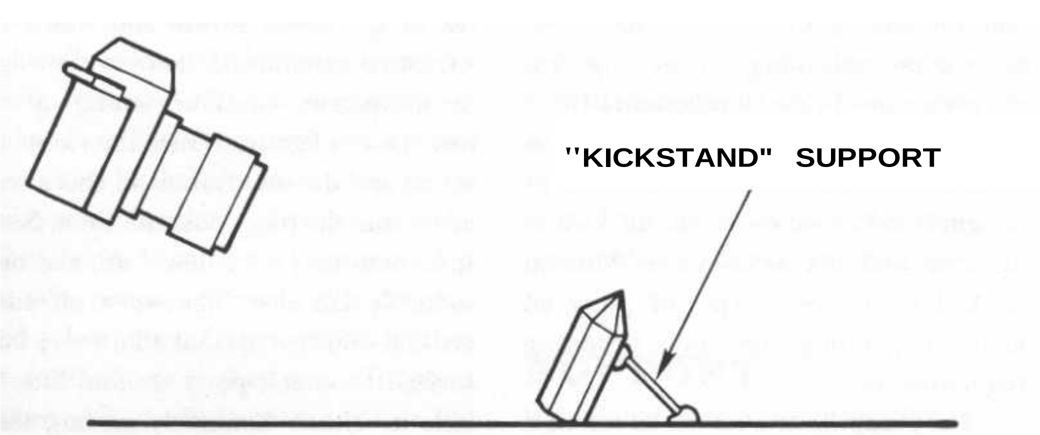


Figure 2-3 Kickstand-style support for instances when the standard blob of putty at the base of a specimen is impractical. Rod is held in place with dab of putty at either end.

Another material I´ve found quite useful is beeswax, which can be bought in small bars and is quite tacky. It is especially useful for holding gemstones in position. You will find that a very tiny bit goes a long way. Scrape a small amount onto your fingernail or the end of a toothpick and apply it sparingly to the stone. Be careful what you touch it to, as it leaves smears everywhere. You may also find that it is visible through the stone as a greasy looking spot.

SCALE

In the photography of minerals, gems, and jewelry, a scale is rarely used for aesthetic reasons. If a scale must be used, be sure it is clean, legible, and professional in appearance. Place it near the edge of the photograph so that it can be cropped out if necessary. It is critical that the scale be in the same principal plane of focus as the specimen. If it is not, you'll have a false sense of scale. If the scale is behind the subject, the subject will look proportionately larger, and vice versa.

Collector and dealer Rock Currier carne up with a novel way of including a scale in his photos. He uses as a scale a flat brass bar 1 inch long, with a line scored 1 centimeter from the end *(Plate 6).* In *Plate 3,* Stefan Weiss has used a hand for scale.

In the photography of fossils, an accurate scale in the photograph is usually necessary, especially if the photo is to be used for research and/or publication in a journal. Requirements for the scale and its position are the same as already discussed.

No matter the subject, an accurate record of its size needs to be made at the time of the shooting session. On 35-mm slides, the size as well as other data such as species, location, ownership, and date should be clearly marked.

CHAPTER 3

Cameras, Lenses, and Equipment for Minimizing Vibration

There are hundreds of cameras available to today's photographer, with thousands of accessories and features. In this chapter, 1 consider only 35-mm cameras because of their popularity, availability, versatility, and cost. Medium- and large-format cameras are discussed in *Chapter 4.*

Figure 3-1 A 35-mm single lens reflex (SLR) camera.

CAMERAS

There are basically two types of 35-mm cameras available: *single lens reflex* (SLR) and *rangefinder* cameras. An SLR, as its name implies, has one lens that is used both for picture taking and viewing (Fig 3-1). In most SLRs today a small hinged mirror sits at an angle in the light path between the lens and the film plane *(Fig. 3-2).* The mirror reflects the image up through a focusing screen into a prism that directs it to the eyepiece. When the picture is taken, the mirror flips up out of the way, then the shutter, located in front of the film/focal plane, opens and exposes the film. Such a shutter is a focal plane shutter.

In a rangefinder camera, the main lens is used only for picture taking *(Fig. 3-3).* The viewfinder looks through a small window above and to one side of the lens. The optical rangefinder is coupled with the lens mount so that focusing can be accomplished *(Fig. 3-2).*

Rangefinder cameras limit how close you can get to a subject and still get accurate focusing and framing because at

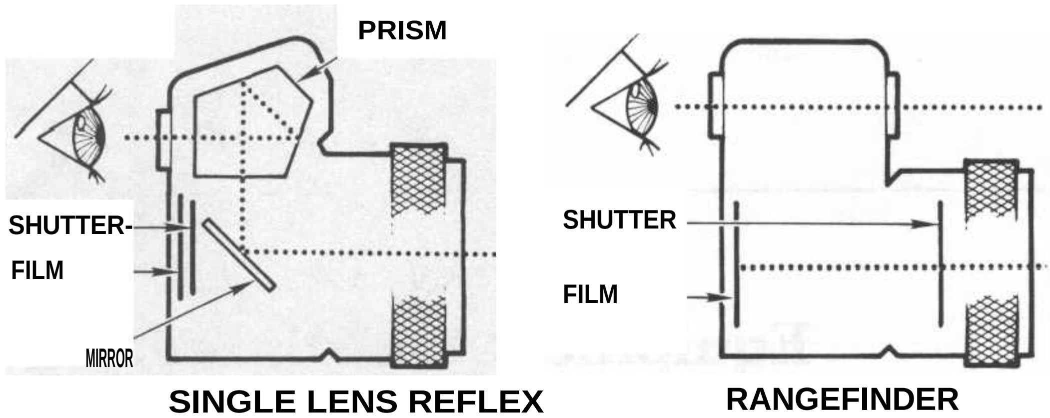


Figure 3-2 Light paths in single lens reflex and rangefinder cameras.

short distantes the rangefinder and lens are looking at different subjects. This condition is called parallax *error.* Some rangefinder cameras have a built-in parallax correction to overcome this problem, but it still does not help at very short distantes. Because of the parallax problem, 1 don't consider rangefinder cameras viable tools for the photography of mineral specimens.

Similarly, the numerous "point-and-shoot" cameras on the market today are very limited in their usefulness. They were designed for taking snapshots and do not Nave the ability to deal with the specialized needs of mineral photography. Such cameras do most of the work for you, but they have fixed lenses or, at best, a limited zoom capability (a zoom lens has the ability to change focal length). Your camera should have interchangeable lenses so you can use the accessories and different focal length lenses needed for close-up work.

SELECTED FEATURES

The range of features available on today's cameras can be truly bewildering. Some of these features are considered basic on any good SLR camera, while some are available only on automaed cameras. The following is a discussion of the advantages and disadvantages of some of these features.

Through the lens (TU) metering is standard on most of today's cameras, and while

lf you buy a camera with automatie metering, be sure it has an aperture priority funetion, which allows you to set the aperture and the camera to choose the shutter speed.

Figure 3-3 An older model Leica rangefinder camera. (Courtesy Bob Markow)

not a must, it will save you a lot of trouble. With TTL metering you get accurate readings of the light actually coming through your lens. You don't have to compensate for filters, extension tubes, or bellows, all of which reduce the amount of light reaching the film. If desired, you can use a hand-held light meter and then calculate the exposure and the compensation for the accessories. But this is a lot of extra work and something else to forget to do in the heat of a shooting session. Some cameras offer a choice of metering options, usually including *spot metering,* which is the most useful for our purposes. See *Chapter* 9 for details about metering.

Another handy but optional feature to have is a *mirror lock* that fixes the mirror in the up position before taking an exposure. This feature is helpful because it eliminates the mirror as a source of vibration during the long exposures sometimes necessary for close-up photography. There are ways to get around this problem though, so if your camera doesn't have this feature, don't worry about it. A difficulty with mirror locks is that, when engaged, you can no longer see your subject through the camera, and the mirror must be unlocked for each new subject. However, this is not a real problem in close-up photography. By the time you need to use the mirror lock you have already focused, composed, and set up your lighting and have no further need to view the subject.

Most cameras have a central split-image focusing screen, which is fine for most photography. When doing close-up work, however, it makes focusing more difficult by obscuring the subject. Some of the cameras designed for professional use have *interchangeable focusing screens.* In place of the split-image screen you can use a matte screen designed for photomacrography. Such cameras also have two other useful features for the eyepiece arca of the camera. The prism housing can be replaced with a *waist-level (right-angle) viewfinder* that allows you to look straight down onto the focusing screen. This feature is very handy when the camera is mounted looking down as in a copy stand set-up. Some cameras that do not have interchangeable focusing screens and prism housing have such a waist-level attachment that fits over the eyepiece. For those who wear glasses some camera makers offer *corrective lenses* that fit over the eyepiece. These can be very useful as eyeglass wearers cannot get close enough to the eyepiece to see the full frame.

Many cameras today have

Most are designed for the average picture-taking situation, not specialized applications such as close-up photography. Such features include auto focus, motor drives, auto exposure, data backs, and off the filmplane (OTF) flash metering. Some of those features can be handy, but are not really necessary for mineral photography, with the possible exception of a few as discussed in the following.

Metering is discussed in greater detail in *Chapter* 9, but a note here about automatic metering is appropriate. If you buy a camera with automatic metering, be sure it has an aperture priority function, which allows you to set the aperture and the camera to choose the shutter speed. This function is necessary because while shutter speed is of little concern to us, the aperture is of great concern. The aperture determines depth-of-field and sharpness of the final image.

The OTF flash metering could be extremely helpful when doing close-up mineral photography with a flash. Such photography can be very touchy with respect to exposure, and OTF flash metering would make the technique less problematic.

The data back feature enables you to put important data, such as date and exposure, directly on the edge of the neg ative. This feature can simplify record keeping but the data is not very attractive on color slides.

Another useful feature is automatic film advance and rewind. Advancing the film manually can knock out of align ment a delicate camera setup. Loading and unloading film can also be a touchy operation. Most cameras now have a DX cede reading system that allows them to automatically read the kind of film you have loaded and its ISO speed (formerly known as ASA). With this feature you'll never again ruin a roll of film by forgetting to change the ISO setting en the camera.

LENSES

When buying a new camera, you may be given a choice of lenses with different maximum apertures rated by f-number. The standard and least expensive is f 2 with fl.8, f 1 A, and fl.2 also available at correspondingly higher prices. For our purposes, a wide aperture is not critical, but small apertures are. So unless you have the money, it is not necessary to go after the f1.2.

The mínimum focusing distance for the standard 50-mm lens is about 18 inches. You'll need to get much closer than that to do your specimens any jus-

As we move back to use a longer focal length lens,
the perspective is compressed and the subject seems less distorted.
The ideal portrait lens has a focal length of about 90 mm.

tice. If your budget can take it, it would be wise to buy a macro lens. A macro lens is designed to focus much closer than a standard lens and attain as much as a life-size image (a 1:1 magnification ratio). The optics in such lenses are also better designed for close-up work and thus your photographs will be much sharper when using one.

Macro lenses fall into roughly two groups: those of about 50 mm and those of about 100 mm in focal length. The 100-mm lenses give you a little more working distance, meaning you will not be getting in the way of your own lights. Those in the 50-mm range, though, afford higher magnification with less extension and slightly better depth-of-field. On the other hand, a 100 mm gives slightly better perspective and representation of the subject because when you use a shorter focal length lens, you must move in closer to the subject to have it fill the frame. When you do, you expand the perspective causing a foreshortening of the subject. An extreme example of this would be the wide-angle portraits we have all seen where the person's nose appears abnormally large and the face obviously distorted. As we move back to use a longer focal length lens, the perspective is compressed and the subject seems less distorted. The ideal portrait lens has a focal length of about 90 mm.

Most macro lenses come in two parts: the lens, which can produce a one-half life-size image, and an extension that allows you to get a life-size image (a 1:1 magnification ratio). Some lenses, however, don't require this extra tube to go to 1:1. A macro lens does everything your standard lens will do, and more. So if your budget allows, buy a macro instead of the standard lens. Macro lenses are fairly expensive but they can save you a lot of time by not having to juggle extension tubes or bellows (see *Chapter 12)* for much of your shooting.

As for macro zooms, they will not get you as close as a macro lens, and their optical quality is not as good as a macro. The quality of macro zooms is quite good, but in order to function as they do, they have more optical elements than a comparable fixed focal length lens. The more glass you have in a lens, the greater the potential for optical aberrations. Such lenses are also more complex mechanically, which means more opportunities for misalignment of the optical elements. Their optics are also not designed for optimal performance in macro mode.

EQUIPMENT FOR MINIMIZING VIBRATION

Because of the longer exposures involved

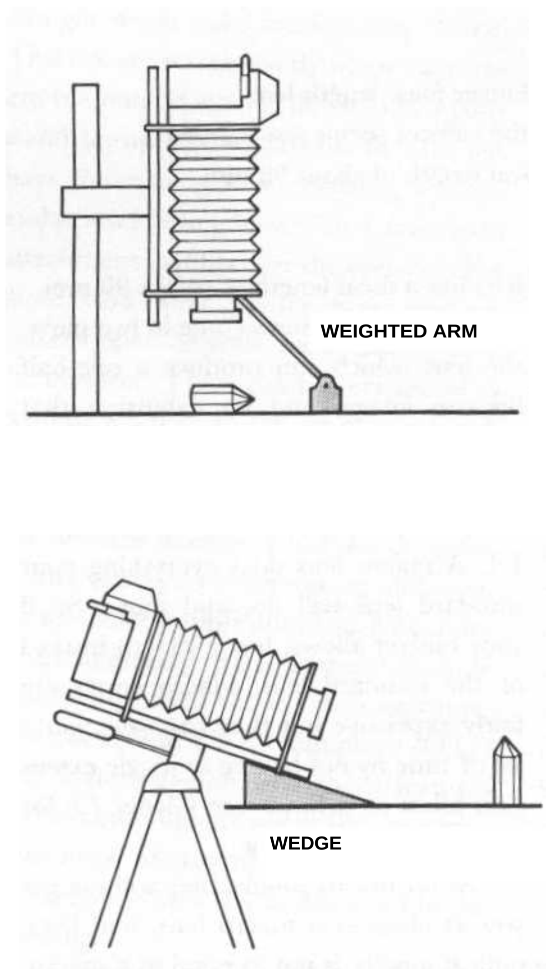


Figure 3-4 Use of a weighted arm and wedge to stabilize long bellows

in close-up photography, a steady camera mount is essential. A sturdy tripod is the answer, and the heavier the better. A lightweight portable tripod will work, but the heavier the tripod, the less chance of vibration ruining your work. There are also a variety of camera clamps on the market. They allow you to clamp the camera to the edge of a table or other convenient support.

Some photographers use a setup looking straight down at the specimen, which is especially useful for micromount photography. For this arrangement, a sturdy copy stand is needed to hold the heavier and less stable camera when fitted with an accessory such as a bellows. The extra weight of accessories also makes it harder to adjust the camera vertically on the copy stand. A copy stand with a gear drive is a good way to deal with this problem. A friction drive is less dependable because it may be subject to slipping with heavy equipment.

When using heavy equipment or tall copy stands, it is also wise to brace the stand. It can be bolted to the tabletop or floor and braced against a wall.

The longer the bellows or extension tubes, the more susceptible they are to vibration. To correct this condition you can attach a moveable weighted arm to the end of the tubes or bellows (Fig. 3-4). A heavy weight that rests on the table surface is attached to the arm, stabilizing the equipment. This arrangement is good for copy stand setups. Tripod-mounted setups can be braced by inserting a wedge between the end of the bellows or tubes and the table top (Fig. 3-4).

The table you use should be heavy and well braced. If possible, the floor should be concrete. If it is a wooden floor, it should be on the ground floor and not near anything that will cause vibration, such as a refrigerator or furnace. You should also stand still during exposures and not touch the table, the specimen, or the camera setup.

Koivula (1981) suggests the following for a vibration-proof table to shoot on:

Start with a solid, thick-topped table on which you place a dense rubber cushion, such as a typewriter pad. On top of the pad place a quarter- to half-inch thick steel plate, then another cushion. Finally, place a 1- to 3-inch thick slab of rock (cut, not necessarily polished). The rubber cushions stop short, sharp vibrations, and the steel and rock reduce rolling vibrations of longer wavelength.

Micromount photographers frequently use fiber-optic light sources. Many of these lights are fan cooled, and the motors can cause vibration. To eliminate this source of vibration, the light should not be connected to the table, but can be mounted on a shelf over the worktable holding your specimen and camera setup. You can also rest the light source on a thick, dense rubber pad. To help to reduce wobbling of the light source, place a book or thin board between the light and the pad.

The camera itself can be a source of vibration from the shutter opening and closing, and the mirror flopping up and down. Some cameras come with a mirror lock. If yours does not, employ the following procedure. When ready to take an exposure, turn off the room lights so that it is dark (you will probably have to short at night). With the camera set on B and a locking cable release attached, open the shutter, wait a few moments for vibration to cause, then turn on the photographic lights for the required exposure time. Close the shutter, turn the room lights on, and the shot is complete. This procedure is good only for exposures longer than one second. If you are using more than one light, they can be operated simultaneously by plugging them all into a switch-operated multiple outlet. An even better option is to plug all lights into a darkroom enlarger timer. Its phosphorescent dial can be set to the proper time for accurate exposures. When set on B, the shutter will remain open as long as the shutter release button is depressed.

For exposures of less than one second or of very long duration, shutter vibration should not be much of a problem. Vibration presents the greatest difficulty with exposures of only a few seconds. With long exposures, vibration time is short relative to the total exposure time and therefore has minimal effect.

CHAPTER

4

Medium- and Large-Format Photography

course on the subject of medium- and large-format photography, but an introduction to the basics and the advantages of the two formats. There are a number of good books that cover the topic thoroughly, some of which are included in the Bibliography (e.g., Koch, 1977; Koch and Marches¡, 1983).

MÉDIUM FORMAT

The definition of medium- and large-format photography includes both the type of camera used and the image size. Medium-format cameras are also called "roll film cameras" because they use rolls of film just as 35-mm cameras do. Most medium-format cameras are also reflex cameras, having a mirror that moves out of the light path during the exposure. Some are single lens and some are twin lens, the latter having one lens for viewing and another for exposing the film (Fig. 4-1). Medium-format cameras come in an incredible variety of styles. Some look like oversized 35-mm cameras, some are of the "old fashioned" twin-lens variety in which you look down into the finder, and some are the more standard single-lens style typified by the Bronica (Fig. 4-2).

Image size varies a great deal too. The usual size is 2 ¹/₄ x 2 ¹/₄ inches square (6 x 6 cm), but can also be 4.5 x 6 cm, 6 x 7 cm, and larger. The backs of most models are interchangeable so that only one body is needed when using diferent film types. This feature also permits the use of bulk film backs, digital backs (for digital electronic imaging for a few models), smaller format backs (e.g., 35 mm), and Polaroid film for test shots.

Lenses are completely interchangeable and on many cameras, so are film winders, finders, and metering systems. Medium format cameras are versatile, self-contained systems. Their advantage over 35-mm systems is the larger image and the removable backs. Their advantage over large-format units is their smaller size, greater speed and ease of use, and their reflex viewing systems. They find their greatest use in portraiture and fashion pho-

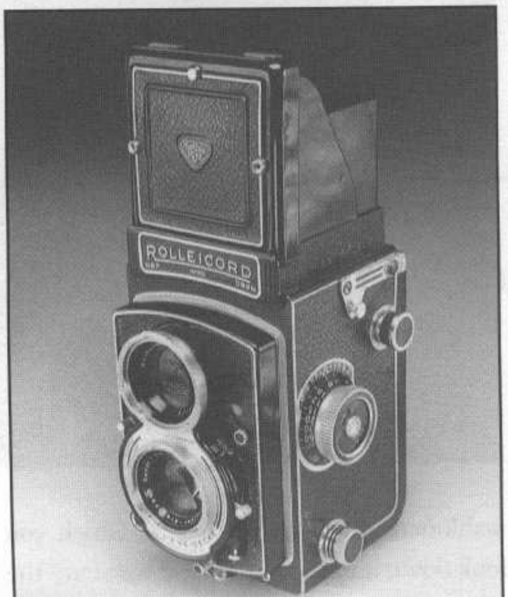


Figure 4-1 Rolleicord twin lens reflex (TLR) camera. (Camera courtesy of Photomark)

Figure 4-2 Zenza Bronica medium-format camera with reflex mirror as is found in a 35-mm single lens reflex camera. (Camera courtesy of Photomark)

Figure 4-3 Linhof Technika large-format 4 x 5 camera, with a retractable front standard and folding bed, for use in the field. (Camera courtesy of Photomark)

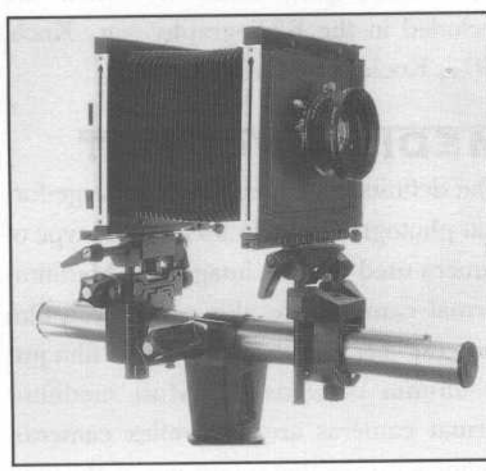


Figure 4-4 Sinar F studio 4 x 5 large-format camera.

tography where speed and case of use is an asset because of moving models. Medium format spans the gap between 35 mm and large format, having characteristics of each.

For those of you who wish for the versatility of a medium-format camera but like 35 mm, you have two options. Most medium-format systems have reducing backs so that you can shoot 35-mm film. A reason for continuing to shoot 35 mm is for the slides. While there are slide projectors available for medium-format transparencies, they are expensive and not compatible with 35-mm slide projectors. So you won't be able to mix the two formats for shows (unless you use special larger size mounts for your 35-mm slides), to borrow other peoples slides, or to lend them yours.

The second option is the Rolleiflex 3003, which is a 35-mm camera designed like a medium-format camera. It has all the features of that format but is slightly smaller.

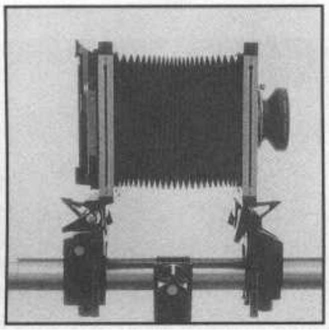
LARDE FORMAT

While the Image size of some of the smaller large-format cameras overlaps the Image size of the larger medium-format cameras, the greatest difference between the two formats is in the design of the camera. Large-format cameras are also known as "view cameras." They basically consist of a front standard that holds the lens and shutter. The rear standard holds the film, which is usually contained in a film holder that holds two sheets of film, one on each side. The film is protected from light and damage by a dark slide, which is removed from the camera-mounted holder before exposing the film.

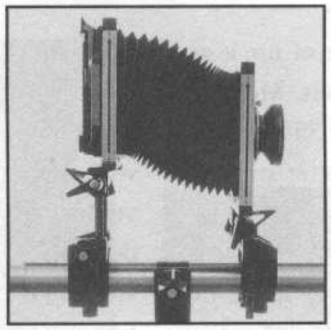
The standards have the ability to move vertically and laterally, and to rotate about vertical and horizontal axes. Viewing is done through a ground glass in the rear standard before insertion of the film holder. The two standards are connected by a bellows that excludes all light. All of the components are attached to a rail or bed. Image size ranges from 2'/4 x 3 1/4 inches to 16 x 20 inches and even larger. The standard size is 4 x 5 inches. Focusing is accomplished by movement of the standards because the lenses do not contain a focusing mechanism.

There are basically two types of view cameras: Flat bed or field cameras, and studio or monorail cameras. Flat bed cameras are so named because the components rest on a flat bed, which folds up for packing and for carrying the camera into the field. These cameras are usually made of a hardwood such as mahogany or cherry. More precisely engineered field cameras of all metal construction are often referred to as *technical cameras,* a good example of which is the Linhof Technika *(Fig. 4-3).* Technical cameras usually have supplementary viewing systems such as coupled rangefinders. A limited range of movements is possible with the front standard, and none with the rear standard.

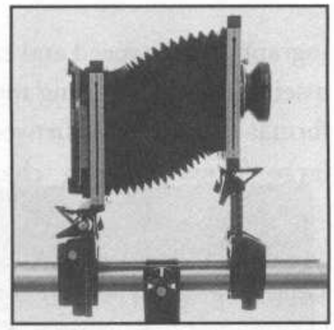
Studio or monorail cameras are designed primarily for studio use with the components riding on a single rail and both standards having a complete range of movements *(Fig. 4-4).* Studio cameras



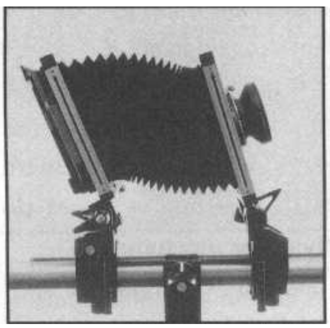
(a] Side view with all movements at zero points



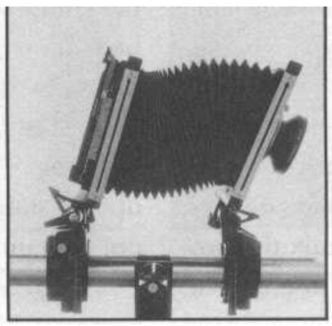
[b] Rear rise



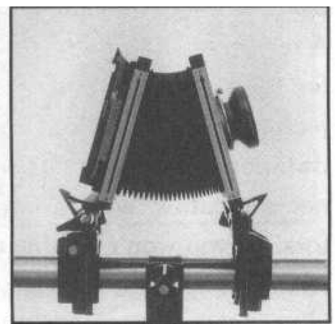
[c] Front rise



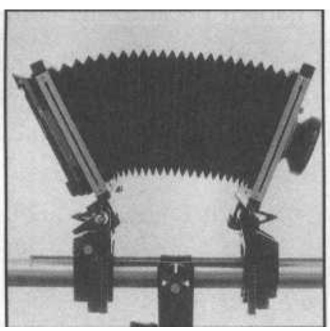
[d] Rearward tilt



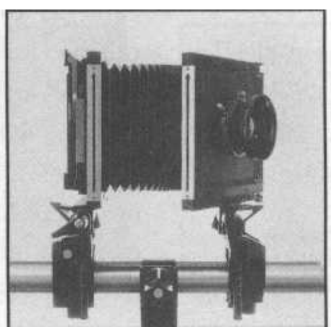
(e] Frontward tilt



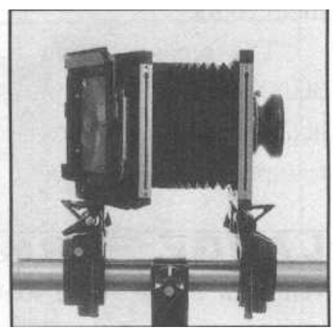
(fl Standards tilted toward each other



[g] Standards tilted away from each other



[h] Front swing [i]



Rear swing

[j] Front shift

Figures 4-5a through 4-5j

Careful placement of the plane of sharpness, along with selective focus can also serve to isolate certain subjects or portions of a subject. View camera movements also allow you to control cropping of an image without moving the camera or the subject.

are completely modular, with all components removable. With a studio camera, you can essentially custom build your camera to suit any possible shooting requirement and situation.

CAMERA MOVEMENTS

Vertical movements are called rises and falls; lateral movements are shifts; rotation about the vertical axis is a swing; and rotation about the horizontal axis is a tilt *(Fig. 4-5).* These movements have a number of important uses. We are probably all familiar with the "keystone" effect of a slide being projected upward onto a screen from a projector that is too loes The image on the screen is narrower at the bottom than at the top. We are also familiar with the apparent tapering of a tall building as we look up at it. You can get the same effects using the swing movements of a view camera. Now you might ask, "What good is this?" If we were to photograph that same building with a view camera and tilt the top of rear standard back, we would correct that distortion. By the same token, if we look downward at a tall object, it appears to taper from top to bottom. The tilts of a view camera can correct that distortion too. The same would hold true for a wall that is tapering in a horizontal plane. The taper could be removed by using the swing movements of a studio camera.

Another critical use for the cameras movements is the placement of the plane of sharpness. With a 35-mm camera and most medium-format cameras, the plane of sharpness is parallel with the film plane and perpendicular to the lens axis. You must be careful to keep key elements of the subject in a plane parallel with the film plane to minimize depth-of-field problems. However, doing so isn't always possible, especially with group photographs of a number of objects distributed on a horizontal plane. The depth-of-field obtainable by stopping the lens down all the way is seldom able to encompass the total depth of the subject setup. By using the tilt of the standards, you can place the field of sharpness parallel with the subject plane and still keep the camera at the necessary viewing angle, as shown in *Figure* 4-6. It is occasionally necessary to use several movements together to deal with complex situations.

Most lenses are not designed for maximum sharpness at minimum aperture (and maximum depth-of-field). The use of camera movements for optimal placement of the plane of sharpness can minimize the peed for use of extremely small apertures, thereby maximizing sharpness. Careful placement of the plane of sharpness, along with selective focus can also serve to isolate certain subjects or portions of a subject. View camera movements also allow you to control cropping of an image without moving the camera or the subject.

ADVANTAGES

There are numerous advantages to the use of view cameras. The first and most obvious is that the larger film size enables you to retain far more detail in a subject than with a smaller format. Any time an image is enlarged, it suffers due to enlargement of the film grain, focusing errors, depth-of-field problems, and dust or scratches on the image. AB these problems are minimized with large format because of the minimal enlarging necessary. A standard 8 x 10 inch print is about a 60x enlargement of a 35-mm image. A 4 x 5 inch image (which is about 25x the size of a 35-mm image) blown up to 8 x 10 inches is only a 4x enlargement. The larger image size also allows you to make much bigger enlargements than you can with 35 mm.

Larger images are also much easier to manipulate for purposes of retouching. They may also allow you to dispense with enlargements for some purposes by contact printing them. Any time an enlarger is used, a whole new set of errors can be introduced from enlarger lens aberrations, dust, and focusing problems. Contact prints are much sharper than enlarged prints, plus they are easier and cheaper to do.

The single sheets of film used in view cameras can also be processed individually for maximum image control. This capabil ity is especially important in black-and-white work. Since film batches can vary slightly, a single sheet from a series can be processed first to determine processing

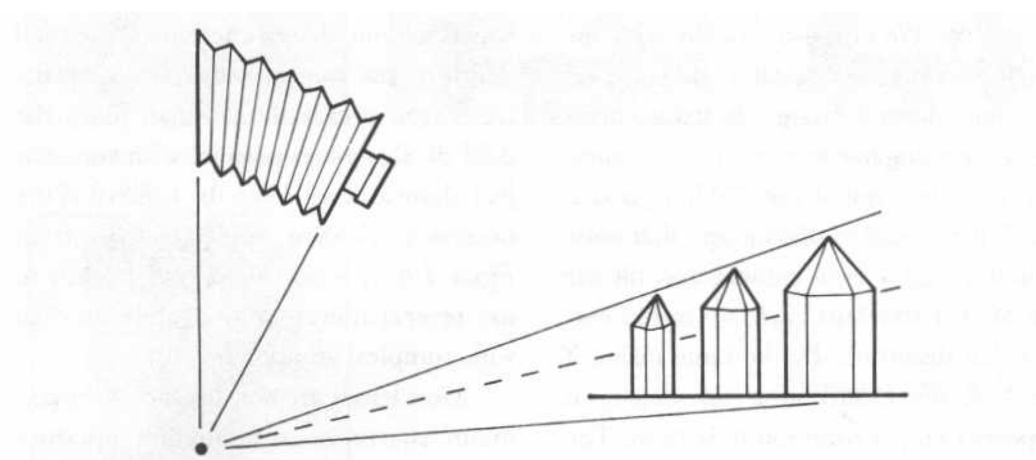


Figure 4-6 Use **of camera tilts to place the place of sharpness parallel to the major subject plane.**

needs for the rest of the batch or filtration for the rest of the shooting session. Sheet film has a thicker base than smaller formats, making it more durable and less susceptible to damage. There are also a greater range of emulsions available on sheet film than on roll film, including copying and graphic arts films. Larger original images are also preferred by most publishers.

Just as with medium format, switching film types or even formats is easy with large-format cameras. There is no need to keep several bodies around, loaded with different films as you would have to do with 35-mm cameras. The use of Polaroid film for test shots is also a great advantage. They are used to check composition, highlights, lighting, and exposure. Polaroids can be given to a client for approval before the final images are taken. This preview can cut down on reshoots, film, and darkroom time.

The advantage of movements for perspective control and sharpness distribution have already been discussed and need no further elaboration. With large-format cameras it is also easier to make multiple exposures using mattes and masks with precise placement of the images. The modular system of view cameras makes them much more versatile than smaller formats.

While most of the advantages of view cameras are restricted to that format, there are a few notable exceptions. A number of 35-mm cameras have available what is called a *perspective control lens.* Such lenses have the ability to rise and fall like the standards of a view camera. They are sold primarily for perspective control in architectural photography. Some of them can even shift laterally.

The Aragraph Corporation makes a bellows unit for 35-mm cameras that has all of the movements of a view camera.

Also available from Aragraph is a widefield lens to ensure that the use of the movements does not throw the image off of the film plane, plus adapters for various camera systems. It can also be used without the movements for macro work.

Medium-format users shouldn't feel left out, as Fuji makes the GX680 and GX680 II Professional. The 6 x 8 cm format camera has a front standard with the movements of a view camera, attached to the body by means of a bellows. Since it lacks the rear standard movements of a view camera, it is no substitute for one. However, it makes this medium-format camera much more versatile, and a fine hybrid of medium and large format, with advantages of both.

Hasselblad has just introduced their new FlexBody. It is essentially a lens en a bellows with a rear standard rather like a small view camera. Two other manufacturers are now making "miniature" view cameras. The Cambo 23SF has all the features of a larger view camera, but with an image size of 6 x 7 or 6 x 9 cm. Linhof has introduced the Technikardan S, a monorail-style studio camera with all the movements but in a 6 x 9 cm format, and the Super Technika, a flat-bed style field camera in a 6 x 9 cm format.

DISADVANTAGES

There are a number of disadvantages to the use of large-format cameras. They are generally more expensive to buy and operate, they are slower to use, and the lenses are slower. The latter means that their maximum apertures are not very large. Because they were designed for tripod-mounted studio work, fast lenses are not a necessity. Since each lens contains its own leaf shutter, they are fairly expensive. On the other hand, leaf shutters allow you to synchronize flash at any speed (most 35-mm film plane shutters synchronize up to 1/60 of a second). The longer focal length lenses require longer bellows extensions, which means greater light fall off and longer exposures. Depth-of-field is also less with longer focal length lenses. So while f-64 sounds great, it may actually only be comparable to f-22 on a 35-mm camera.

Most of the operational disadvantages are of little concern when you consider that view cameras were designed for studio use under very controlled conditions. The slowness of operation and of lenses is also not a problem because in the earth sciences and lapidary arts, the subjects generally are not moving.

MECHANICS

Because medium-format mechanics are not so different from that of 35-mm photography, here 1 discuss primarily large-format mechanics.

If you have a reasonably good grounding in the basics of 35-mm photography, then large format should not be too diffcult to matter. Because of the quality inherent in a large image, and the slowness of the process, large-format photography helps to bring out the best in you. Working slowly forces you to concentrate on details more, to fine-tune the image and your technique. Large format demands more of you in terms of effort and technical knowledge. Lens choice is no longer just a matter of image size, but of film coverage and appropriateness for the job at hand. The use of camera movements requires that you truly understand some basic optics, the path of light within the camera, and how those movements will effect the image. Extensive bracketing is commonplace in 35-mm work to assure proper exposure (with attendant waste of relatively inexpensive film). With large format work, the shotgun approach is not viable. Film is more costly per image and the time investment is greater, and so a more finely tuned approach is necessary. You will find that after working with large format, your 35-mm work will improve.

CAMERAS AND LENSES

The standard rule of thumb is to buy the best that you can afford. This does not mean that you have to break the bank to buy a view camera. There are many models to choose from, and all the bells and whistles will not make you a better photographer if you don't have the desire and put forth the effort. Check your local camera stores, camera clubs, and newspaper adds for used equipment. Some

With large format work, the shotgun approach is not viable.
Film is more costly per image and the time investment is greater,
and so a more finely tuned approach is necessary.
You will find that after working with large format,
your 35-mm work will improve.

incredible deals can be found with a little looking.

The most important thing on your camera is the lens. Some of the better known (and better quality) lenses are Schneider, Zeiss, Rodenstock, and Nikkor. Talk to the people at a good camera supply or to a professional photographer and get their recommendations. If you buy a used camera, have the lens cleaned and calibrated by a good repair shop.

SUPPORT AND VIBRATION

Good camera support and the elimination of vibration is even more important with large-format equipment than with other formats. Tripods designed for use with larger cameras are larger and more massive. The píate that the camera rests on is also much larger to provide better support. The use of a cable release is a must.

When you're finally ready to take the exposure after loading the film holder, setting the aperture, closing and cocking the shutter, and withdrawing the dark slide, you should wait for all vibration to cease. 1 usually wait at least 10 seconds before carefully squeezing the cable release.

FILM

Chapter 5 covers film in detail, but information specific to medium- and large-format photography is appropriate here. The major difference is that of size. Medium-format cameras use roll film just as 35-mm cameras do, but the film is not contained in a metal canister. It is, instead, covered by an opaque paper to protect it from light.

Unless you are using a reducing back to make use of roll film of a smaller format, view cameras use sheet film. Since you must load this film into the holders yourself, you will need to have a room that can be completely darkened for that purpose. A closet with heavy black felt or rubber strips added around the edges of the door will do the job nicely. If your makeshift darkroom is not quite lighttight, use it at night with the house lights out.

If you do not have a room you can convert to a loading room, most pro labs have one available for their customers. Bring all the holders and film you need for a planned shoot. lf hhere is a fluorescent light fixture in the room, check to make sure it does not phosphoresce for a long period after it is turned off . lf it does, it can fog your film. To check it, turn the light out in the loading room and wait several minutes until your eyes are dark adapted, then look at the light fixture.

Cleanliness is also important, be sure that your hands are clean before loading and that there is a clean surface on which to work. Inspect all film holders and remove any dust with compressed air. If you do not Nave a compressor, compressed air is available in small cans from camera supply stores.

Another great difference in films is the availability of instant, or Polaroid, films. Their usefulness in checking composition and lighting for customer approval has been mentioned earlier in this chapter. There are a number of Polaroid films available, including color, black-and-white, and positive/negative film, which produces a negative as well as a print.

Polaroid films do not require loading into a holder in a darkroom. They come prepackaged as single sheets enclosed in lighttight paper wrappings. For use, they are inserted into a special holder that is used in place of the film back or holder on the camera. For exposure, the paper covering is pulled out like the dark slide in the normal back/film holder, but it does not detach from the film. After exposure, it's pushed back in, a lever on the holder flipped, and the film removed from the holder. The lever closes rollers that squeeze the developing chemicals onto the film as it is withdrawn. After processing is complete (usually in less than a minute), the paper cover is peeled off and the print is finished. Some types, such as the positive/negative film, require a coating to protect the image after the paper is peeled off, and the negative portion must go through a special bath if you wish to keep it.

LIGHT SOURCES

There are few differences in the light sources used with medium and large format versus 35 mm (see *Chapter 6).* Because of the potentially longer exposures with large-format cameras, it may be necessary to use stronger light sources than you would for 35-mm work.

Some large-format photographers prefer to use studio flash because it minimizes vibration problems. I use mostly flash and find that for small subjects at small apertures, one pop of the flash may not be adequate. I use a fairly powerful unit of 2400 watt seconds and find that the average subject requires two to four pops of the flash at full power. This illumination may sound like a lot until you consider the light loss from using the main light in a soft box, shooting at f-45, the long bellows extension, and splitting the power with another head that is used for a background light.

Incandescent or "hot lights" are preferred by many photographers. They are much more controllable and come in a wider variety than flash. Incandescent lights are also less expensive than studio flash, especially if you use spodights and fiber optics.

METERING

Most medium-format cameras have built in metering just as 35-mm systems do, so there is no difficulty there. On the other hand, large-format view cameras do not contain metering systems. Metering is usually done with a handheld meter, with the standard calculations to take into account bellows extension. Taking Polaroid test shots is extremely useful as a check of exposure. However, warning concerning the use of Polaroid test shots for exposure determination is in order here. It is wise not to rely on the Polaroids for exposure determination. Just as different batches of one type of film can vary, so can two different types relative to each other. Theoretically, an instant film with the same ISO as the film you use for the actual shot should produce a comparably exposed picture. In reality this is seldom the case. Use of a good light meter that you are familiar with should be the basis for exposures, not Polaroids. Use of instant photos for exposure checking should be one of their minor functions. I've found that the Type 55 ISO 100 black-and-white Polaroid film 1 use is fairly consistently l/3 stop faster than the Kodak Ektachrome 100 Plus film that I use for most of my work. That doesn't sound like much, but since 1 bracket in l /3 stop increments, it is significant.

There are several light meter manufacturers who produce a meter with a probe. The probe can be inserted into the film plane for accurate spot metering. Several readings can be taken and averaged if necessary. Just as with built-in meters in 35-mm cameras, the use of such a probe means you do not have to make calculations for bellows factors. (See also *Chapter 9).*

MAGNIFICATIONS

Magnifications are achieved with medium and large format the same way as with 35-mm cameras (see *Chapter 12).* Macro Tenses, extension tubes, and bellows are available for many of the medium-format systems.

There are no special bellows needed for large-format cameras. The further you extend the bellows, the greater the magnification. A point will be reached where the bellows will extend no further, either because you run out of rail, or because that is the maximum extent of the bellows. To extend beyond that point you need to add another length of rail, and/or another bellows. Additional rails are easy to add, usually just by screwing on another length. Very long rails can get unwieldy and require the additional support of another rail clamp on a connecting base plate. The addition of another bellows means the use of another front standard as a connecting device and to prevent sagging of the long bellows assembly.

Just as with smaller formats, standard lenses are not designed for close-up and photomacrography. Special macro lenses are made for view cameras. They are rarely available in focal lengths shorter than the standard lens (ca 150 mm). There are lenses of a shorter focal length that require less extension, such as the Zeiss Luminar lenses.

While use of short focal length lenses reduces the need for long extensions and attendant long exposures, their use has some disadvantages. Foreshortening of the subject is undesirable, and the working distances can be miniscule. With a 50-mm lens, 1 found my lens-to-subject distance was less than 2 cm.

The use of other lenses, especially enlarger lenses, can yield excellent results as they do with smaller format cameras. To keep working distances reasonable, keep focal lengths longer than 90 mm. A problem with enlarger lenses is that they seldom stop down beyond f-22. This is a serious problem because the use of small apertures is necessary for maximum depth-of-yeld in photomacrography. Since enlarger lenses were not designed for use with view cameras, they may not be able to cover the image arca once you start using extreme movements.

Specialty macro and enlarger lenses do not contain shutters, so exposures must be taken another way. The dark slide is removed in a darkened room, the lights turned on for the proper exposure duration, the lights turned off, and the dark slide replaced.

FILTRATION

The filters for medium-format cameras screw onto the front of the lens the same as with 35-mm cameras. Gelatin filters can also be used with the appropriate filter holders.

Most filters for large-format cameras are gelatin and must be used with holders that do not attach directly to the lens. Because gelatin filters are more prone to damage than glass filters, some photographers minimize their potential for image degradation by attaching them to the back side of the lens. (See also *Chapter 10.)*

CHAPTER 5

Film

GENERAL CONSIDERATIONS

n any type of photography, film choice is important and is dependent on subject material, lights, and the use of the photographs. Color film is usually the choice for mineral photography because of the incredible range of colors found in the mineral kingdom. On the other hand, some photographers feel that black and white is better because it forces you to work more with form, line, and texture. If you have your own darkroom, black and white is less expensive and easier to work with, and you have much greater control over the results.

The *speed* of a film is a measure of its sensitivity to light. The higher the number, the greater the sensitivity of the film. Film speed is designated by an ISO number (formerly ASA number). In a film designation of ISO 64/19° the number 64 is the ISO number, an arithmetical measure, and the second number is the European DIN speed, which is a logarithmic measure. In this book I refer to films only by the ISO film speed designation.

Films with low ISO numbers generally are better choices than those with higher numbers. Though they are less sensitive and slower, resulting in longer exposures, they have advantages over faster, more sensitive films. Slower films have much finer *grain* and better *color rendition.* Fine grain is especially important if you plan on making large prints, and accurate color rendition is important for proper representation of a specimen.

Most films are DX coded, which means that the canister has a pattern of black and silver squares that is read elec tronically by the camera. The code tells the camera what the film ISO is, so if you forget to set the ISO on the camera, you will still get proper exposure. There is also a bar code on the canister as well as on the film itself. In addition, there may be raster (hole) pattern on the film leader. These codes give the film-processing labs necessary information.

**Slower films have much finer grain and better color rendition.
Fine grain is especially important if you plan on making large prints,
and accurate color rendition is important
for proper representation of a specimen.**

COLOR FILM

Color film is available as either *slide* (transparency) or *print* (negative) film. If you lecture, slide film is the obvious choice, but if you peed prints for display, use print film. Prints can be made from slides and though the quality of such prints is quite good, prints from negative film are less expensive. Print film tends to be less contrasty and is more forgiving of exposure errors than slide film. If you're having many prints made, the cost factor can be an important consideration. lf few prints are needed, you can kill two birds with one stone and just use slide film. 1 solved the problem by having two camera bodies on hand, one loaded with print film and the other with slide film. 1 can then shoot specimens with both films by just switching bodies. If you plan on having your color photographs published, slide film is a must, as that is what most magazines use for producing color separations for reproduction.

Color films are *balanced* either for daylight or artificial light. Daylight tends to be more blue due to its ultraviolet light content. Incandescent light is more orange, and many fluorescents are greenish. In order to use outdoor film indoors, you must use flash, which emits a daylight-type light, or use the proper conversion filter. Indoor film used outdoors also requires a conversion filter. (See *Chapter* 10 for more about filters.) Indoor films are balanced for different kinds of artificial light, so make sure that your film matches your light source. The data sheet packed with the film gives you the information you peed on color balance and light sources. Most film manufacturers have publications listing the films they produce and important data about them, including filtration needed for different light sources.

Probably the most popular transparency film used today for specimen photography is Kodak Ektachrome 64T (tungsten) Professional, code name EPY 64. The film is balanced for use with tungsten lights rated at 3200 kelvin, which is a standard studio light. It is very fine grained, has good color rendition, soft highlight contrast, and high resolving prwer. Because of its case of processing, most labs can process it in three hours. lf you process your own color film, the E-6 chemistry makes it easy to process at home. Another advantage to the short processing time is that you can finish a shooting session, process the film, and see if the results are satisfactory before tearing down your setup. The "Professional" designation on the Ektachrome means it is designed for immediate use and processing and therefore must be kept refrigerated until used. The only complaint I have about EPY 64 is that it cannot deal with certain shades of greenish blue.

Another excellent transparency film is Kodak Kodachrome 25. It has long been the standard by which color slide films are measured. It is daylight balanced and very fine grained, with a high resolving power and rich, accurate color reproduction. 1 use an 80a blue conversion filter to match it with my 3200 K tungsten lights. There are several good reasons for using Kodachrome. When using a daylight-balanced film, if you do not use the whole roll on specimens, you can take the conversion filter off and use the rest for outdoor photography or indoors with a flash. It also can record more faithfully the troublesome greenish blue shades with which the Ektachrome has difficulty.

The disadvantage of using a slow daylight-balanced film with conversion filters is that exposures can be very long. The 80a blue filter reduces your light about two stops and the use of extension tubes, bellows, and small apertures reduces it even further. The longer your exposure, the greater the chance of vibration blurring the picture. With longer exposures you may also run into the problem of *reciprocity failure.* When films are used at either extremely short or long exposures (beyond that which they were designed for) they have shifts in color and speed. As a result, the color will be incorrect and the photograph improperly exposed. These problems can be dealt with by increasing your exposure (experime ntation and careful record keeping will tell you how much) and by using a color compensating filter. A CC l OM is recommended for Kodachrome and 3200 K lights.

Another consideration is that of

30 or 40 years, while Ektachrome dyes may last only 20 years with accurate color.

There is, unfortunately, no one film that will equally and accurately render all colors. Kodachrome does well with warm colors (i.e., red) and Ektachrome is excellent for cool colors (i.e., blue). There are some minerals that are difficult to photograph with any film, the dark blue of azurite and the deep Breen of dioptase being cases in point.

When it comes to color print (negative) film, you'll encounter considerations similar to those for transparency film. One big difference, however, is that the vast majority of print films are daylight balanced. As a result, unless you use flash, you must use a conversion filter. The same rule equating fine grain with a lower ISO applies to print films, few of which have an ISO lower than 100. If you are not planning on having large prints made, you can use the faster films. They allow you shorter exposures and reduce the problem of vibration.

There are many other types of film available both by Kodak and other manufacturers. Experiment with different films and see which suits you and gives acceptable results.

BLACK-AND-WHITE FILM

There are numerous black-and-white films from which to choose. They have a range of ISOs from 25 to 4000 and often are designed for very specialized purposes such as infrared photography or copy work.

There are a number of advantages to using black-and-white over color films. Processing is easier and cheaper and is usually the first thing you learn to do in the darkroom. Color balance is of little concern, so you can use nearly any kind of light source without filtration.

Most black-and-white films available today are panchromatic, meaning that they are sensitive to all colors of light. This is not entirely true, as they are slightly more sensitive to blue. When shooting outdoors this characteristic means that blue skies will turn out a little too light. This problem can be corrected by using a light-yellow No. 8 filter. For the greatest accuracy, the same filter should be used when photographing blue minerals with daylight. When using incandescent lights indoors, use a yellow-green No. 11 filter. The green portion of the filter helps compensate for the excessive orange in incandescent lights.

Reciprocity failure must be contended with when using black-and-white films, but it only affects the film speed.

With black-and-white film you Nave much greater control over the end result. You can increase or decrease contrast, density, and tonal range in the film processing, and in printing, you can do all kinds of creative or corrective work.

Another major difference in color versus black-and-white is *latitude.* The exposure latitude is how much you can over- or underexpose the film and still retain detail in the highlights and shadows and produce an acceptable photograph. The latitude of a film is closely tied to how much contrast a film can handle. Films vary in their ability to handle wide ranges of light to dark tones and still retain detail in the extremes. The difference between the light and dark illuminated portions is known as your *fghting ratio.*

Generally, black-and-white films have the greatest latitude, followed by color print film, with color slide film having the least. For color work, the light arcas should be no more than three times as bright as the dark arcas, a ratio of 3:1. For black-and-white work, the ratio should not exceed 7:1. Some of the new color print films have an extended range and can tolerate a 4:1 ratio.

The exposure latitude is how much you can over- or underexpose the film and still retain detail in the highlights and shadows and produce an acceptable photograph.

You can see that more care must be taken in lighting for color work. The lighting ratio is controlled by relative place ment of your lights. Your main light provides most of the illumination, while other lights (or reflectors such as mirrors or cards) are used to fill in the shadow arcas and thereby decrease the lighting ratio. Fill lights are moved closer or further from the subject to establish the best ratio that can be determined visually and double checked with a light meter. This is where a handheld spot meter comes in handy unless your camera has TTL spot metering. You read the brightest and darkest arcas of the scene, and compare. A difference of one stop is a 2:1 ratio and two tops is 4:1.

Fine grain and low ISO also go hand-in-hand with black-and-white films. There are many options available in the low ISO range such as Kodak TMax 100, as well as much faster films such as Kodak Tri-X (ISO 400). Since black-and-white will always be used for prints, cower ISO, finer grain films are advisable.

Black-and-white prints can be made from color slides by copying the slide on black-and-white film then making a print. Unfortunately, whenever such copying is done, you lose detail and increase contrast. So if at all possible, use black-and-white film in the first place.

CHAPTER 6

Light Sources

The most important consideration in photography is lighting, for it is light that enables us to see the world around us and that creates an image on a photographic emulsion. There are two major sources of light: the sun and artificial sources. But before 1 discuss light sources further, 1 had better explain *color temperature* here.

Different kinds of light sources emit light with varying color characteristics. This variation is measured in kelvins (K). It is based on a hypothetical heated material that at red hot would be about 2000 K; at white-hot, about 5000 K; and at blue, over 6000 K (Freeman, 1984). It is by this Kelvin scale that films and lights are rated. Film color temperature must match that of the light source for accurate color rendition. If the temperatures do not match, a color-balancing filter must be used.

The proper filter can be chosen by checking the information sheet packed with the film or by consulting a reference such as Using *Filters KW 13* (Kodak, 1988) (See also *Chapter 10.)*

SUNLIGHT

The most obvious light source that few mineral photographers think about is the sun. It's free for the taking but does present some problems. As the day progresses, the color temperature of the light changes with the height of the sun above the horizon. The color temperature also varies depending on how overcast the sky is and whether it is foggy or smoggy. Color temperature also goes up (becomes bluer) in the shade. All this means that it is difficult to maintain constant and accurate color rendition using sunlight. Another problem is long shooting sessions under a hot light source you cannot turn off. You may find experimenting with the sun as a light source worthwhile though. Dr. Erich Offermann, a fine Swiss photographer, has done a great deal of excellent mineral photography using just sunlight (Wilson, 1975) *(Plate 7).*

Direct sunlight is often too harsh, producing deep shadows and high contrast. When using the sun as a light source, it is best to shoot in open shade, or shoot under a diffusing material that can cover you and your photographic gear, or just the subject. Fill illumination can be provided by white cards, foil, or mirrors, just as you would with artificial light sources.

ARTIFICIAL LIGHT

CONSTANT SOURCES

There are many different kinds of artificial light sources available. The most common is a *tungsten bulb,* such as the standard household lightbulb. Tungsten bulbs for photographic purposes are rated in two ways: by their wattage and color temperature. The most common wattages are 250 and 500. Color temperature is usually 3200 K, for use with Type B color films. With their slightly bluer light, 3400 K bulbs are suited for the less common Type A professional films. Tungsten bulbs with a blue tint (rated at 4800 K) are also available. They approximate daylight, but must be used with a cooling filter to equal the approximately 5400 K of daylight when used with daylight film.

A problem with tungsten bulbs is that as they get older, their color temperature changes. For accurate color rendition the bulbs should be changed before they get too old (about 3 hours for 500-watt bulbs). Another type of bulb, the *quartz halogen,* maintains its color temperature throughout its life. Photographic halogens are much smaller than tungsten bulbs and Nave higher wattages, generally 750 or 1000 watts. Their disadvantage is that they get much hotter and are more expensive than standard photoflood bulbs. Tungsten and halogen light sources are known collectively as "hot lights."

Don't be tempted to control the relative brightness of your lights by varying their voltage. When you change the volt age you change the color temperature too. However, if you are shooting in black and white, you peed worry little about color balance, and thus, varying the light voltage might be a useful way to control your light ratio. (For more information on this topic, see the discussion of reflectors in *Chapter 8.)*

Any household light can be used for black-and-white photography. Because they come in so many varieties, color temperature can be a real problem, though, when such lights are used for color photography. Since they were not designed for photographic usage, their color temperatures are not generally available. Often the dealer or manufacturer of the light source can tell you its color temperature. Photographic data books that publish ranges of color temperatures for different types of light sources provided limited information on the color temperature of nonphotographic lights.

If the information is not available, the color temperature may be determined by the use of a color temperature meter. Several brands are available at better camera stores. Such meters are fairly expensive, especially considering the limited usage you will probably give them. You may be able to borrow one from a photographer friend, or rent one from a professional photography supply store.

It was determined by Wendell Wilson (Wilson, 1987) that the Tensor Model 6500 Super Swivel high-intensity desk lamp has a color temperature of 3198 K. This color temperature is quite close enough to the ideal for use in photography with tungsten-balanced films. There are several advantages to using these lights: they are inexpensive, light, and portable, and relatively cool because they are low wattage. Diffusing materials can be taped directly across them without fear of burning the material or discoloring it. Unfortunately, the #6500 has recently been discontinued. If a used one can be found at a yard sale or flea market, it is well worth getting. The only comparable lamp Tensor makes is a Model 8500, which is the same as the 6500 except that it has two bulbs in the reflector. I'm told though, that it too is scheduled for extinction. The Art Specialty Company of Chicago has taken over production of the Model 6500, but calls its version #5120.

Fluorescent lights are one source of light of little use photographically. Just like household light bulbs, they come in a variety of color temperatures and are difficult to filter properly to balance with films. There are some fluorescent lights balanced for 5000 K daylight and used in high-quality light tables for viewing photographic transparencies. *Neon lights* present problems similar to these of fluorescent lights.

The Rosco company makes a line of color correction gels for the purpose of raising or lowering the color temperature of light sources. The line includes gels for converting tungsten temperatures all the way to daylight, daylight sources to tungsten, daylight to fluorescent, and fluorescent to daylight. Gels can be obtained that make the conversion in small steps, if you just want to warm up or cool down a light source a little.

FLASH SOURCES

Another source of artificial light is

burst of intense light, with a duration from 1 / 100 of a second to 1/50,000 of a second depending on the unit and its setting. The color temperature of flash is usually 5500 K. Flash lighting comes in an enormous variety of small portable units, or as larger more powerful studio

Some minerals, such as sulfur, are very sensitive to heat and crack when exposed to hot lights. Other minerals, such as realgar, are photochemically reactive and permanently change composition and color when exposed to light for prolonged periods. Heat can also dehydrate some minerals, causing them to turn milky and even powdery.

units. The studio flashes have the advantage of including an incandescent modeling light that is used to illuminate the subject at a much lower intensity until the actual exposure is taken with the flash.

With its low heat output, flash is especially advantageous for close-up work that often requires long exposures with hot lamps. The heat output of right sources is of great concern to micromount photographers who may find that some of the older microscope lights are so hot that they melt plastic micromount boxes and scorch paper. Also, some minerals, such as sulfur, are very sensitive to heat and crack when exposed to hot lights. Other minerals, such as realgar, are photochemically reactive and permanently change composition and color when exposed to light for prolonged periods. Heat can also dehydrate some minerals, causing them to turn milky and even powdery.

The heads on most studio flash systems are fan cooled, making even the use of modeling lights safe. Some of the more expensive studio incandescent lights are also fan cooled. The cooler operating temperatures of studio flash also make it possible to use a wider range of light-modification accessories, which would either become incredibly hot or burn up with tungsten or quartz halogens.

The power of studio flash units is rated by their output. The measurements used are watt-seconds or joules, which are equivalent. Units range from 100 watt-seconds to 4800 watt-seconds. The power supplies can be either separate, as is the case for the more powerful models, or built right into the light heads, as is the case in many lower powered units. Nearly all of these units have variable power output. On the built-in models, it is adjusted by switches. In the big units it is controlled by switches, the number and kind of heads you are using, and where they are plugged into the power pack. For most 35-mm work, 400 watt-seconds should be sufficient. For large format work, a 2400 or even a 4800 watt-second model may be necessary. Several power packs and their attendant right heads may be used simultaneously for extra power. (See Fig. 6-1 for examples of different right sources.)

A more specialized type of flash is a *ringlight.* It has a circular flash tube that

Figure 6-1 **Light** *sources. Top* **to bottom: studio flash, incandescent bulb in spotlight housing, and quartz halogen.**

fits around the end of the lens. Ringlights are designed for close-up photography but produce a very flat, even illumination that tends to reduce the three-dimensional nature of crystals. The use of a ringlight is usually not recommended.

Lacking modeling lights, small portable units, and those that come built into cameras, are of limited use because you can not see exactly what you are going to get until after processing the film. With a little practice you can get good results, though still with the lack of fine control. Rock Currier *(Plate 6)* has done some fine work with small flash units.

Flashbulbs are also a source of artificial light. I don't discuss them here, though, because they are not useful for mineral photography for the same reasons as portable flash units, and they are seldom used any more.

FIBER-OPTIC SOURCES

Keeping the size of your lights proportionate to your specimen size is an important consideration. The larger your lights are, the more difficult they are to control and maneuver. The use of smaller lights also makes for smaller catch lights those small reflections you see that cause an object to sparkle. The smaller the catch lights, the less obscuring and distracting they are. If all you Nave are lights in reflectors, removing the reflector (or painting it black with a high temperature paint) will reduce the size of catch lights (Kodak, 1969).

Microscope lights are excellent light sources for illuminating small specimens

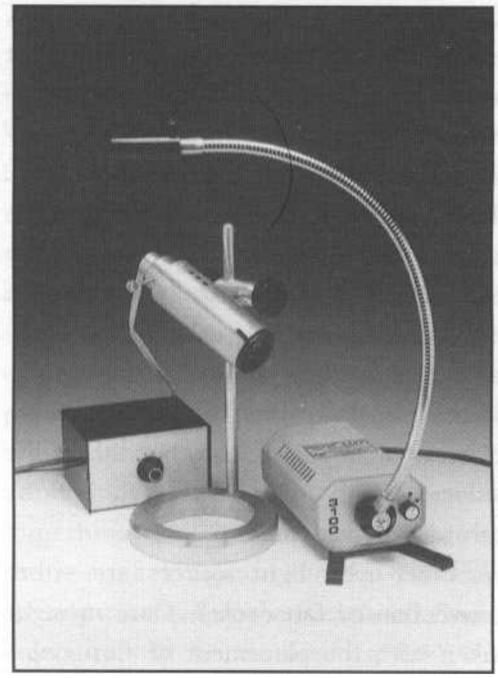


Figure 6-2 **Microscope lights: de Haas incandescent** *(left)* **and Dolan Jenner quartz halogen fiber-optic** *(right)* **lights.**

such as thumbnails and micromounts. Many of them are focusable, with variable light output. A much better alternative is a fiber-optic light source, most of which also have variable light output as well as focusing capability. Their advantage is that the hot light is at a distance from the specimen with its light transmitted via the fiber optics. Keeping the heat from the specimen is important during the long exposures often necessary for close-up photography. Because of their flexible, armored light guides, they are also highly maneuverable and self-supporting, easing photographic work (Fig. 6-2). (See also the discussion of light sources in *Chapter 13.)*

An interesting fiber-optic lighting unit is available from Chiu Technical

Corporation. It is the R-90 ringlight, consisting of a standard fiber-optic light source feeding into a flexible, armour-sheathed guide that terminates in a ringlight that fits around the camera lens. The ringlight has eight point light sources, the angles of which relative to the lens axis are adjustable by means of a rotating disk that keeps the light sources aimed at a single point of convergence. With this unit, you have the lighting effect of a ringlight flash, but the ability to see exactly what the result will be through the viewfinder.

Fiber-optic light sources are either convection or fan cooled. Care must be taken with the placement of fan-cooled models. Vibration caused by the fan can ruin your long exposures. If the unit does vibrate, you may be able to place it on a surface separate from that of the camera and specimen. Another option is to place a vibration damping pad beneath the light unit (a dense foam pad with a small board on top for stability of the light will do). If you can't afford an off-the-shelf unit, you may be able to make one yourself, or have a friend make one for you if you lack the electrical know-how. The basic light source can be made from a used film strip or slide projector (watch your color temperature). Fiber optic bundles may be bought from supply houses such as Edmund Scientific.

Fiber-optic light sources usually come with either a single light guide or one that is split into two separate guides, each with its own focusing lens. When making your own, a number of smaller light guides can be used together, each one carefully aimed for optimum illumination of the microscopic subject. Rermenber that each time you add another light guide that splits off the main guide, you are reducing the light output of each guide.

HYBRID SOURCES

There are advantages to the use of either tungsten or flash light sources. Tungsten is generally less expensive, you Nave somewhat greater control, and you can work with longer exposures if you want them. Why would you want them? Light painting is one reason (see *Chapter 7* for more on that subject), and another might be for special effects such as time and multiple exposures. Flash, on the other hand, can give you a great deal more power that (with the exception of fiber optics) is cooler, daylight-balanced (so if you want to use daylight balanced film you won't have to bother with pesky filters), and of short duration so that you don't have to worry about vibration.

Sometime back I was thinking about the advantages of combining flash with fiber optics-what a wonderful union that would be! After a bit of research, I found that several such units are commercially available. Elinchrom, a Swiss manufacturer of studio flash equipment, makes the Fiber Lite Kit. The Fiber Lite Kit is designed to fit any of their standard flash heads (and maybe other brands with a little tinkering?). The system has a mounting cap that can hold up to three fiber-optic light guides, each 20 inches long. The guides are not self-supporting, but come with adjustable stands. An assortment of snoots and lenses, and a gel cutter also come with the system. The Fiber Lite Kit runs about $1600 and is distributed by Bogen in the United States.

A somewhat more sophisticated system is Fibrolite by Broncolor, another Swiss manufacturer of studio flash. The system does not attach to existing flash heads, but is a unit containing a flash light source with four ports to accept as many fiber-optic guides. Each outlet is adjustable across three f-stops and has its own 75-watt halogen modeling light. The unit is powered by most Broncolor power packs. The system includes the following: four 100-cm long fiber optic guides, focusing lenses, filter holders, color filter, grey filters, stand arms, stand clamps, the Fibro stand base, and a two-arm swan neck with semiflexible, 75-cm long fiber-optic guides. The system is available in several versions in a range of prices from about $1700 to $5000.

The Microlite System is made by Balcar and is designed to fit on the head of existing Balcar head or Monobloc. It holds up to three 42-inch light guides held in position by stands. Accessories include diffusers, spot attachments, and filters. The basic system costs about $900.

Another interesting system is the Macrolight Plus by Novoflex. The unit contains a 150-watt modeling light and three light guides, and comes with focusing lenses and filters. A port in the unit accepts portable and studio flash units. The system runs about $950.

If three fiber-optic/flash hybrids sound wonderful but expensive, take heart-you can build something similar for a lot less money (assuming you already own a studio flash system). Fiber-optic guides can be bought individually in a variety of lengths and styles, some that will even accept focusing lenses. One end is mounted so that it is nearly touching the flash tube/modeling light assembly in the flash head. You can combine something to hold them in place with something to contain stray light by reversing a reflector on the reflector already mounted on the flash head. Some ingenuity will be required to design a mounting system and still allow for ventilation. The guides enter through the opening where the bulbs would normally go. The opening around the guides will also have to be plugged to support them and block light not being directly transmitted by the guides. I´ve seen a similar setup using instead the standard bulb protector. The foam padding is removed, backward angled slots cut in the sides for ventilation, and holes drilled in the end to accept the light guides.

CONTROL OF LIGHT

Whatever light source you use, control is critical. You must be able to get your light on the subject, keep it off what you do not wish illuminated, and manipulate it to get the desired results. To control light, whether incandescent, flash, or even sunlight, it can be concentrated, difused, or reflectod.

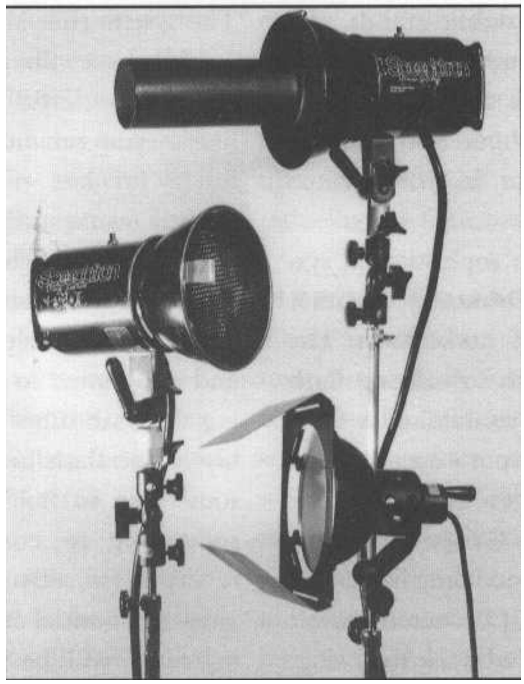


Figure 6-3 **Light restricting devices. Top to bottom: snoot, honeycomb grid, and barn doors.**

CONCENTRATING LIGHT

The primary reason for concentrating light is to direct it to a specific arca. When a bare bulb is used, the light spreads in nearly all directions. Various sorts of housings are used to concentrate its light for greater efficiency, intensity, and control. When lights are housed in a large metal reflector they are called floodlights, and the light is spread over a fairly wide arca. Reflectors of smaller diameter and greater depth reduce the spread of light. To further reduce the arca of coverage, a cylindrical tube or "snoot" is placed over the light source. To this can be added a reducing ring that further restricts the light's coverage. Even greater restriction can be attained by using a cone. It's similar to a snoot, but is tapered instead of having parallel sides. Snoots and cones actually do little to concentrate light, they primarily restrict its coverage *(Fig. 6-3).*

A similar effect, but with more control is through the use of a honeycomb grid (which looks like its bee-made counter part, except in black metal). It creates a spodight effect but is less expensive than a spot *(Fig. 6-3).* Honeycomb grids usually come in sets of three, with the holes in each of a different size. Each has a different degree of coverage usually in the following ranges: 35-40°, 25-30°, and 15-20°. Honeycomb grids can be used in various combinations to give different

Figure 6-4 Soft box for diffusing light and enlarging light source. (Litedome by Photoflex)

angles of coverage. One small disadvantage of using grids is that they reduce the amount of light transmitted to the subject.

When a bulb is mounted in a cylindrical housing with a focusable lens in front, it is a spotlight. Lenses can be of either a standard configuration, or more commonly the Fresnel design with concentric ridges. Spotlights concentrate light and keep it within a small arca (see Fig. 6-1).

Another way to control light is through the use of barn doors, which are movable, black flaps attached to the reflector. They come in sets of two or four per reflector, and on some, the flaps are adjustable in shape to fine-tune your light control (Fig. 6-3).

An advantage of light concentration is that the light has a specific shape, controlled by the light-concentratiog device. Snoots and spots create round shapes, and barn doors create straight edges. Keep in mind that the further the light source from the subject, the softer the edges of the shadows will be.

These lighting techniques have characteristics other than coverage that must be kept in mind. Floodlights give broad diffuse highlights and shadows with indistinct edges and some detail. Spotlights produce small specular highlights and shadows with distinct edges and no detail.

DIFFUSING LIGHT

Diffusing accomplishes two things: a spreading of the light source so that it is effectively larger, and changing the quality of the light so that it is "softer." The primary reasons for diffusing light are to soften shadows and to reduce harsh reflections from shiny surfaces.

Diffusion can be accomplished a number of different ways, each with a subdy different effect. Options include reflecting light off a white photographic umbrella or using the light transmitted through it; the use of various materials in front of the light source, including opal glass, Plexiglas, double matte drafting Mylar, finely woven white cloth, tissue paper, Lexan Plastic, and white ripstop nylon; or the use of a deep-bowl, matte reflector. There are several companies that make materials designed specifically as diffusers. The Rosco company produces a line of colored and textured gels for filtering light, as well as diffusion materials that come in three different grades for different degrees of diffusion.

Some of three materials are flammable and should not be placed near very hot light sources, particularly the photofloods and halogens. If the light sources are low wattage and fairly cool, the diffusing material can be taped over the reflector using masking or photographic tape. Otherwise, they must be held a distance in front of the light in a suitable frame. Such frames or "gel holders" can be bought at a good photographic supply house or be homemade.

Be careful when choosing materials for diffusion, as they must be colorless or neutral so as not to alter proper color rendition of the subject.

When photographing highly reflective subjects, you can build up several layers of material for greater diffusion. When doing so, you may find that what is fairly neutral in a single layer has a definite color when in multiple layers. If that's the case, use a

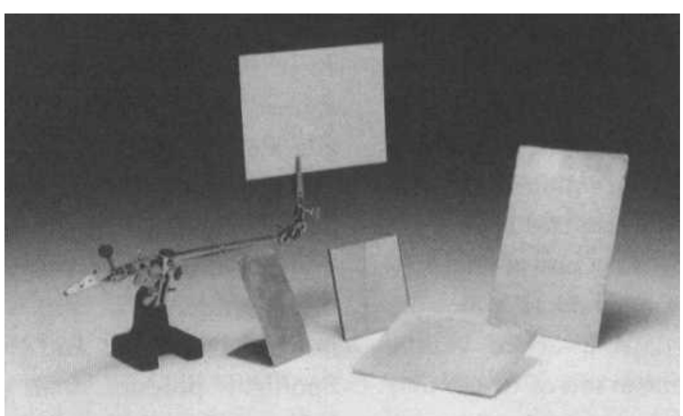


Figure 6-5 Reflectors. Clockwise, starting at right: metallic-coated cardboard, matte aluminized inner surface of Polaroid film box, mirror, aluminum foil (matte side out), white card in electricians' helping hand.

single, thicker layer of another material. You may also find that as a diffusing material ages, it will yellow. Check your diffusers regularly and replace them at the first sign of yellowing. Some materials such as Mylar also tend to get brittle with age and start to crack.

One popular diffusion device is the "soft box" *(Fig. 6-4).* The light source is contained within a large reflective enclosure, with diffusion material making up the surface opposite that of the light. Such boxes can easily be made from white Foam Core taped together with an opening at one end for the light and a means of attaching it. The opposite end is covered with a layer of white diffusion material, usually nylon. Commercial models are, of course, available, usually as collapsible fabric units. They hold their shape by means of flexible wire, the ends of which insert into adaptors on your light. They come in all sizes, some with a variety of options including removable diffusers, and liners in white or reflective silver.

REFLECTING LIGHT

There are two reasons for reflecting light: to broaden a light source and to provide fill-in illumination (see *Chapter 8).* The most common method of reflecting and broadening a light source is the use of an umbrella. The light is directed away from the subject and into a photographic umbrella that bounces the light back on to the subject. If the umbrella's surface is white, it will diffuse the light. Some umbrellas have a silvered surface so as to reflect more light and not diffuse it as much. Umbrellas come in a variety of sizes and shapes, and some are designed to transmit the light as a diffuser. Walls, ceilings, and large sheets of Foam Core or white fabric stretched on a frame can also be used. Unless the mineral specimen is very large, umbrellas and large reflectors are rarely used, though they can be very useful when photographing large fossils.

The primary purpose of reflectors in close-up work is to provide fill-in illumination. Since subject material can vary a great deal as to reflectivity, it is wise to keep a variety of reflectors on hand of different sizes and surfaces. For dull specimens with a matte or earthy luster, you may wish to use a highly reflective fill such as a mirror or metallic Mylar-coated cardboard. Such reflectors can also bring to life finely crystallized, drusy specimens by creating more specular highlights. In decreasing order of reflectivity, reflectors include mirrors, the shiny side of aluminum foil, the matte side of aluminum foil, the matte foil lining of Polaroid film boxes, and white cards *(Fig. 6-5).* As a rule, the more lustrous the subject, the less reflective the reflector should be. Concave shaving mirrors can be used to concentrate reflected light.

Cards can be bent into an L shape so that they stand by themselves. Aluminum foil can be folded for strength and bent in a similar manner to stand by itself. Putty can be used to hold mirrors, or just a couple of clothes pins clipped together at right angles and then attached to the mirror will do. The inside of Polaroid film boxes is a matte aluminum surface and is an excellent reflector material. It has a softer effect than the matte side of aluminum foil, but is slightly harsher than a white card. There are several manufacturers now making sets of reflector cards for photography. They come in a variety of sizes, are reversible with one side foil covered and the other white, and have adjustable stands.

Electricians' "helping hands" can be very useful in holding reflectors at odd angles or at a height above the shooting surface. A variety of commercially made clamps and extending arms to hold reflectors and lights are available at camera stores. I made some very useful extending reflector holders from the legs of an old pocket tripod. (See *Appendix A*, "Gadgets and Gizmos," for details on those and other holders.)

CHAPTER 7

Lighting Techniques

There are a number of different ways to illuminate a specimen so as to reveal properties not easily visible with standard lighting techniques. The techniques vary primarily with respect to the direction the light comes from relative to the subject.

DIRECT LIGHTING

The most commonly used technique is direct lighting, where the light is usually positioned above the subject or to one side *(Plate 3).* This technique is generally considered "normal" lighting because it approximates the way we see objects illuminated in our daily lives by either the sun or by artificial lights in our homes and work places. By careful manipulation of direct lighting, we can define shape, color, texture, transparency, and a host of other characteristics of the subject *(Fig. 7-1).* The specifics of direct lighting are covered in *Chapter 8,* Lighting Applications. As shown in *Plate 8,* Olaf Medenbach made good use of direct lighting, as did Lee Boltin *(Plate 9)* in utilizing a spotlight.

TRANSMITTED LIGHT

Transmitted light techniques concentrate on what light reveals when traveling through a translucent or transparent subject, rather than reflecting off its surface as is the emphasis with direct lighting. Transmitted lighting reveals a host of details not normally visible, including cracks, inclusions, zoning, color, and transparency. The technique is also called "backlighting."

The light source impinges upon the subject anywhere from 90° to its side, to directly behind it. The correct angle depends on the position and nature of the internal details, presence or lack of matrix and its location, degree of light spillover onto the front of the specimen, and intensity of the light source, among others *(Fig. 7-2).*

Just as with direct lighting, backlighting must be controlled carefully. It is rare that a standard light is used as-is for transillumination because the light is not concentrated and controlled enough. At the

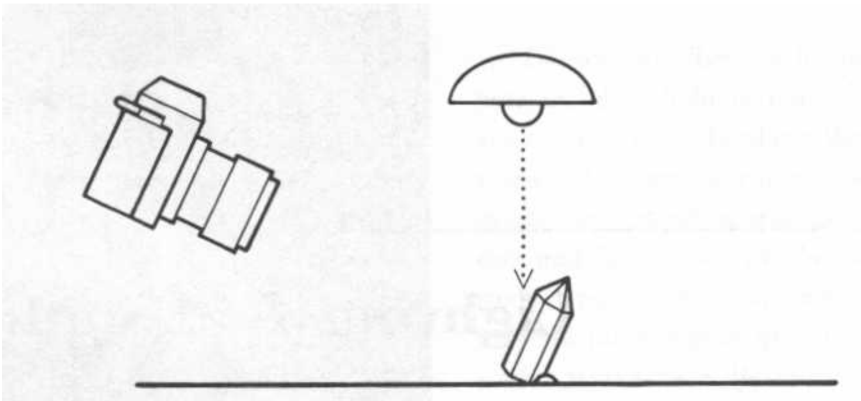


Figure 7-1 Direct lighting with undiffused light source.

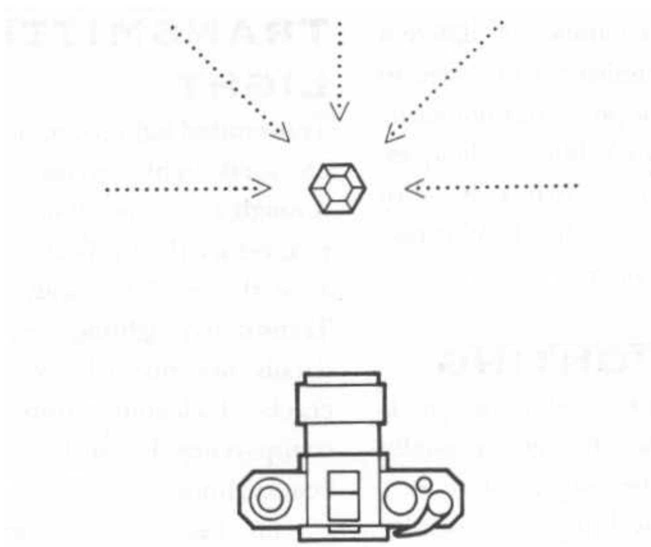


Figure 7-2 Backlighting angles.

very least, a snoot should be used in the absence of a more appropriate light source. For large subjects, a spotlight or baby spot can be used. With smaller subjects, a microscope light is preferable because of its smaller size, maneuverability, and ability to focus (usually). The preferred microscope light source is a fiber-optic-based unit. The advantages of such a unit are its great maneuverability and high intensity, and, especially, its being a cool light source. The use of a microscope light enables the photographer to control the light to minimize spillover onto the front of the specimen or onto the background. The ability to concentrate light, as with a good microscope light, also minimizes long exposures due to the great amount of light lost when transmitted through a specimen. Earl Lewis is a master of backlighting, as you can see in Plate 10, and Wendell Wilson

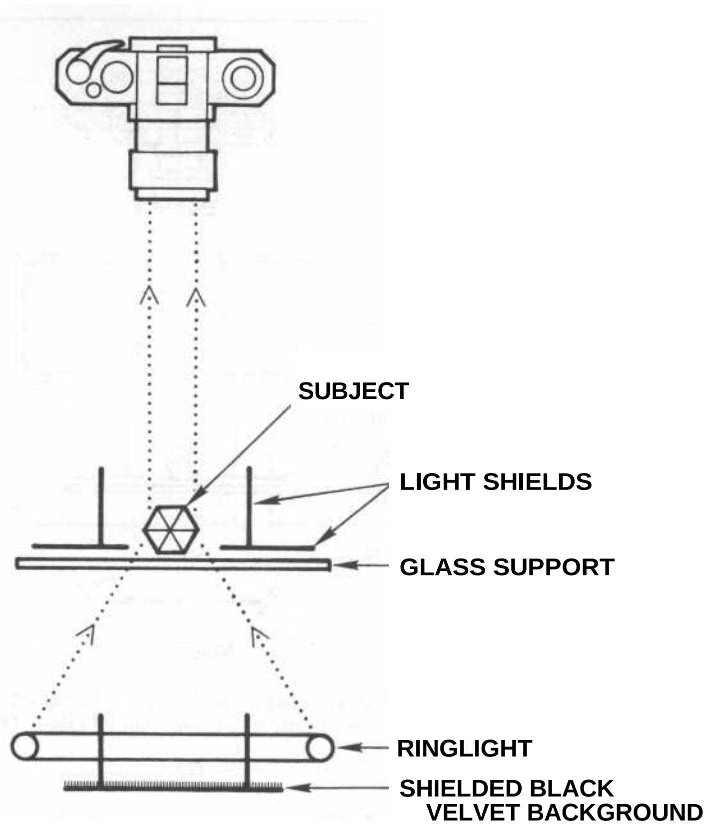


Figure 7-3 Dark-field lighting with a ringlight. The vertical shield on the background keeps light off the background while the horizontal shield on the glass keeps direct light off the lens. A second vertical, circular shield on the glass keeps ambient light off the subject. Only the light refracted from the subject reaches the lens. (After Blaker, 1989)

made excellent use of the technique as shown in Plate 11.

Backlighting can also be accomplished through the use of reflectors such as mirrors or aluminum foil when used in conjunction with a standard light source and even combined with direct lighting of the specimen. With the main light above, the reflector is placed so as to reflect light into the specimen from behind. When using this technique, the photographer must be careful that the reflector does not show or reflect light directly into the lens so as to cause flair.

Another useful means of backlighting is through the use of a "light table" or light box. Such a unit consists of a suitable box painted white on the inside, containing a light source and having a top of translucent Plexiglas or double-flashed opal glass. A sheet of clear glass that has been sand blasted to diffuse the light is frequently used for this purpose but does not work as well as the other two materials mentioned.

The use of a light box will produce a very even, white background, and is ideal for photographing slabbed materials such

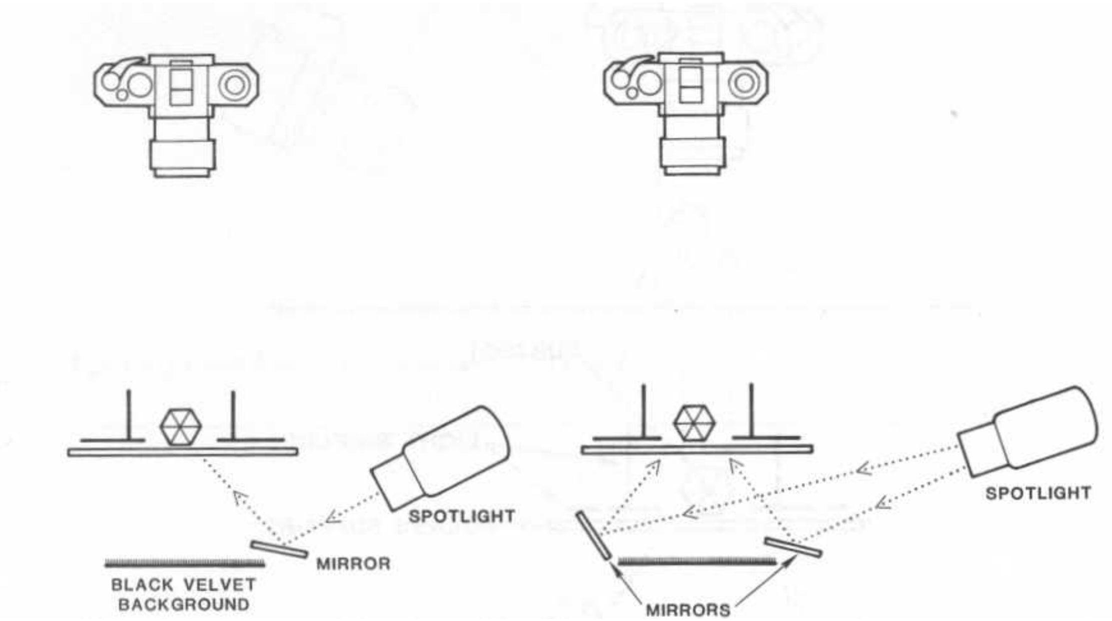


Figure 7-4 Directional dark-field lighting using mirrors can bring out linear effects, especially if more than one mirror or lamp is used with different lighting angles. (After Blaker, 1989)

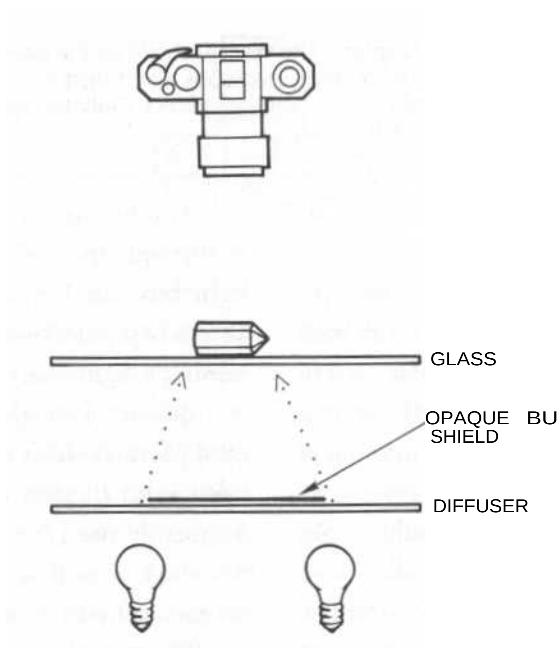


Figure 7-5 Dark-field lighting with a light table, for larger subjects.

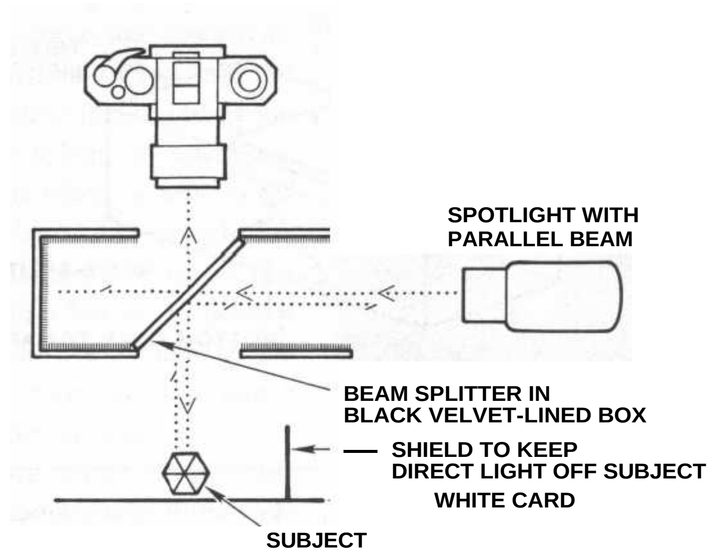


Figure 7-6 Diagram of a coaxial lighting setup. (After Blaker, 1989)

as agates or tourmaline slices. All portions of the diffusing surface that are not in the field of view must be masked off so that the excess light does not create flair in the lens. If you wish to have a background color other than white, colored gels (available at art or theatrical supply stores) can be placed over the background with a hole in them cut to the shape of the specimen. A black background can be achieved using an opaque black material instead.

DARK-FIELD LIGHTI NG

This technique has found its greatest use in the realm of gem inclusion photography, but also has applications in other arcas.

Dark-field lighting is a variation on transmitted lighting except that the light does not travel directly through the sub ject. Instead, the light reaching the lens is

The use of a light box will produce a very even, white background, and is ideal for photographing slabbed materials such as agates or tourmaline slices.

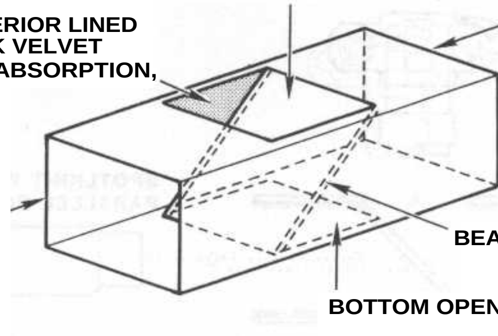


Figure 7-7 Diagram of a beam-splitter housing

that which is scattered or "refracted" by the subject. In a gemological (or biological) microscope, there is an opaque disc below the specimen that allows the light to come around it in a hollow cone to illuminate the specimen (see *Fig. 16-7, page 160)*. The specimen is supported either on a glass stage or by a pair of built-in forceps. As a result, the background is black, even directly beneath the sample. This technique is used because it reveals remarkable detail in inclusions. (In biological work it excels at revealing fine hairs along the edges of specimens.)

The lighting can be achieved through the use of a ringlight (not flash) placed below a sheet of glass on which the specimen rests as shown in *Figure 7-3*. Optimal effects can be achieved by raising and lowering the light while observing the results through the camera. Directional effects can be obtained by the use of one or two mirrors placed below the glass, and illuminated by a spot or microscope light instead of using the ringlight *(Fig. 7-4)*. You can also get similar results by masking off portions of the ringlight.

A light table can also be used for dark-field lighting of larger subjects. Suspend a sheet of glass above the light table to hold the specimen, then place a sheet of opaque black paper below it on the diffuser surface *(Fig. 7-5)*. Experiment with the size, shape, and distance of the paper to achieve optimal results as well as with selective masking of the light table outside the field of view. The latter may also be necessary to reduce flair.

COAXIAL LIGH ING

Coaxial lighting is a technique whereby light is transmitted to the subject along the axis of the lens, from the direction of the camera *(Fig. 7-6)*. This method of lighting is accomplished by placing an optical flat or beam-splitter at a 45° angle between the camera and the subject. The beam-splitter should be housed in a box that has an opening above and below the splitter and is lined with black velvet or flocked black paper *(Fig. 7-7)*. The box eliminates all light except for that from the intended light source, and absorbs all unnecessary light transmitted or reflected by the splitter. A light is directed at the beam-splitter that reflects it downward along the lens axis where it reflects off the subject and back up through the beam-splitter to the lens. The use of this technique results in a loss of 75 percent of the light, as each time the light strikes the splitter, 50 percent of it is either transmitted or reflected uselessly.

Best results are achieved with this technique when the subject is relatively flat and reflective such as a polished sur face. Coaxial lighting reveals in minute detail the microtopography of the subject's surface, otherwise difficult to record due to its very low relief. This sort of image can be a great aid in the analysis of

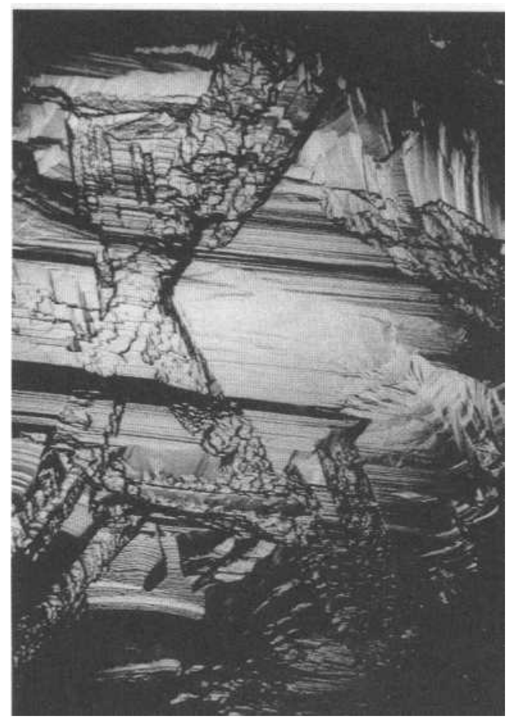


Figure 7-8 Growth pattems on a quartz crystal face illuminated by coaxial lighting

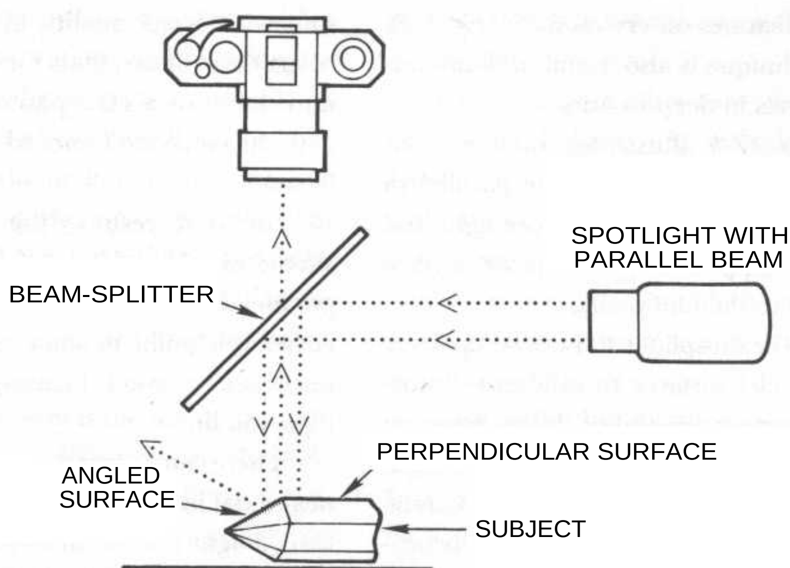


Figure 7-9 Principle of coaxial lighting. Surfaces perpendicular to the light path reflect more light back to the camera, appearing brighter than surfaces inclined to the light path. (After Blaker, 1989)

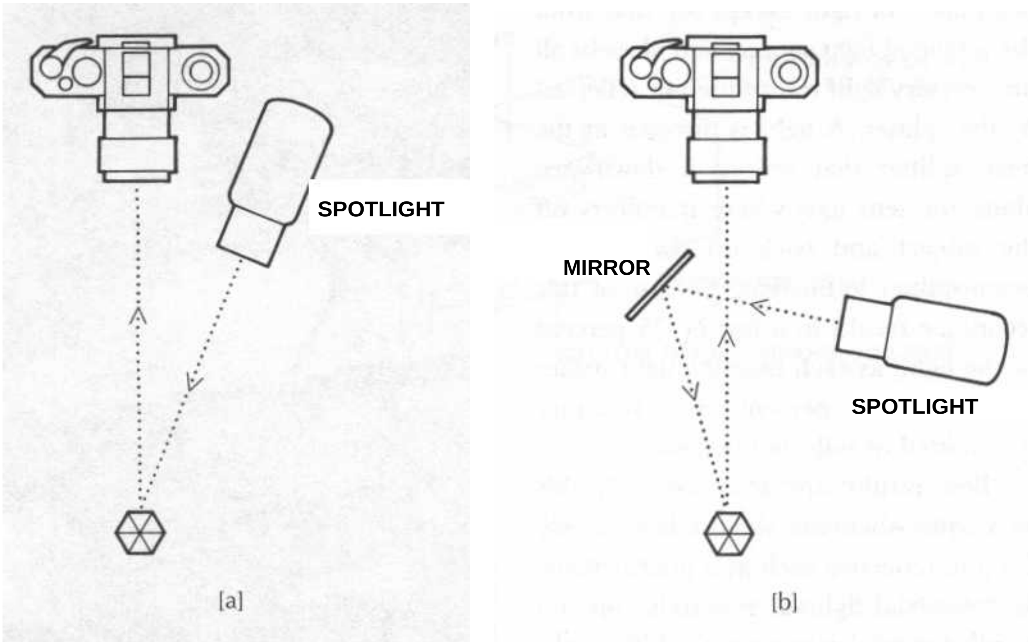


Figure 7-10 Near-axial lighting methods (a) Lamp axis Glose to that of lens. (b) Mirror redirects the light Glose to lens axis.

the surface detail of low relief fossils and growth features on crystal faces *(Fig. 7-8)*. The technique is also useful in illuminating objects in deep cavities.

Figure 7-9 illustrates how coaxial lighting works. A flat surface parallel to the film plane will reflect more light and therefore appear brighter than a surface inclined to the film plane.

The beam-splitter must have optically flat, parallel surfaces to minimize distortion. A certain amount of linear distortion is unavoidable due to the offset of the light beam by refraction. This problem can be minimized by using the thinnest beam-splitter possible. Beam-splitters are available commercially through scientific supply houses such as Edmund Scientific. You can make your own, of somewhat lesser quality, by using microscope cover slides, glass for mounting 35-mm slides, or a glass photographic plate with the emulsion removed (by soaking in bleach).

For best results, the light suurce should provide a beam of light that is as parallel sided as possible. Hine (1971) dis cusses this point in some detail. For our purposes, a good focusing microscope light will do.

There are several ways to achieve near axial lighting, all of which avoid the loss of light that occurs with the use of a beam-splitter. These techniques however, do not achieve quite the same results as coaxial lighting (see *Fig. 7-10)*.

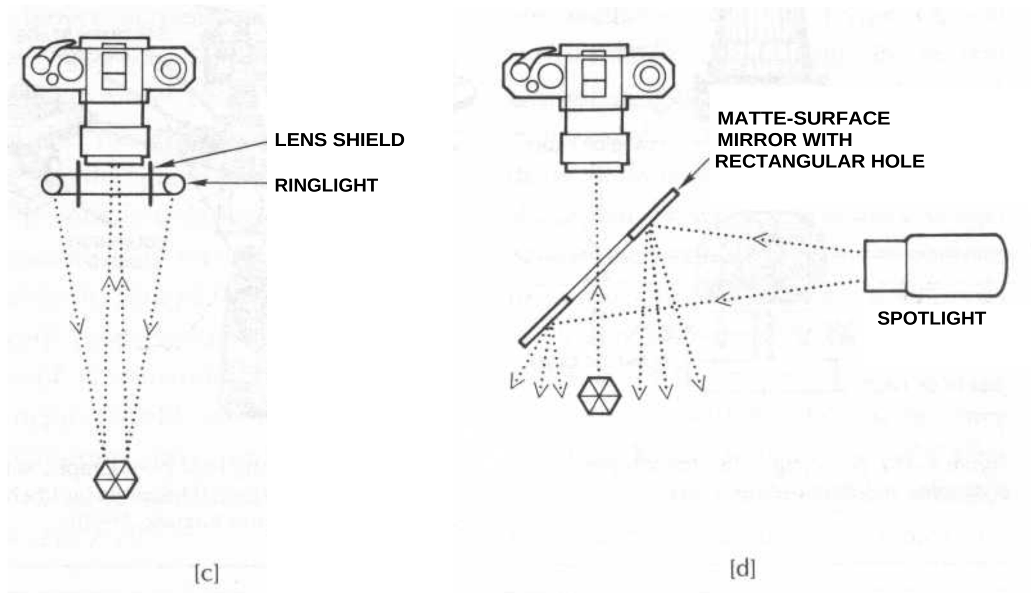


Figure 7-10 (c) Ringlight surrounds the lens to provide near-axial lighting from all around the lens. (d) Matte surface mirror (matte side of aluminum foil) with a rectangular hole can be closer to lens axis because of the small hole size.

The closest approximation is achieved by the use of a mirror with a hole in it. It is positioned and illuminated just as with the beam-splitter. Instead of a mirror, a sheet of cardboard can be coated with aluminum foil, matte side out, and pierced in the same manner. The matte side of the foil diffuses the light, making it more even and eliminating the possibility of "hot spots" from the use of the shiny side.

Another option is the use of two mirrors placed at a 45° angle to the light source, just as in the use of the beam splitter. The camera looks through the gap between the mirrors. The mirrors must be perfectly parallel, in the same plane, and their adjoining edges must be aligned with the lamp axis. Achieving proper alignment with this technique can be difficult.

Ringlights are also very useful for near axial lighting. As mentioned in *Chapter* 6, many flash manufacturers make them, but you have the problem of not seeing what you are getting until the film is processed. For black-and-white work, ringlights are available with neon or fluorescent tubes.

Less useful, but another possibility, is the placement of small mirrors near the lens, aimed at the subject, and illuminated by a focusable light source. And finally, you can place your light source or sources close to the lens and aim it at the subject.

Background choice is more limited

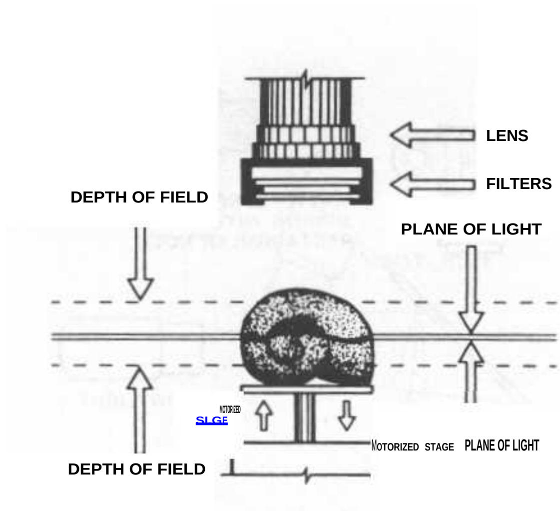


Figure 7-11a Scanning light photography principles and depth-of-field limits.

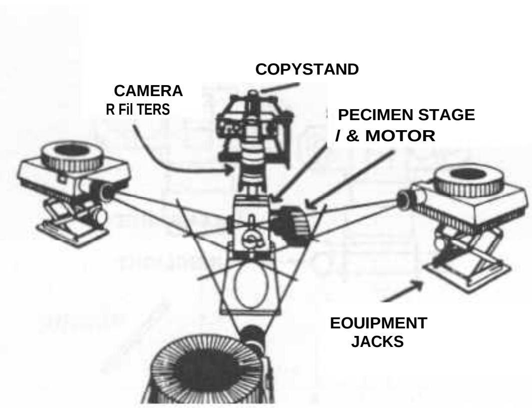


Figure 7-11b Scanning light photography setup and projector mounting. (Drawings by Michael junius, from Sharp and Kazilek, 1990)

with coaxial and near-axial lighting. Any background will be uniformly lighted and little can be done to make it more artistic. For paleontological photography, this is not a problem usually, as backgrounds typically are plain black or white for scientific publication. With near-axial lighting using either a ringlight or pierced mirror, a white background can be created using aluminum foil. Use it matte side up and be careful not to wrinkle the foil. When using a spotlight or mirror nearly on axis, a shadow will be created if the subject is resting directly on a white background. The specimen may be placed on a sheet of glass suspended above a separately lighted background material.

You may find that with axially lighted small subjects, the background is magnified enough to reveal distracting texture. If this is the case, raise the subject above the background on a small pedestal.

SCANNING LIGHT PHOTOMACROGRAPHY

A major problem with the photography of small subjects is the lack of depth-of-field. The use of small apertures helps, but has its limitations and introduces the problem of reduced sharpness of the image (see *Chapter 12* for more on depthof-field). There is a way to overcome this problem-a technique called Scanning light photomacrography (SLP) or deep field photomacrography.

The technique has been around since the early 1960s and has been written about by several authors (MacLachlan, 1964; Root, 1985; and Sharp and Kazilek, 1990). 1 have not seen the technique used on minerals or gems, but with some restrictions it could produce excellent results. It is an ideal technique for photographing small fossils.

The specimen is mounted on a stage that moves perpendicular to the film plane (*Fig.* 7-11). During the exposure, the subject moves either toward or away from the camera, passing (scanning) through a thin plane of light. This procedure is done in a darkened room so that the camera only records what is illuminated by the thin plane of light. In order to work properly, the thickness of the plane of illumination must be less than the depth-of-field at the aperture and magnification used. The result will be that all parts of the subject will be in focus (*Fig.* 7-12).

The components for an SLP system are available from the Irvine Optical Corporation, which calls its system Dynaphot. It is built for use with a 4 x 5 camera or 35 mm and with either two or three illuminators. The system is not cheap, but for those with a small budget or who like to tinker, a usable system can be put together for less than $200 if you are a good scrounger or can borrow or rent some of the components.

In Sharp and Kazilek's setup, they use three Kodak Ektagraphic AF-2 slide projectors as light sources. Each is outfit ted with 102-152 mm zoom lenses and

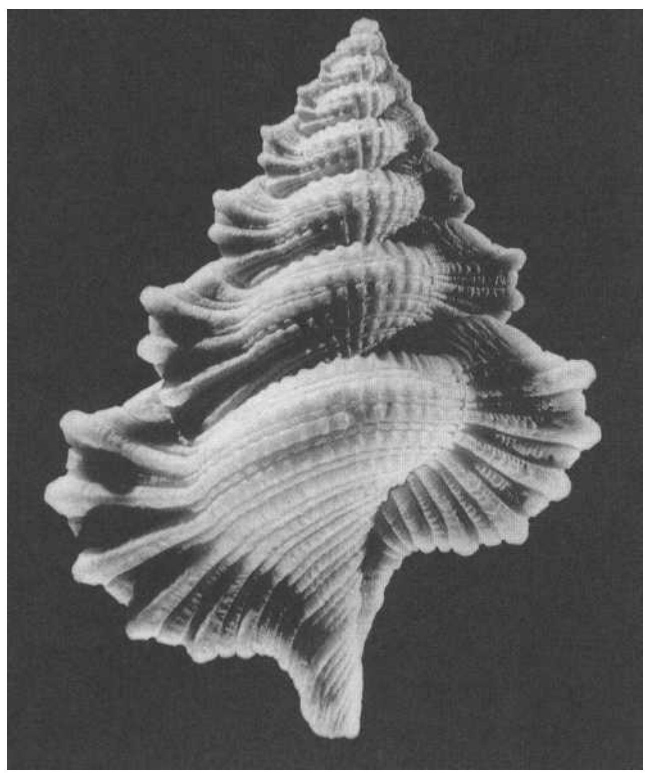


Figure 7-12 Seashell, Argobuccinum pulchellum, **photographed with scanning light photography. (Photo by Charles Kazilek, courtesy of Arizona State University)**

ELH lamps that are rated at 3360 K. To create the thin horizontal beam of light, they mount portions of double-edged razor blades in plastic side mounts. The slit is centered in the slide opening in the long dimension. Any gaps that can pass light are covered by two layers of metallic slide masking tape. The projectors are spaced equally around the subject and are mounted on equipment jacks. These jacks look like a car's scissors jack, and can be bought from scientific supply houses or borrowed from a university or appropriate business if you have the connections.

The first step is to level the projectors by placing a level on top of the slide trays both front to back and side to side. Sharp and Kazilek's test subject was a three-sided pyramid of clay oriented so that its edges were aligned with each projector lens. Final adjustment is done with the jack controls and focus and zoom adjustments on the lenses. The three light beams should form an even band around the test subject. The subject should also be centered on each of the beams by placing a white card on the far side of the pyramid from the projector and centering the projected beam on the subject. This last step is critical so that illumination is even and to assure that no part of the subject will be missed during the scan.

Sharp and Kazilek use a modified microscope dissection stage for mounting the subject. It moves up and down by a focusing motor attachment controlled by a foot switch. They also suggest using a telescope eyepiece focusing assembly connected to a motor. Any smooth rack-and-pinion movement that can be motorized will work. Be sure that the device you are using will travel a distance at least equal to the height of the subject to be scanned. Determine the rate of travel for the unit you are using. This figure is needed to determine your exposure times.

The camera is mounted on a copy stand looking down on the subject. Be sure that it is parallel with the stage and perpendicular to the vertical movement of the stage. When making the exposure, the room lights are turned out and the shutter opened and locked on B. Color-compensating filters have to be used to balance the light to the film. At 3350 K, the lights are 150 K too cool (see *Chapter* 10, Filters). Exposure is best determined by doing a series of test exposures in half-stop increments. If proper color balance is critical, you may wish to determine proper color filtration for each batch of film you buy. Examine your test exposure roll on a color-balanced light box using color-compensating filters until proper color is achieved. To assure that all your film is of the same batch, buy it by the "brick." A brick contains 20 rolls of film.

There are several problems to overcome when using SLP Since the technique records great detail, the subject must be very clean. The technique also produces very contrasty images. The use of three light sources instead of two helps reduce contrast. If possible, use a low contrast film. If slides are not necessary, print film is inherently less contrasty. Another problem is "light piping," where transparent-to-translucent subjects transmit the light through to other portions of the subject. This can create ghost images if these other portions are not within the light beam. Light piping is a major problem with crystals and gemstones because many such subjects are transparent to translucent. It may be best to restrict yourself to opaque or just slightly translucent subjects.

Another problem arises with subjects that are very complex in form so that portions shade other portions, or if there are caviúes present that the light can not enter. Such shaded areas or caviúes will come out black.

Viewers of SLP photographs sometimes have problems with perspective and depth because such photos lack the usual reference points. Portions out of focus indicate depth, and shape is often defined by shadows. The best way to deal with this situation, if it is seriously disagreeable, is to take a stereo pair of the subject with SLP Gerakaris (1986) recommends mounting the subject on a tilting stage. The subject is mounted over the axis of the stage so that when it is tilted from one extreme to the other, the subject moves

the required amount to create good threedimensional modeling. For more on stereophotography, see *Chapter 14.*

One final limitation is that the background will be black. This condition is generally not a problem, unless the subject is dark and tends to blend in with the background. You may wish to experiment with double exposures as a way to introduce a background other than black. The double exposure must be done at maximum extension of the subject towards the camera or you will get ghost images around its edges. Be sure that the illumination on the background does not strike the subject. To be sure of a shadowless background, the subject should be elevated above it on a pedestal.

LIGHT PAINTING

The basis of light painting is quite simple. Orient your subject, compose and focus, then darken the room. With the room lights off, open and lock the shutter on B, then "paint" the subject with a movable light source. Turn off the light source, then close the shutter and turn the room lights on again and you are done. So why would anyone want to use such a seemingly unpredictable technique?

With light painting you can actually be highly selective in what parts of the subject you do or do not illuminate, and to what degree. You also have a great deal of control over the angle from which the light comes. Admittedly, these advantages are gained with some sacrifice. Just as with nonstudio flash, you cannot see what you

lt will never replace more standard techniques, but light painting can have very interesting results with some mineral specimens and some striking effects useful in jewelry advertising photography.

are going to get, although experience with the technique can give you a pretty good idea. It will never replace more standard techniques, but light painting can have very interesting results with some mineral specimens and some striking effects useful in jewelry advertising photography.

With minerals a good example might be a sample with a lot of uninteresting matrix, or broken and damaged crystals. Light painting would allow you to eliminate these problem arcas and concentrate on important crystals. Backlighting certain crystals can be difficult because of uneven illumination, light spill creating overexposed crystal edges, or just the inability to back light a crystal enough. With light painting systems you can concentrate your backlighting on a single crystal with no light spill and not affect surrounding crystals.

In its simplest form, light painting can be done in a darkened room with an assistant to operate the camera and a hand carried light source. The assistant covers or uncovers the lens as needed while you maneuver from one position to the next or experiment with the proper angle for lighting a particular feature. You should wear dark, nonreflective clothing and be sure not to get between the subject and the camera during exposures. Be careful that you don't forget to paint an important area. Exposure must be determined by experimentation with a test roll or two, varying the length of time you hold the light in one spot and varying the aperture. Depth-of-field is still a consideration here, so keep apertures small. A small aperture also gives you more time for painting and reduces the recording of any ambient light in the room.

Light painting systems available today are fairly sophisticated, letting you do the work yourself with much more control. The Hosemaster made by Aaron Jones, Inc., is considered to be the top of the line. lis power unit contains a 300-watt quartz arc lamp that is daylight balanced. A 15-foot fiber-optic "hose" transmits the light to a fitting at its tip. The fitting is essentially a light valve that accepts filters and different masks that control the shape of the light. A whole series of attachments are also available as short light "pipes" that also control the shape of the light beam from pinpoint to a long wand that emits light along its whole length. The wand attachment when moved over the surface of the subject acts as a large, diffused light source. Some of the small wand attachments have an angled tip, making it easy to get into tight places and behind things. With such a tip, you can run the light up and down the back of a crystal to backlight it very evenly or selectively.

The end of the hose also has controls for turning off and on both the light source and an auxiliary shutter. This auxiliary shutter is placed in front of the camera lens and can be closed while you reposition yourself or the light wand and experiment with positions and anges. The auxiliary shutter can also be fitted with filters that can be placed in front of the lens or removed by the controls at the working end of the hose. Such versatility has its price-depending on the bells and whistles you want for your unit, it starts at around $6,000.

There are less expensive units available with different or fewer features. Light FX makes a small handheld unit, called Light FX, with a rechargeable battery carried in a holster. It contains a 75-watt halogen projector bulb with a removable dichroic filter for daylight color balance. It has a very handy built-in audio timer for repeatable exposures, and comes with interchangeable fiber-optic accessories and a soft box attachment. It is priced at about $l,400.

The least expensive unit is the Light Tech system by Photographers Specialized Services. The system incudes an AC power unit, lightweight hand wand, mask holder, aperture masks, light hoods for backlighting, and other accessories.

A similar system is the Lightbrush by Broncolor. The basic unit looks like a hair dryer, except that the light source is a continuous strobe. It is actually like a sophisticated automotive timing light, except that the daylight-balanced strobe fires at a rate of 30 times per second. It comes with an aperture mask and lens, a built-in filterholder, and a one-second audio metronome for timing exposures. The unit costs about $l,000.

CHAPTER

8

Lighting Application

n this chapter 1 discuss how to use your lights to properly illuminate and define a specimen. The discus sion is based primarily on the use of reflected lighting because that is the typc most commonly used.

There are basically four components in setting up the lighting of a subject: the main light, fill light, highlights, and background lights.

MAIN LIGHT

First, orient your specimen so that it presents its best face to you and what logically or aesthetically looks to be its right side up (this is covered in detail in *Chapter 1).* Our society's esthetic preferente is to see things lighted from above and slightly to one side (usually the left). You must keep this preferente in mind when locating your main light source, otherwise the result may be disorienting to the viewer of the finished photograph. Our society also prefers that columnar and pointed objects point upward. Objects with an unequal distribution of mass (such as a triangle) usually have the larger end downward so that they do not look top heavy. Obviously, the best crystals should face toward and not away from you. lf there are damaged crystals, locate them so the damaged arcas are not seen, or are minimized by therr angle or by shadows.

Set the main light above, and slightly in front of, the specimen. Adjust the position of the main light or lights, if neces sary, to highlight faces to best advantage and to minimize damage or defects. It's important to always adjust your lights and reflectors while looking through the viewfinder so as to see exactly what will be recorded by the film.

If you are trying to bring out the surface texture of an opaque specimen, a low-angle, grazing light is best On the other hand, if color is more important, keep the lights higher and more diffused. These considerations are important when photographing something other than crystals. Flat fossils in matrix, such as leaves, fish, tracks and so on, need a low grazing light to bring out the low relief. Lapidary materials require a more highly diffused light to subdue reflections off polished surfaces.

When working with highly reflective subjects, the main light source should be diffused. To do so you can place a neutral colored material in front of the light such as double matte drafting Mylar, rip-stop nylon, or commercially available diffusing materials. Diffusion spreads the light more evenly and softens it so the highlights are not so harsh. It's like photographing outside on an overcast day when the lighting is very even and shadows are almost nonexistent.

FILL LIGHTS

After the main light has been positioned, add fill lighting. Fill lighting illuminates the shadowed arcas on the specimen created by the main light. As a general rule, fill lighting should not be as strong as the main light. If it is, all shadows are eliminated and you lose the three dimensionality of the specimen created by the shadows. Shadow location also helps the viewer orient the specimen right side up.

It is important that the fill light not create secondary strong shadows around the base of the specimen on the back ground. People are used to seeing one shadow from a main light (usually the sun) and multiple shadows are distracting and unnatural looking.

The problem can be minimized by diffusing the main light and positioning it above and slightly in front of the subject so that its shadow is below and behind it. Fill lights can also be kept low, diffused, or carefully aimed so as to just illuminate the proper arcas. Excess light from reflectors, fill lights, and even main lights can be controlled by the use of strategically placed and cut pieces of black construction papen Such devices are known as "gobos" in the trade. As mentioned in *Chapter* 6, barn doors attached to lights are also very useful.

REFLECTORS

Fill lighting is often provided by lights, but theie are alternatives. Try using small mirrors, aluminum foil, or white index cards as discussed in *Chapter* 6 under "Reflecting Light." An advantage to using reflectors instead of lights is that you do not have to deal with a dangerous tangle of wires or numerous hot lights.

Reflectors are also much more maneuverable than lights with their attendant stands, and can provide finer tuning of fill-light quality.

Each of these reflector materials creates a different quality fill light. The mirror provides a hard, bright fill with sharp

If adjacent faces are highlighted, make sure that they are of different intensities or are gradational without bright areas next to each other. If they are of the same intensity, the faces will blend into one another and the two faces will appear as one.

edges and bright high-lights. The matte foil has a softer more diffuse light, and the white card an even softer diffused effect. If your specimen is metallic and giving you harsh bright highlights and a lot of glare, the use of white cards as reflectors will solve the problem. Very lustrous non-metallic minerals can be dealt with the same way. For subjects that are not very lustrous-fibrous minerals such as malachite, or those with fine, drusy crystals-the more reflective surfaces of mirrors add a little more specularity, giving them more "life."

HIGHLIGHTS

The next step in lighting is to create highlights. In the case of minerals, this procedure overlaps the previous procedure of fill lighting. Highlights are created by positioning your reflectors or fill lights to produce edge lights and soft reflections that define the faces. Edge lights separate the subject's planes, giving it depth, and differentiate between the specimen and the background. They are usually created by using undiffused lights that are behind and to the side of the specimen, at its edges. This placement creates a thin "rim light" on the illuminated portion.

Generally, it is a good idea not to let any part of the specimen disappear into the shadows or a dark background. If this happens, the viewer has a hard time defining the specimen. What is its shape? Where does it begin and end? This danger is greatest around the bottom of the specimen. Of course, if there are no crystals at the base, just uninteresting matrix, it might be to your advantage to let it fade into the background. Highlights and edge lights are what pull the specimen out of the background and define it.

Your lighting setup should accurately define the specimen. Being able to see just its shape and color is not enough. You must be able to see the individual faces of the crystals. Illuminated faces make the crystal identifiable and give it much of its beauty.

In order to define the crystal faces, you need to highlight them by reflecting light off of them. Conversely, an unlight ed face surrounded by lighted faces will also be defined. Be careful not to get too much light reflecting off a face or it will be a white, distracting hot spot.

There are several ways to deal with hot spots. A soft, diffused, uniform highlight is created by using the white card or matte foil. Another method is to produce a gradational highlight. While looking through the viewfinder, get a hard, bright reflection off the face. Then slowly move the light source or reflector until you see the reflection diminish and grade in intensity across the face.

Sometimes you get a secondary highlight off a face. This happens when light reflects off the background material onto a face, or off an adjoining face. Such highlights are usually coincidental, but valuable.

Try not to get highlights of the same intensity on adjacent faces. If adjacent faces are highlighted, make sure that they are of different intensities or are gradational without bright arcas next to each

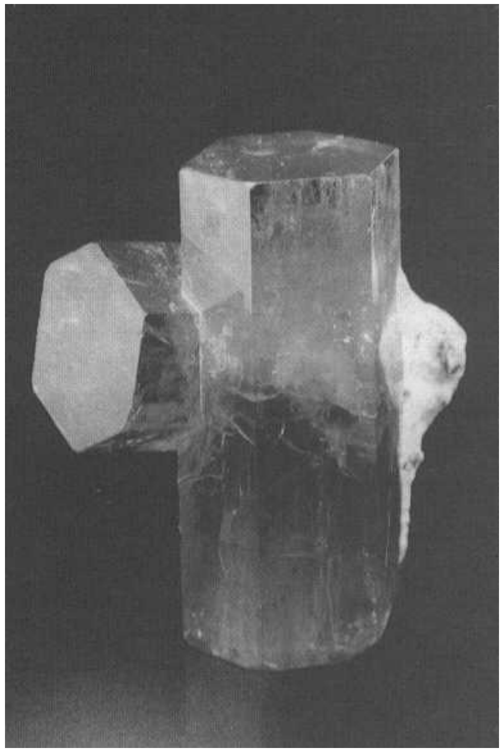


Figure 8-1 Highlights on the faces of this beryl, from the Wah Wah Mountains of Utah, have been placed so as not to obscure interior detail.

other. If they are of the same intensity, the faces will blend into one Another and the two faces will appear as one. This illusion will cause confusion as to the shape, number, and placement of the crystal's faces. It's preferable to light alternate faces, which will then define the unlighted faces between. Imagine if you will, a checkerboard, the red squares are the lighted faces, and the black squares unlighted. Even though the black squares are unlighted you still know that they are there because their shape is defined by the surrounding red squares that are illuminated.

Another advantage to keeping reflections soft and diffused is that surface details of the faces will be revealed. The tiny, subde growth hillocks, striations, and etch pits on a crystals faces add character to a specimen's photograph and are important features to students of mineralogy. Remember, accuracy as well as beauty are the goals of the mineral photographer.

Keep in mind that the more reflections you have, and the brighter they are, the more they obscure the interior of the crystal and its important characteristics of color, zoning, and inclusions that also must be recorded. This situation calls for faces that are not highlighted in the arcas

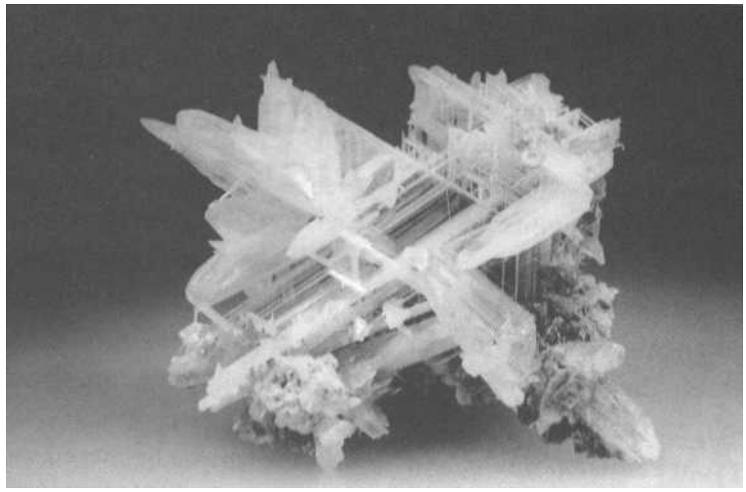


Figure 8-2 Gradation of lighting on the background achieved by forward angling of diffused light sources. Cerussite from Tiger, Arizona. (Broken Back Minerals)

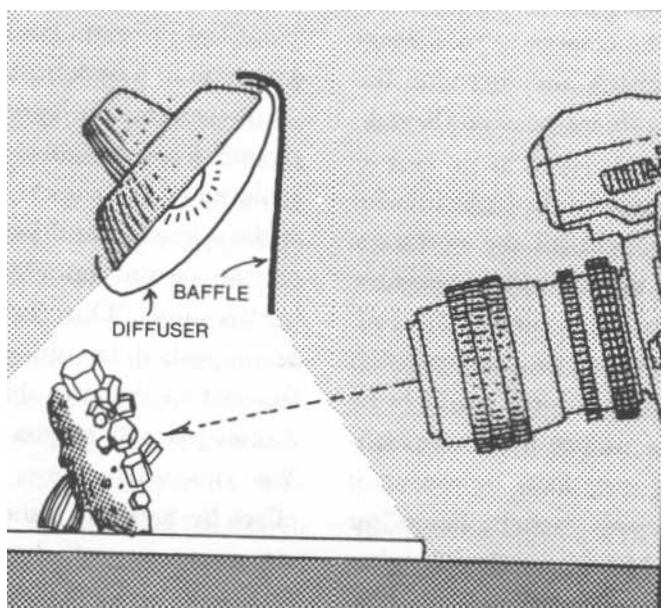


Figure 8-3 Side view of lighting setup. Black paper baffle keeps light off the lens. (From Wilson, 1987)

that show these interior details, or for the use of very soft or graded highlights on those faces (Fig. 8-1). Refer to *Figure 1-2* (pape 5) for orientation and lighting sequences.

Placing your lights or reflectors for highlights is more difficult than establishing your main light. If your setup is small enough, you may be able to reach all your lights and reflectors while looking through the viewfinder. While so viewing the specimen, maneuver your lights and reflectors to achieve the desired results.

If you can't reach your lights and reflectors from your camera position, and you Nave no assistant, use the following procedure. Place your fill light in front of the camera, aimed at the specimen. Then walk around the specimen looking at it from all angles. When you see a good highlight, place the light or reflector that was in front of the camera in your exact position. Then check and fine-tune the results from the camera position (Kodak, 1969).

Once you have finished placing the reflectors to highlight all the necessary faces, your setup may look like a veritable forest of cards and pieces of foil. Frequently, you may not be able to position a reflector to get the desired highlight by placing it on the surface the specimen is resting on. You may have to elevate it using an electrician's "helping hands" or something else. I have used flexible wires attached to bases, to the main light, or to the camera itself to position the reflector properly. Camera manufacturers make a variety of stands and clamps that allow you to attach accessories to light supports and tripods. These are modular systems with clamps, and flexible and jointed arms.

BACKGROUND LIGHTS

Lighting of the background is important too. If the subject is directly on the background material, they are lighted at the same time. Some control can be exercised over the lighting of the background. Most specimens are shot sitting directly on a background material such as colored paper or cloth that curves up behind them. Lighting the background is often opposite the rule of specimen lighting about being light on top and dark on the bottom. This reverse lighting provides a contrast where the brighter specimen top is not lost in bright background, nor the dark base in a dark background.

Preventing the specimen and background from blending together can be achieved by keeping the main light aimed at the specimen and foreground and not en the curved upright portion of the background. This lighting is usually accomplished by tilting the main light forward so that the shadow its housing throws partially shades the background. You can also achieve, or enhance, the effect by hanging a sheet of black construction paper off the back of the light so that its shadow falls across the background.

One of the goals in this technique is to achieve a smooth, not sudden, grada tion from light to dark (Fig. 8-2). The higher the light source is from the background, the softer the transition will be. A diffused light source will also soften the transition. One last factor to be considered is the angle of view. The lower your angle of view, the sharper the transition will be, and, conversely, the higher your angle of view, the softer the transition will be.

When angling your lights toward the camera, you run the risk of shining them right in the lens and causing fiare that will ruin the photograph. Flare can manifest as an overall image degradation due to loss of sharpness and contrast, or as bright streaks and "ghosts" in the image. To eliminate this problem, hang a sheet of paper off the top of the lampshade so that it keeps the light off the lens, as illustrated in *Figure* 8-3.

The use of a good lens hood at all times also reduces the risk of lens flare. If you cannot get a lens hood for your par ticular lens (especially if it is a specialized macro or enlarging lens) you can easily make one. Take a strip of black construction paper and wrap it snugly around the end of the lens, then tape the overlapping ends. Look through the camera with lens and lens hood attached. If you can see the lens hood in the corners of the frame (this is called *vignetting),* cut it down in length until you can no longer see it in the view finder. If you are using the lens on extension tubes or bellows, you may find that at shorter extensions the lens shade may be too long and vignette the picture because of the wider field of view at shorter extensions.

The use of barn doors on the main light can also control lighting of the background. Another technique is to spotlight the specimen *(Plate 9).*

These techniques all basically create a graded lighting of the background, but there's more you can do. Once the back ground is darkened you can light it separately with spodighs or microscope lights to create spotlight or halo effects.

Background treatment is further discussed in *Chapter 11.*

TRANSMITTED LIGHT

At the beginning of this chapter 1 said I would discuss techniques having to do primarily with direct lighting. There are many cases, however, where transmitted light (light traveling through the specimen) is of great use.

Besides external reflections, there are internal reflections. The light will often reflect off of internal fractures and inclu sions, adding great depth and interest to a specimen. You may wish to concentrate on there interior details on purpose. Keep exterior lighting to a minimum, and aim a bright concentrated light, such as from a microscope light, into the back or side of the specimen. This approach is very effective in minerals with inclusions or phantoms. Translucent, strongly colored minerals with this "piped in" lighting seem to glow. The effect can be very dramatic (Wilson, 1974). The effect also can be misleading if done to excess. I have heard of many instances where people were very disappointed to see a specimen after viewing its backlighted photograph. In real life, the specimen did not have the brilliance and color the people were led to expect by the photograph.

When using this technique, you must also be careful not to have too much of the backlight spill over onto portions of the crystal visible from the front. A small amount can create the useful edge lighting previously discussed. Too much can create burned out highlights.

Another useful and more subtle technique is to place a reflector behind the specimen. Aluminum foil is best for this as it can be carefully cut and folded to match the shape of the specimen. Be sure that it cannot be seen from the front, and angle it so that if the specimen were not theie, it would be reflecting your main light right into the lens. The advantage to using the foil for backlighting is that the effect is subtle and theie is no problem with the light spilling around the edge of the specimen creating burn-outs. It can also more evenly illuminate a specimen than a spot- or microscope light can.

These backlighting techniques have their limitations. Backlighting cannot be used on crystals that lay flat on the matrix. Both techniques work best with translucent crystals. It is the inclusions and defects that scatter the light, making a crystal's color intense. A problem with absolutely transparent, gem crystals is that you can see right through them and see the reflector. Backlighting a flawless gem crystal will have little effect on it because most of the light passes right through it.

CHAPTER 9

Metering

ment in photography and in order to use it to advantage, we must measure it accurately with a light meter. Exposure meters have light-sensitive metering cells that measure the intensity of light falling on them, and then translate this information into suggested f-stop/shutter speed combinations.

HANDHELD METERS

There are basically two types of meters, *reflected* and *incident,* both of which are often available in a single unit in handheld models. All camera-mounted meters are of the reflected light variety. *Figure 9-1* shows a variety of light meters. Among the handheld reflected light meters there are spot meters and standard meters with a wider angle of coverage. The spot meter has an eyepiece and lens like a camera. You view the subject with it, taking readings of the dark and light arcas to determine the brightness range, and then come up with a good exposure determination. The angle of coverage on a spot meter is very narrow so that you can read small arcas on the subject.

All meters are calibrated to 18 percent reflectance as the standard. As a result, the metering of a highly reflective white subject will render it an underexposed gray. The opposite will be true for dark subjects.

When spot metering a scene, you should determine what the midtone (18 percent gray) is, and then meter the light est and darkest arcas of the subject. In order for either extreme to hold detail, they should not be either lighter or darker than the midtone by more than three stops for black-and-white, and no more than about two stops for color work. If they exceed these values, adjust your lighting ratio via the use of fill lights or reflectors. Extreme contrast due to bright highlights can be reduced by diffusing your lights more. Diffused lighting must be used for lustrous dark minerals such as schorl and cassiterite, or lustrous metallic minerals such as pyrite.

Reflected light hand meters that are not spot meters, do not Nave a lens system

Figure 9-1 Light meters. Left to right: meter for incident and reflected ambient light, flash meter, and spot meter. (Spot meter courtesy of Photomark)

that you must view through and have a much wider angle of coverage meant to take in the whole area being photographed. The meter's light-sensitive cell must be held close to the specimen so that it receives only light reflected from the specimen. (A significantly lighter or darker background can throw the meter reading off.) The result is a reflected light reading.

Incident light readings are done with a translucent white dome over the sensor. When in the incident mode, you place the meter in the position of the specimen, aimed at the light source. The meter reads the amount of light falling on the specimen, as opposed to reflecting off of the specimen. This method is usually more accurate because it does not get thrown off by the luster, lightness, or darkness of a specimen, or by the background on which the specimen is sitting. These characteristics are important, however, and must be considered when determining exposure. This is discussed further in the section on using gray cards.

CAMERA-MOUNTED METERS

There are two types of camera-mounted meters. Older cameras have the meter mounted on the front of the camera either over the lens or near the top front edge. This meter arrangement is not desirable since it is not accurate for close-up work. At close range it will not be aimed directly at the specimen, and its angle of coverage is too great.

The second type of meter reads the light coming through the lens. Through the lens (TTL) metering has its greatest advantage when used with extension tubes or bellows. There is a great deal of light fall-off when you extend your lens. With some simple calculations you can compensate for this fall-off with hand-held meters. With TTL metering, no calculations are necessary because you read the amount of light that is actually falling on the film.

There are a variety of TTL metering options depending on the brand of camera. Some average the whole image arca, others are center-weighted averaging and read all the light but favor the central portion. There are also semispot meters reading the central 13 percent, and spot meters reading the central 1-3 percent of the image arca. Those that are more of a spot meter are preferred, for the same reasons already cited for handheld spot meters, assuming the readings are taken with the metering arca of the frame on the specimen or its arca of interest.

Through-the-lens metering is also advantageous when you use filters. Filters can substantially reduce the amount of light reaching the film. This amount of light reduction is known as a *filter factor.* Filter factors for different films are usually supplied with the filter, or in books concerning filters (see Kodak, 1988). A filter factor of 2 means you must get two more stops of exposure than your meter indicates (when the reading is taken without the filter). It would seem logical to assume that TTL metering would compensate for the light loss due to filter use, but that is not necessarily true. Light meters do not have equal sensitivity to all colors in the spectrum. If you are using a filter of a color that the meter is not equally sensitive to, you will not get an accurate reading. It's best to meter the subject without the filter, and then compensate using the suggested filter factor. Some filters, such as neutral density and polarizing filters, do not affect color, only the amount of light. Through-the-lens metering can be used accurately with them for exposure compensation. The use of filters is discussed further in *Chapter 10.*

FLASH METERS

If you are using studio flash as a light source, you must use a flash meter because the duration of the flash tube's output is too short for a standard light meter to reg-

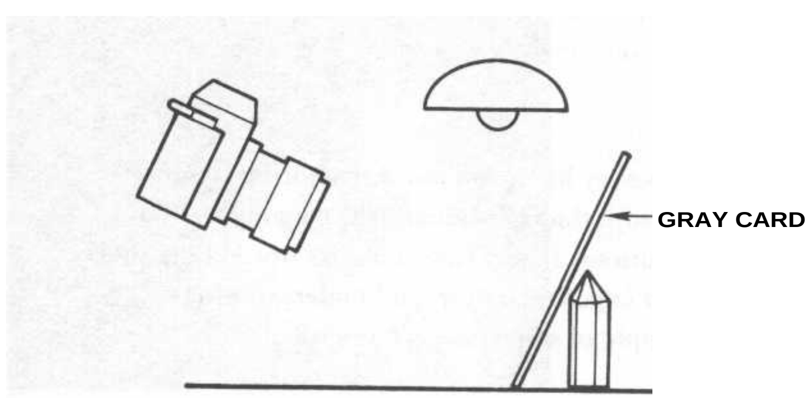


Figure 9-2 Setup for taking a light reading using a gray card.

ister. Flash meters look essentially the same as a standard meter, and most can be used for incident or reflected light readings of both flash and available (ambient) light. They all can be attached to the flash via a sync cord so that the flash is activated when the meter button is depressed. The reading is then locked into the meter until you zero it out or take another reading. At the time this is being written, there is only one 35-mm camera with built-in flash metering: the Contax RTS 111.

USING GRAY CARDS

Reflected meter readings can be inaccurate because of differences in color, reflectivity, and relative brightness of both the subject and the background. Incident light meters deal with these lighting situations more accurately. If you do not have one, you can get the same results with reflected light meters (including the one in your camera), as outlined next.

Once your lighting is set up, substitute an 18 percent gray card for the specimen and then take the reading. Available from photo supply stores, these 8 x 10 inch cards are gray on one side with 18 percent reflectance, and white on the other with 90 percent reflectance. They are designed with a reflectance that has been determined to be the average for most subjects (Fig. 9-2).

Care must be exercised when using a gray card. If the lighting angle is oblique enough, the gray card will act almost as a mirror. The resultant light reading will give you an underexposed photograph.

The use of a gray card makes metering easier, but is not perfect. If the specimen is very dark, open up a stop or two from the recommended exposure (or take a longer exposure). If the specimen is very light, stop down one or two stops (or decrease exposure time). Incident light meters must be used with the same cautions. In any case, 1 always bracket my shots by taking extra exposures, over- and underexposing a couple of stops just to be safe. A full-sized gray card may be too large for use with small subjects. To make it easier to work with, I cut a usable sized piece from the large card. For micromount photography, a 1-inch-square piece can be laid across the top of the micromount box for a reading.

If the specimen is very light, stop down one or two stops (or decrease exposure time). Incident light meters must be used with the same cautions. In any case, 1 always bracket my shots by taking extra exposures, over- and underexposing a couple of stops just to be safe.

[PLATE

1] Rhodochrosite from the Wolf Mine, Siegerland, Germany (crystal ea. 3 mm long). Photo by Rupert Hochleitner taken with a medium-format (6 x 6 cm) Linhof camera, a 100-mm Schneider Symar-S lens, and Kodak Ektachrome Professional Tungsten 64 film.

[PLATE 21 Picropharmacolite from the Anton Mine, lleubachtal, Black Forest, Germany. Photo by Werner Lieber taken with a medium-format (6 x 9 cm) Aristophot camera, a Leitz lens, and Agfachrome 501, film.

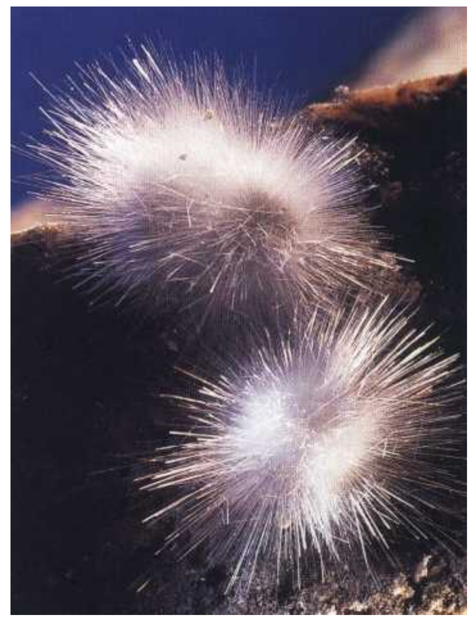


PLATE 3} Lazurite from Sar-e-Sang, Afghanistan (crystal is 3.5 cm; Andreas Weerth collection). Photo by Stefan Weiss taken with a medium-format (6 x 4.5 cm) Mamiya 645 camera, a Rodagon SO-mm lens and extension tubes, and Kodak Ektachrome Professional Tungsten 64 film.

S. Weiss/Lapis © Chr. Weise-Verlag

[PLATE 4] Topaz from Mursinka, Ural Mountains, Russia (Sorbonne collection). Photo by Nelly Bariand taken with a large-format (9 x 12 cm) Aristophot camera, a 65-mm Leitz Wetzlar Milar lens, and Kodak Ektachrome 50 film.

[PLATE 5] Barite on fluorite from the Rock Candy Mine, Grand Forks, British Columbia, Canada (Steve Smale collection). Photo by Steve Smale taken with large-format (S x 10-inch).

[PLATE 6] Wulfenite from the 79 Mine, llayden, Arizona (bar is one inch long; Wayne Thompson collection) Photo by Rock Currier using a flash light sourcc.

[PLATE 7[Quartz from Feldbade, Switzerland (crystal is 1,7 cm high). Photo by Erich Offerman using the sun as the light sourcc.

[PLATE 8] Vanadinite from Taouz, Moroceo. Photo by Olaf Medenbach using direct light undiffused from the right.

[PLATE 9] Marcasite from Montreal, Wisconsin. Photo by Lee Boltin (National Museum of Natural llistory) using direct light from an overhead spotlight. Photo by Lee Boltin Boltin Picture Library.

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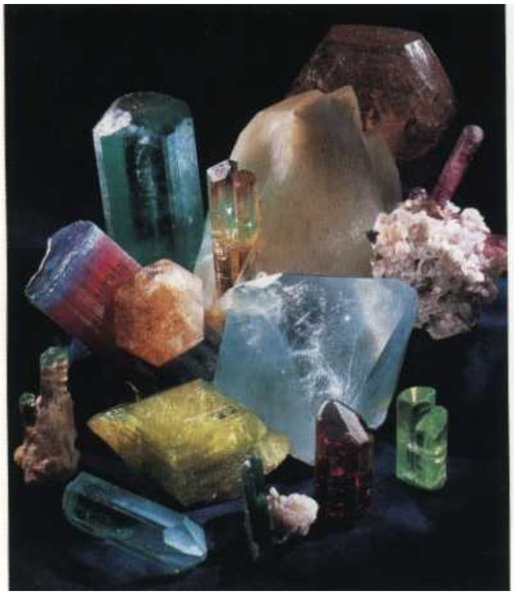
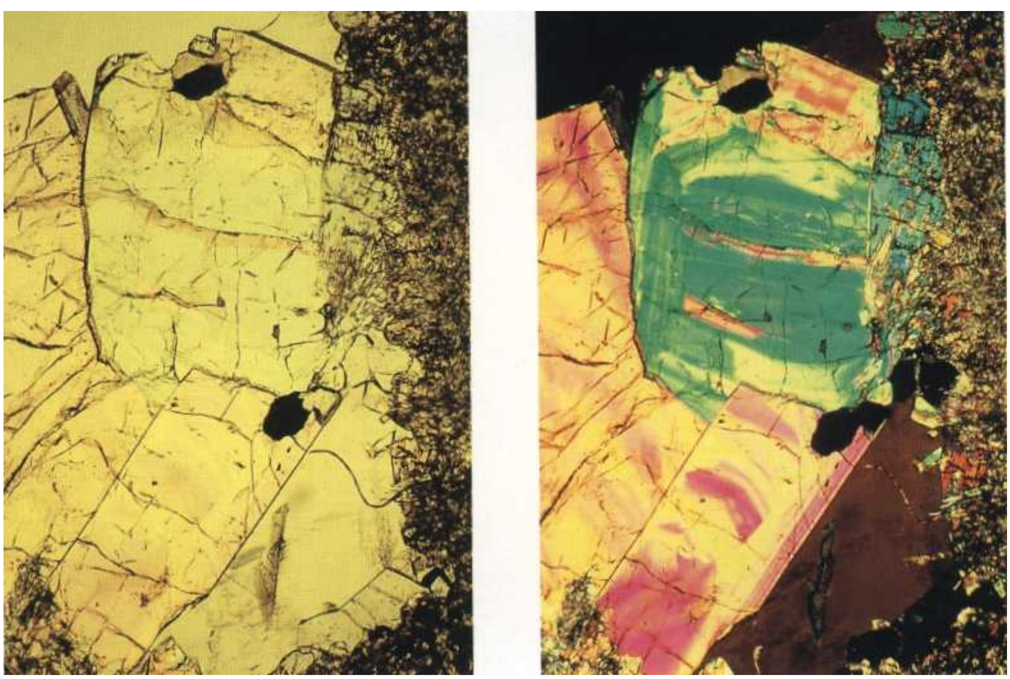


[PLATE 10] Gem crystals (Keith Proctor collection) Photo by Earl Lewis using backlighting with fill light from the front.

[PLATE 11] Cinnabar from llunan, China (erystal is 2 cm high; A. Chrapowiki collection). Photo by Wendell Wilson using backlighting with diffused overhead light.



[PLATE 12] Epidote minerals from McCullough Butte, Eurcka County, Nevada (Field, 2.5 cm). Photo bv Mark l). Barton (University of Arizona) using (a) at left, plano polarized light and (b) crossed polarizers.

CHAPTER 10

Filters

Some may think that there is little use for filters in the photography of minerals, gems, jewelry, and fossils; that filters are primarily used for "effects." However, accurate rendition of the subject matter is our first and foremost consideration, and filters can help us to achieve that goal.

Before discussing filters, a brief review of the nature of light is in order. White light is actually made up of three primary colors: red, green, and blue. Equal portions of any two of these colors produce the secondary colors: yellow, cyan, and magenta. Unequal combinations of the primary colors produce all of the colors we can see.

Light is not always usable as is because of variations in film sensitivities, proportions of the color components in "white" light from different sources, and our requirements. A filter's primary use is to alter light. This is accomplished by (1) selective color filtration, (2) polarization, (3) reduction of intensity, and (4) creation of special effects. The last function obviously does not aid in accurate rendition of subjects, but does have its uses in the photography of jewelry and is discussed in more detail in *Chapter 16.*

The filters that accomplish these alterations come in a variety of materials, each with their advantages and disadvantages:

- Colored-glass filters do not come in a wide variety and can be subject to fading through time.

- Coated-glass filters have the light altering material applied to their surface in a very thin layer. Neutral density filters are usually made this way. The coating on these filters can be easily scratched.

- Gelatin filters (Fig. 10-1) are a thin, colored plastic material, usually as unmounted squares. They are the best optically because of their thinness, are relatively inexpensive, and can easily be cut to size or shape as needed. Their disadvantages are case of damage by scratching, fingerprints, or wrinkling.

- Gelatin sandwiched between glass is protected by the glass and given rigidity. Such filters are generally of good quality.

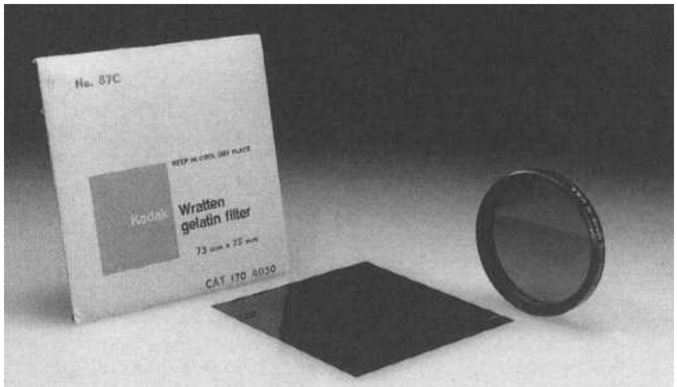


Figure 10-1 Gelatin filter with its envelope and screw-in glass filter.

It must be remembered that in all glass filters, the glass must be of good optical quality and properly mounted for squareness to the optic axis to minimize distortion.

Most glass filters are fixed in a rigid metal or plastic mounting. Most mountings are threaded so that they can screw onto the front of the lens. Some are unthreaded and designed to be mounted in special adapters. Most gelatin filters come as unmounted squares that must be used in special holders. Polaroid material comes as a gelatin filter that is either sandwiched between glass, as sheets, or in roles.

FILTERS OR BLACK-AND-WHITE PHOTOGRAPHY

Although the vast majority of photography of minerals, gems, and related materials is done in color, there are occasions when black-and-white photography is necessary. Not all publications print in color, and some specimens simply do not warrant color photography due to their lack of appreciable color.

Most black-and-white films today are panchromatic, meaning that they are sensitive to the whole spectrum of visible light. In reality, they tend to be slightly more sensitive to blue and less sensitive to red. In landscape photography this is a slight problem because skies tend to come out too light.

This characteristic is of little concern to us except when photographing blue minerals. Our main concern is the use of color filters for tonal separation because different colors with similar tonal values may look very similar when rendered in black and white. If you were to photograph red wulfenite on green pyromorphite, the two shades would be almost indistinguishable in a black-and-white photograph. To change those tonal values so that the eye can more easily distinguish between the two, you must use a color filter.

First we must understand how color filters work. Any color filter transmits mostly light of its color, and blocks other wavelengths of light to varying degrees.

The use of a colored filter will render that color lighter, and other colors (especially complementary colors) darker. Any secondary colors that contain some portion of the filter's color will also be rendered lighter to some degree. You can get some idea of how much a color will be lightened by viewing the subject through the colored filter you plan to use. The image will be monochromatic, but you'll still see relative brightness.

Lefs get back to the example of red wulfenite and Breen pyromorphite. If we were to photograph the specimen through a Wratten 58 green filter, the pyromorphite would come out very light and the wulfenite quite dark. This wouldn't look natural to the average person. If instead we used a Wratten red 25A, the wulfenite would be very light and the pyromorphite dark, which would seem more natural to the viewer. We may find, though, that the difference between the fght and dark is too great. So we choose a slightly lighter filter that does not pass so much red light. The idea is to achieve tonal separation and still get a natural look.

Other filters that can be used with black-and-white films include polarizing, neutral-density, and some special effects filters. They are discussed in the following section. See *Chapter* 15 for a discussion of the use of filters for the photography of fluorescent minerals.

FILTERS FOR COLOR FILM

COLOR FILTERS

TYPES OF COLOR FILTERS

Strongly colored filters are rarely used in color photography because they would dramatically alter the proper color rendition of the subject and everything else in the field of view. There are, however, important uses for weakly colored filters.

Color-conversion filters are used when you must match a film to a particular light source. For instance, in order to use Kodachrome 25 (a daylight film) with 3200 K tungsten lights, you must use a Wratten 80A blue conversion filter (in the United States, filters are designated by the Wratten system. The use of the word "Wratten" will not be continued in this book when referring to filters in that system). To convert Ektachrome 160 (a 3200 K tungsten film) to daylight, an 8511 orange filter must be used.

Light-balancing filters are used when the mismatch between film and light is a small one, such as when using a film balanced for 3200 K (e.g., Ektachrome 160) with 3400 K lights, in which case you would use an 81A yellow filter.

Color-correction filters are the palest of all the color filters. They are used for fine-

In all glass filters, the glass must be of good optical quality and properly mounted for squareness to the optie axis to minimize distortion.

tuning hue differences caused by such things as different film batches, reflections of colored walls, reciprocity failure, and so en. Color-correction filters come in the three primary and three secondary colors. A typical designation might be CC l OM, where CC stands for color compensation, the 10 is the density, and M stands for magenta.

Color-correction filters are also used to deal with reciprocity failure. At extremely long or short exposures, the different emulsion layers in film do not react equally. As a result, you get color and film speed shifts. The speed shift is compensated for by increasing exposure by an amount recommended on the film information sheet. The sheet will also recommend the proper filtration to use. For example, when using daylight Kodachrome 25, you must use a CC 10M filter to compensate for reciprocity failure with exposures from 1-30 seconds.

Color correction is best done at the time of exposure. With print film, it can be done at the time of printing, but the results may not be as accurate and the process is more expensive.

GENERAL CONSIDERATIONS FOR COLOR FILTRATION

There are two scales of color variation: color temperature (see *Chapter* 6) and hue. It is the latter that is of concern with fine-tuning color. For most professional photographers, fine control of hue is essential. Besides the great variety of light sources and their different color temperatures, variables in proper color rendition come from the color of studio walls, variations in the dyes in different batches of films, and even diffusers and reflectors.

Ultimately, it's best to buy your film in quantity, all of the same emulsion batch. Then test one roll to determine proper filtration. The test can be done shooting a standard color separation guide and a gray scale, plus familiar objects including your hand (for skin tones). Shoot on transparency film, examine the results on a color-corrected light box, and make sure that the ambient (room or window) light is at a minimum. Have a set of color-correction and light-balancing filters on hand. Determine the direction of the color cast and select opposite color filters. Lay them on the transparencies until the color separation guides match. It is best if you use no more than two filters to achieve correction. Once the filtration has been determined, shoot a test roll with the filters and compare again with the color separation guides.

Filters can be used in combination with one another if one alone will not achieve the desired result. It is wise,

It is wise, though, to keep the number of filters used to a minimum. The more filters you use, the greater the possibility of image degradation due to defraction from dust, scratches, and misalignment.

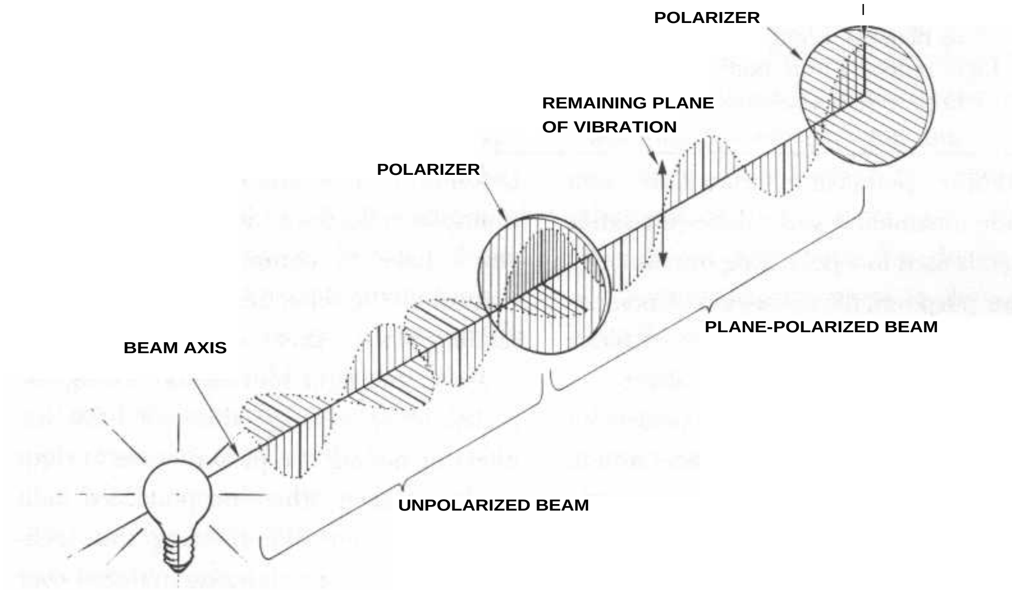


Figure 10-2 Polarizing of light by a polarizing material. Of the many possible wave directions, two vibrating at right angles are shown here.

though, to keep the number of filters used to a minimum. The more filters you use, the greater the possibility of image degradation due to diffraction from dust, scratches, and misalignment. Multiple filters reduce light transmission and degrade color saturation and contrast. Ideally, it is best to place filters over the light sources.

To keep color "pollution" from the room at a minimum, paint your studio white, black, or neutral gray. The same holds for studio accessories and props. Mask off arcas of colored backgrounds that are not in the field of view. Inquire at your local photo supply for industry approved neutral paints. It is also best if such paints are a flat finish to minimizc the possibility of flair.

POLARIZING FILTERS

To understand how polarizing filters work, we must first look a little further into the nature of light. Light travels in waves, in a manner similar to a stretched out rope that is shaken at one end rhythmically. The action creates a series of waves in one plane, but in light, the waves travel in all directions around the axis of the light beam. A polarizing filter acts like a picket fence, restricting the wave motion to one direction. The result is called place polarization (Fig. 10-2).

There are three sources of polarized light:

1. Clear blue sky. Light becomes partly polarized by air molecules and dust.
2. Light reflected from nonmetallic, smooth surfaces.
3. Light passed through a polarizing material or device.

While polarizing materials can include tourmaline and calcite (the latter is what is used in a polarizing microscope), for our purposes, the discussion of polarizing materials is limited to Polaroid filters (and other manufacturers' equivalents).

In general photography, polarizing filters are used to darken blue skies and to saturate colors. The latter is accomplished primarily through the elimination of numerous reflections that desaturate colors. In studio photography, polarizing filters are used primarily for the control of reflections.

As light is reflected off a nonmetallic surface, it becomes polarized. If that reflection is visible from the camera position and is unwanted, it can be eliminated or reduced by the use of a polarizing filter. Polarizing filters have a maximum effect when the light is reflecting at an angle of 36° to the surface.

Polarizing filters are designed to rotate in their housings. As you view the subject with the filter in place, rotate the filter until you see the reflection reduced to a minimum. If you have a subject with multiple reflections at different angles, youT have to compromise for partial control of the reflections. For total polarization, place a sheet of polarizing material over the light sources too. Using the picket fence analogy, this will have the effect of having two picket fences at right angles to each other: no polarized light comes through. When using this technique, rotate the polarizing material over the light, not over the lens. If you are using more than one light, adjust the filter on one light at a time with the others turned off.

Remember that metallic surfaces do not polarize light, so polarizing filters will not reduce reflections from them. On the other hand, such surfaces do not affect the polarization of light striking them at all, which means that if the light is already polarized when it strikes the metallic surface, it can be reduced with a polarizing filter over the lens.

When photographing minerals and gems, their form and surface features are

Because of the optical characteristics of minerals, some [polarized] light is passed through producing what are called *interference patterns* and *interference colors.* These patterns and colors are distinctive to different minerals and, as such, are a great aid in their identification.

defined by careful manipulation of reflections. A polarizing filter is rarely useful because it can greatly complicate such subtle manipulations. You may find that in controlling one problem reflection, you have killed several necessary reflections. Polarizing filters can, however, be extremely useful in the photography of jewelry with all of its highly polished metallic surfaces. When photographing on glass, you may get an objectionable reflection of the subject on the glass. A polarizing filter will often be able to remove or reduce this reflection.

Another use for the polarization of light in mineralogy is how it is affected by passage through a mineral. Typically, a thin section of a mineral or rock is placed between two polarizers in a petrographic microscope. Light is passed through this "sandwich" and interesting optical effects are observed. The effects are changed by rotating the filters or the subject. When the two filters are at Lght angles to each other (remember the picket fence), no polarized light should pass through. Because of the optical characteristics of minerals, some light is passed through producing what are called *interference patterns* and *interference colors.* These patterns and colors are distinctive to different minerals and, as such, are a great aid in their identification *(Place 12).*

The reason light passes through is because as the polarized light from the first filter penetrates the sample, it is split into two beams. This occurrence is called *birefringence.* One of the two beams is still vibrating in the same plane as the original. The other is vibrating at right angles to the original beam, and is now aligned with the second filter, allowing it to pass through. The effect can be observed by using two Polaroid sheets at right angles to each other, sandwiching a thin section. You can then photograph the effect using photomacrographic techniques without the use of a microscope. You do not need a petrographic microscope to photograph the effect if you are set up for photomicroscopy with your stereo microscope (though the higher magnification of a petrographic microscope is an advantage). To learn more about this phenomenon, consult a book on optical mineralogy or petrography.

NEUTRAL-DENSITY FILTERS

Neutral-density filters, as the name implies, are not colored. They are coated so as to reduce che amount of light entering the lens. They come in a range of densities from 0.1 to 4.0, which reduce the amount of light from 1/3 stop to 13 1/3 stops, respectively. Neutral-density filters are used primarily when switching film of different speeds and you want to maintain the same f-stops and shutter speeds. For instance, you may be switching back and forth between a print film and transparency film of different speeds, or from Polaroid test shots to transparency film of a different ISO. I have found a need for them when photographing using studio flash and 35-mm equipment. Sometimes the flash is too powerful and the only way to get a proper exposure is to use a neutral-density filter.

Neutral-density filters are also available in graduated form; that is, the filter's coating grades from one edge to the other. This sort of filter might be useful if you had a high contrast situation such as a very light matrix in one portion of the frame and a darker crystal on the other. Normally you would have to settle for a well-exposed dark crystal and an overexposed matrix.

SPECIAL EFFECTS FILTERS

There are numerous special effects filters available to the photographer. These include star filters, soft focus, multiple-image filters, and rainbow (diffraction) filters, among others. The only use we might find for these filters would be in the photography of jewelry, and only with discretion. A soft-focus filter with the right setting can add atmosphere, and a star filter can give that extra bit of glamour.

Because filters reduce the amount of light reaching the film, you must compensate by increasing the exposure time. There are tables published in books on filters and included with the filters themselves that list recommended filter factors. A filter factor is the recommended increase in exposure for a particular filter. A filter factor of 2 means an exposure increase of one stop. A factor of 4 is an increase of two stops, and a factor of 8 is an increase of three stops.

Some TTL metering systems easily deal with a filter's light reduction because they read the actual light coming through the filter. Unfortunately, not all meters are sensitive to all colors equally. With certain filters (especially shades of red) they may not be accurate. To check your meter's accuracy with a particular filter, take a reading through the filter, and compare it to a reading taken without the filter and using the recommended filter factor. Filter factors vary slightly with different types of films and light sources, so be sure they always match.

CHAPTER 11

Backgrounds

type of photography, but background treatment is another important consideration. Besides supporting the specimen, backgrounds provide contrast both in color and texture. The background can make the photograph rich and subtle, or so vibrant that the specimen seems to jump off the page.

PAPER

Colored paper is one of the easiest and most commonly used backgrounds. The basic setup for paper use is illustrated in Figure 11-1. A sheet of paper is set on a surface such as a table and curves up behind the specimen that sits near its front edge. The result is a seamless, nondistracting background *(Plate 9)*. You can make a paper background more interesting by illuminating it separately as the Pellmans have in *Plate 13.*

Two of the best papers to use are Color-Aid and Chroma-Rama, which are matte-surfaced papers with the color silk screened on one side only. These papers (or comparable products) can be bought in art supply stores in a vast range of colors. Advantages of these papers are their very matte, textureless surfaces and saturated colors. The papers come in 18 x 24 inch sheets. Care must be taken in the use and handling of these papers because creases and dents show easily. The coating is also easily scraped off.

You can also buy sheets of paper that are printed with a light-to-dark color gradation from one end to the other. Pantone is one of the makers of this kind of paper (they also make a paper that is dark at either end and grades to light in the middle). The use of such paper eliminates some of the problems of attaining the same effect by light manipulation alone. The colors of these papers are not as saturated as the previously mentioned papers, and they do not have a totally matte surface.

Better camera stores sell rolls of seamless background paper 53 inches wide by 12 yards long. Unfortunately, this seamless background paper does not come in as wide a range of colors as Color-Aid and Chroma-Rama.

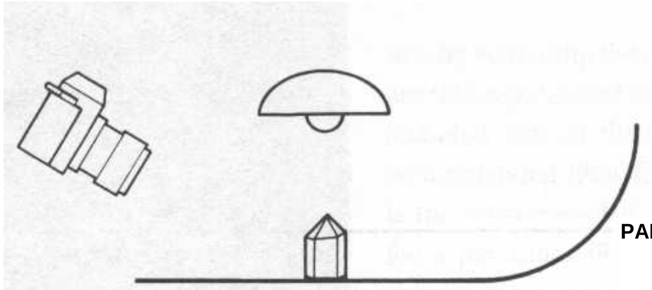


Figure 11-1 Setup for a paper background. The upward curve of the background allows photography of taller subjects.

Colors for backgrounds should be chosen with care. Complementary or neutral colors work best. Keep the colors toned down, as bright colors can be distracting. A good procedure to follow is to set your specimen on several different colored backgrounds until you find the one that works best. Try to imagine the color under consideration with the spotlighting or graded lighting that will be on it. Sometimes a color that would be too bright or garish if used as a solid evenly illuminated background, works quite well if most of it is dark and just a small portion is spotlighted.

Solid black is popular because it is very dramatic and nondistracting. However, avoid the use of black with dark minerals or they will just fade into the background.

The best black is produced by using a deep nap black velvet. Somewhat less effective is black flocked paper that can be bought in rolls and sheets from art supply stores as well as store-display supply houses. Unless the specimen is substantially lighter than the velvet or flocked paper, the background (especially around the base of the specimen) may be rendered as a gray. You may also get a slightly "sparkly" effect because of the light reflecting off of the lustrous fibers. When stored, these black backgrounds should be protected from dust. Just before use they should be cleaned thoroughly, which can be done by patting the material with some masking tape wrapped around the fingers, sticky side out. Commercially made lint removers are available that consist of a handle with an attached roller covered with sticky paper. They can be bought at the supermarket or drug store.

The nap of the black flocked paper crushes easily, with the crushed spots showing as light arcas in photographs. It's a good idea to cut off any such damaged arcas before each use so as to maintain a clean, solid black background.

Pure white is rarely used as a background because it is usually too plain and boring unless partially shaded to produce a tonal gradation.

PLEXIGLAS

Another good background material is translucent white plastic. A number of brands are available, the best known

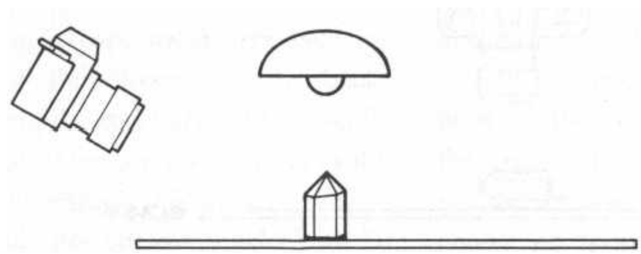


Figure 11-2 **Plexiglas background setup**

being Plexiglas. Such plastics come in a variety of colors and thicknesses. You can find plastics suppliers in the Yellow Pages. Some of them even sell useful scraps by the pound if you don't need a large piece. White is most commonly used as it makes a neutral, but still attractive background when it is partially shaded to produce a tonal gradation. Subtle tints can be added by placing a sheet of colored paper beneath the plastic. Wendell Wilson, editor of the *Mineralogical Record,* popularized the use of Plexiglas as a background *(Plate 14).* George Robinson is also known for his use of the same background material *(Plate 15).*

An advantage to using translucent plastic is that shadows falling on it are diffused and not very distracting. Interesting effects can be achieved by lighting the plastic from beneath with spodights with or without colored gels. For such effects, the plastic should be raised up off the table by some means. For this purpose, a small framework can be made of various materials similar to a table without a top.

Plastic is also quite tolerant of the inevitable scratches from your specimens. Occasionally there will be minor, barely noticeable reflections. If they are objectionable, the specimen can be repositioned to minimize them. Tight framing of the subject (filling the field-of-view), when possible, will also minimize such reflections. The plastic may also reflect objects on the far side of the setup from the camera. To eliminate such reflections, prop up or hang a sheet of black paper or cloth on the far side of the Plexiglas. This procedure will also aid in attaining a dark gradation of the background, as the plastic will reflect the dark material hanging behind it.

Figure 11-2 shows the basic shooting setup using plastic. The specimen sits at the front of the plastic sheet, as with a paper background. However, you must be careful to keep the camera angle such that the far edge of the plastic does not show in the photo. You may find it to your advantage to prop the plastic sheet up at a slight angle.

These plastics are not very flexible and so do not easily curve up behind the specimen. Curvature of the plastic back ground can be accomplished by clamping it down on either side, about even with the specimen, and then propping up the

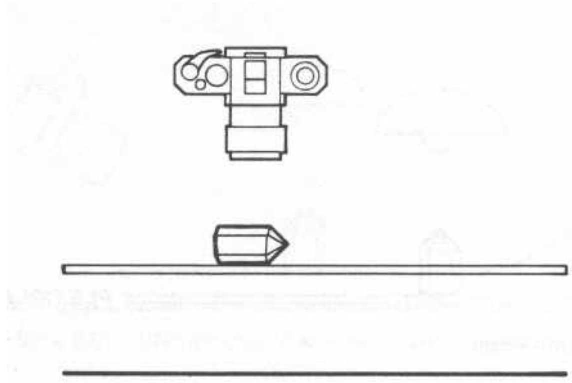


Figure 11-3 Copy-stand setup for shooting on glass. The paper is far enough below the glass so that the subject's shadow does not fa[¡ within the field-of-view.

back end. The open-topped framework table mentioned previously is ideal for this setup. lt can be designed with clips near the front edge instead of clamps, and with an adjustable, extendable back to raise the plastic up to create a curvature. Several manufacturers make a variety of Plexiglas-topped photography tables of this nature. Ads for them can be found in most photography magazines. Sinar Bron and Calumet both carry several models.

lt is handy to have the sheet of plastic the same size as the paper backgrounds that you use. That way, the paper fits underneath the plastic easily when used for tinting. The plastic can also be stored and transported with the sheets of background paper. One-eighth of an inch is a good thickness for this size plastic. Larger pieces (up to 4 x 8 feet) should be one-quarter inch in thickness for strength, especially if used with an open-topped framework table.

GLASS

Photographing minerals on glass has a number of distinct advantages over the usual method of placing a specimen directly on a background material. The technique requires a little more tare to use, but the results, because of the versatility of the method, are well worth it.

ADVANTAGES

With a sheet of glass (1 /8 inch thick is usually sufficient) suspended horizontally above a colored-paper background, the

When specimens (especially highly reflective metallic ones) are photographed directly on a colored background, they can reflect the color of the background. Such reflection can result in pyrite crystals with green faces or hematite with odd purple tints. This distortion seldom happens when shooting on glass due to the distante of the colored background from the specimen.

camera is positioned to look downward at the glass in a copy-stand arrangement. Because of the distance of the background from the specimen and the angle of the light, there are no shadows in the finished photograph (Fig. 11-3).

1 usually use one main light with fill illumination provided by white cards, aluminum foil (matte side), or hand mirrors all placed on the upper sheet of glass. lt's easy to vary their angles and locations so as to fill shadows and define crystal faces. The most obvious advantage to shooting on glass is that there is no shadow around the specimen. A shadow can distract a viewer's attention from the specimen, and dark areas of the specimen may blend into it. Subjects photographed this way Nave the appearance of "floating."

One of the more appealing aspects of the technique is that the specimen and the background are separate and can be lighted independently. This approach is not always possible when the specimen is directly on the background material. I do most of the composing and lighting of the specimen before I give the background much consideration. I then choose an appropriate colored paper to place on the lower level, which is then lighted without disturbing my careful lighting arrangements of the specimen. 1 can photograph the specimen with several different background treatments, including a change of colors, without touching the subject.

Another advantage to shooting on glass is that colored reflections on the specimen from the background are rare. When specimens (especially highly reflective metallic ones) are photographed directly on a colored background, they can reflect the color of the background. Such reflection can result in pyrite crys-

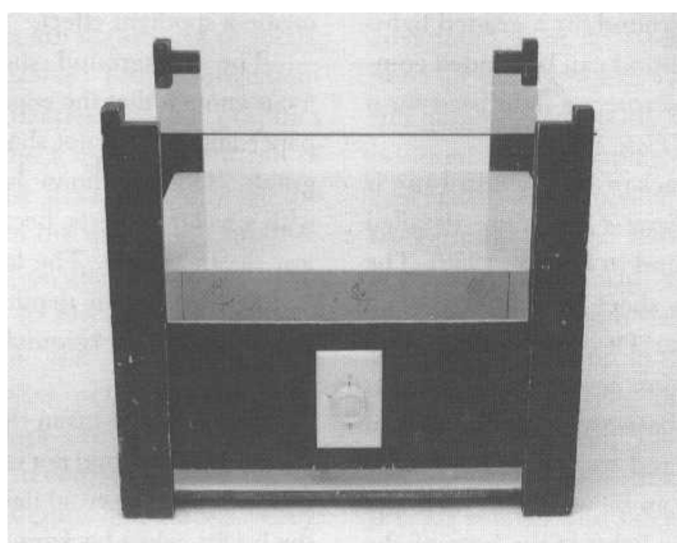


Figure 11-4 Device I use for photography on glass, from plans in Kodak (1962). Two 250-watt photo floods are contained in the lower section below diffusing Plexiglas, and are controlled by a dimmer switch.

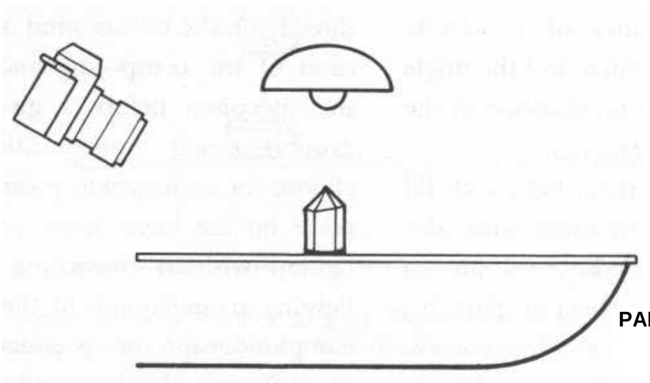


Figure 11-5 Alternate glass setup. The camera is positioned as if for paper or Plexiglas backgrounds. Colored paper hangs from the far side of the glass and curves forward beneath it.

tals with green faces or hematite with odd purple tints. This distortion seldom happens when shooting on glass due to the distance of the colored background from the specimen.

Sheets of black construction paper lying on and hanging from the upper sheet of glass can be used to partially shade the background for a graded lighting. The background can be shaded completely and a microscope light used for a spodight effect (Plate 16).

The glass background system 1 use is illustrated in *Figure 11-4* (more detailed plans can be found in Kodak, 1962). The lower level is a sheet of double-flashed opal glass (white Plexiglas can be used instead). Both glass levels are adjustable. In the enclosed base are two #1, 250-watt photo floods wired to a dimmer switch. The opal glass can be used with no paper covering, and the lights in the base of the unit turned on. This setup creates a perfectly white background suitable for clean scientific illustrative purposes. An alternative is to cover the opal glass with a colored gel and use the dimmer switch to vary the saturation of the background to balance it with the specimen lighting. Sheets of black paper partially covering the gel can create graded effects, and paper with a hole strategically placed can create a spotlight effect.

The background should be out of focus enough that the edge of a shadow or paper laid on it is not sharp in the photo graph. This condition is easily attained with smaller subjects, because of the shallow depth-of-field. The larger the subject is, the greater your depth-of-field and the sharper such background transitions will be.

Care must be taken that all of the illuminated background not in the field-of-view be masked off to avoid flair (especially with the bright, white background), and to keep the specimen from picking up excess transmitted and reflected color from gels.

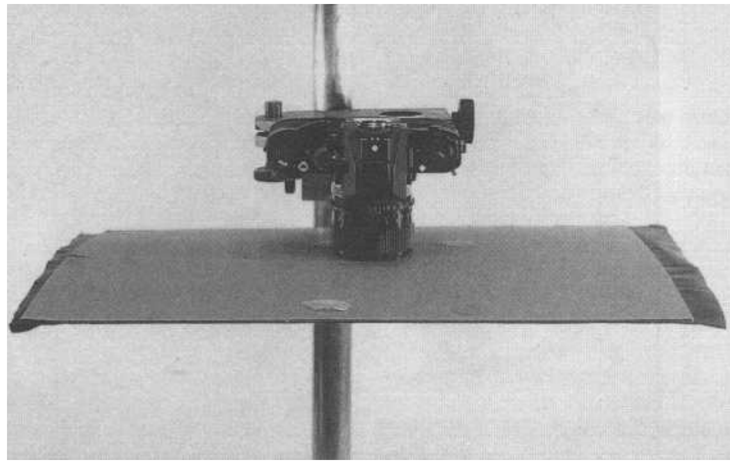


Figure 11-6 Cardboard shield covered with black flocked paper to prevent reflections when photographing on glass.

Various shapes and layers of either gels or papers on the lower level can create interesting effects, especially for jewelry photography. Another interesting effect can be achieved by placing old maps, photography, and the like on the lower level beneath the specimen. The background level should be adjusted so that the graphics are slightly out of focus, but still recognizable. This arrangement is especially effective if the graphics relate to the subject, such as a portrait of the owner of the item, or a shot of the mine from which the specimen carne.

Photography on glass also makes easy. In this method, the light comes through the specimen from behind. Spotlights or focusable fiber-optic illuminators are often the light sources for this technique, which brings out the subject's color and transparency. Frontal lighting and backlighting can be combined when shooting transparent crystals. Shooting on glass also lends itself to the dark-field lighting technique discussed in *Chapter 7.* When using the lights contained in the base for transillumination, be sure to use them at full power, or their color temperature will no longer be balanced with your film.

Many specimens do not naturally sit in a position that shows them to best advantage, or at the particular angle you need for photography. They usually need the help of some putty to prop them in position. The propping of a specimen, especially when placed directly on a background, can be difficult. Long, thin crystals, or those with very small bases are the worst. Some delicate specimens will just not bear up to the handling and putty needed to hold them in position. On glass, however, the specimen can often just be laid down making the process simpler and safer.

Subjects can also be photographed on glass in a manner similar to shooting on a flat sheet of Plexiglas but with some

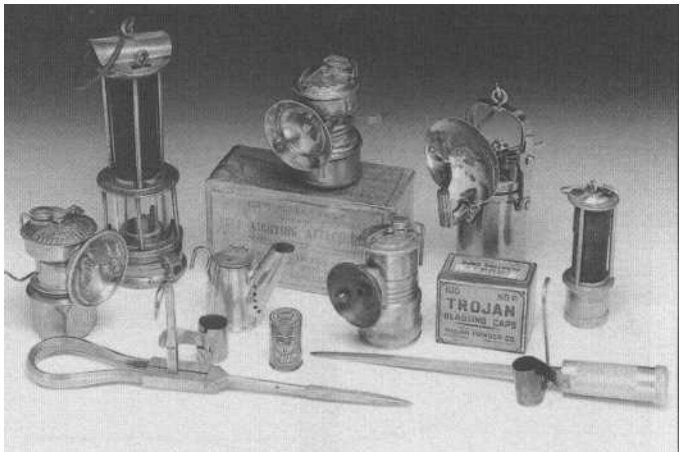


Figure 11-7 Plastic background with gradation airbrushed on. (Antique mining artifacts from Keith Williams Minerals)

of the advantages of shooting on glass as just described. The glass is held horizontally on a framework that has a sheet of background paper hanging down from its far edge, and curving forward as illustrated in *Figure 11-5.* Standard glass may be used, but nonglare glass such as is used in picture framing is more commonly used.

With this technique you Nave the advantages of separate lighting of background and specimen and lack of shad ows around the base of the specimen. Some people don't like the subject to "float" and feel more comfortable with something to indicate that it rests on a surface. With this alternate glass method, there is usually a subde reflection in front of the specimen that indicates the glass surface. The advantage of using nonglare glass is that it softens this reflection and makes it less distracting. The microtexturing of the glass also diffuses and softens lighting treatments of the background. Halo and gradient effects are softer and more gradual. If necessary, reflectors can be placed beneath the glass for highlights that would be unobtainable if the specimen was directly on an opaque background. Harold and Erica Van Pelt were the great innovators with their use of this technique. A sample of my use of the method can be seco in *Plate 17.*

DISADVANTAGES

Some care must be taken with glass backgrounds. Dust is a constant problem, as are fingerprints and putty smudges. The glass should be stored in a dustfree container, and should be carefully cleaned with glass cleaner before each photo session, as well as between the shooting of each specimen. A fine antistatic brush (available at camera stores) should be used to remove dust from around the specimen just before the actual exposure (be sure to dust the bottom of the glass too). It is useful to keep several soft brushes in different sizes on hand for dust

[PLATE 131 Gold from the Eagles Nest Mine, Placer County, California (ea. 10 cm high; Norm and Roz Pellman collection). Photo by Norm and Roz Pellman on a paper background.

[PLATE 141 Cuprite from the Southwest Mine, Bisbee, Arizona (crystal is 2.6 cm high; D & R Graeme collection). Photo by Wendell Wilson on a Plexiglas background.

[PLATF 151 Zircon from Matilda Lake, Quebec, Canada (4 cm high; Canadian Museum of Nature collection). Photo by George Robinson on a Plexiglas background. Reproduced with the permission of the Canadian Museum of Nature, Ottawa.

[PLATE 17] Beryl-variety emerald on calcite from Muzo, Boyacá, Colombia (5.5 cm wide; Bob Johnson collection). Photo by Jeff Scovil on an alternate glass setup.

[PLATE 16] Elbaite from Nuristan, Afghanistan (10.7 cm long; Bill Mickols collection). Photo by Jeff Scovil with the crystal lying flat on glass.

[PLATE 18] Forsterite-variety peridot from Sapat, Kohistan, Pakistan (64.75 ct stone, 5.1-cm high crystal). Photo by Jeff Scovil on black glass with diffused light reflecting off the glass from behind. (Laura Thompson collection)

[PLATE 19] Calcite from Elmwood Mine, Smith County, Tennessee (6.5 cm high; Terry Huizing collection). Photo by Terry Iluizing on colored gel (plastic) background.

[PLATE 201 Tabletop still life: The Gemmary. Photo by Jeff Scovil.

[PLATE 211 Cyanotrichite on spa ngolite from Kamareza, Laurium, Greece (Spray is .5 mm high). Photo by Dan Behnke using bellows and an Olympus Zuiko macro lens.

[PLATE 22] Vanadinite from the Old Yuma Mine, Pima Country, Arizona (field, 5.8 cm-, Les and Paula Presmyk collection). Stereo pair by Jeff Scovil.

[PLATE 23] Kidwellite from the Ouachita Mountains, Arkansas (field, 1.1 cm; Steve Chamberlain collection). Photo by Steve Chamberlain using a Nikon SMZ-10 stereomicroscope.

removal. Good brushes include make-up and sable painters' brushes.

Static electricity can be a real problem with glass and can be aggravated by rubbing it with brushes. To reduce the problem caused by using brushes (if they are not antistatic), breathe on them frequently during use as if you were trying to fog a window. Be careful not to spit on them. Antistatic brushes come in two varieties: carbon fiber and one that contains a slightly radioactive strip at the base of the fibers. The latter type only lasts a few years. The carbon-based brushes will last almost forever, and if they get dirty, they can be washed. An air bulb or canned air can also be handy but must be used with care as they will often stir up more dust than they remove. You can also buy antistatic guns that shoot a static neutralizing spark. When using such guns, you may find that you end up getting shocked by the spark.

If you are lucky enough to have a room devoted to your photography, you might consider using an air cleaner to keep down dust. lf you live in a very dry climate, or shoot in the dryness of winter in a cold climate, a humidifier will also help to keep down dust and static build-up.

Scratches can be a major problem with glass. Make sure that specimens are placed on the glass carefully, and never dragged over it. You may wish to place dabs of putty on the bottom of the specimen to protect the glass, or lay it on a small piece of paper that does not show from the camera's viewpoint. A spare sheet of glass kept handy is also a good idea.

Reflections can be a nuisance when using glass. The darker you make your background, the more the glass acts as a mirror. To eliminate this problem, use barn doors on your lights, or a sheet of black paper or cardboard (called a "gobo") to keep the light from shining directly on the camera. When shooting straight down on glass, 1 use a large "lens hood" made from a sheet of cardboard covered with black flocked paper. This hood fits snugly around the lens, and keeps the camera from reflecting in the glass (see Fig. 11-6). Make sure that none of your mirrors or fill cards are creating reflections. Lastly, turn off all overhead lights so there is no reflection of the ceiling.

Just as with the Plexiglas, reflections of objects on the far side of the glass can be a problem. Black cloth or paper should be hung on the far side of the glass to eliminate reflections. Such reflections can actually be used to advantage. Hang a translucent white material above

Antistatic brushes come in two varieties: carbon fiber and one that contains a slightly radioactive strip at the base of the fibers. The latter type only lasts a few years. The carbon-based brushes will last almost forever, and if they get dirty, they can be washed.

and beyond the far edge of the glass and illuminate it from behind with a spot- or microscope light. This very soft, diffused reflection can be positioned in the field-of-view to create a halo effect that also brings out the subtle texture of the nonglare glass. The technique is very effective when using a black background. The shape of the reflection can be changed by use of gobos or barn doors on the light behind the translucent material. You may also control the shape by taping strips of black paper on the backside of the material *(Plate 18).*

Numerous other materials can be used as backgrounds, especially for gem and jewelry photography. Don't be afraid to experiment.

Cloth is seldom used for minerals because even the finest texture will show and may be distracting. There may be occasions, however, when you wish to have a textured background. If you do, keep the texture subtle so as to enhance the specimen and not detract from it.

Another useful background material that achieves the same graded effect as with Plexiglas or paper is a heavy-gauge, opaque white plastic that comes in a short roll about 43 x 63 inches. A white-to-black gradation is air brushed onto the plastic (Fig. 11-7). This background is durable and can be cleaned with a damp cloth and mild soap, and minor marks can be removed with a soft eraser. It can be bought at better quality camera stores but is fairly expensive. Brandess/Kalt Co., Inc., makes such backgrounds in a variety of colors. A good camera store may be able to sell you a swatch book of the available colors.

You may also photograph directly on photographic colored gels *(Plate 19).* They come in a wide variety of colors, and their reflective surfaces produce interesting effects.

Mirrors can also give interesting results, especially with cut stores and jewelry. Wood, sand, gravel, textured plastics, and plastic laminates, such as Formica, are only a few of the materials you can use. Slabs of stone such as are sold in landscape supply yards are ideal backgrounds for jewelry shots.

You may wish to photograph more than one specimen in a single shot. Various boxes or other supports can be placed beneath an artfully draped cloth on which the specimens are to be placed. These supports may also be exposed if they are attractive enough. The possibilities include clear plastic blocks and rods (which can be bought at a plastics supplier), and wood blocks. Such supports should be neutral in color and of subdued texture. The supports, or raisers as they're also called, can be carefully upholstered in various materials if you wish.

Interesting group shots can be taken with appropriate props such as mining lamps, drill bits, dynamite boxes, and weathered wood. For a more sophisticated look, photograph on an old desk top with props such as old goniometers, assaying instruments, microscopes, books, and mine stock certificates. Lighting on such shots can get quite tricky and will require a great deal of experimentation. The Van Pelts are again the leaders in this genre, with their rich, tabletop groupings used in beautiful magazine ads and articles. Plate 20 shows my use of the technique.

If your specimen completely fills the field-of-view, then you peed not worry about backgrounds. Some people feel that this is the ultimate in mineral (as opposed to specimen) photography. They feel the specimen should stand by itself with no window dressing.

Specimen photography, on the other hand, depends on backgrounds to complement and set off the specimens. Because of the nature of some specimens, the matrix cannot always serve as the whole background. It is then up to the photographer to deal with the situation as he or she sees fit.

CHAPTER 12

Attaining Magnification

attain magnification. The method chosen depends on two factors: degree of magnification required and budget.

Magnifications up to life size are easily handled with either extension tubes, supplementary Glose-up lenses, or macro lenses. Magnifications up to 40 or 50 times can be achieved with bellows, and a microscope can attain even greater magnification. Optical microscopes can reach magnifications of 500 times and more but, because of the limitations of depth-of-field, are seldom used for photographing three-dimensional objects at magnifications much greater than 100 times. Scanning electron microscopes (SEMs) are excellent for high magnification photomicrography; however, they are not discussed in this book because of their expense and general lack of availability. Their use is also limited to highly trained specialists.

DEFINITIONS AND COMPARISONS

Two of the most misused words in photography are probably "macro" and "micro." ***Macrophotography is*** the art of making large photographs. ***Photomacrography is*** the art of photographing small subjects. ***Microphotography is*** the production of very small photographs (e.g., microdots), and ***photomicroscopy is*** the photography of objects through the microscope. The term ***photomicrography is*** interchangeable with photomicroscopy. In addition, the term Close-up ***photography*** generally refers to

Macrophotography is the art of making large photographs.
Photomacrography is the art of photographing small subjects.
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work done between the shortest distance a normal lens will focus and lile size.

This chapter explores the two different ways that you can get closer to a subject to obtain a larger image: photomicroscopy and photomacrography. In the former, a camera is attached to a microscope. The microscope's optics are used to gather the light for the image. In the latter, any one of a number of lenses and accessories, excluding microscopes, are used to obtain the needed image size. The difference between the two is defined both by range of possible magnification and by the method of obtaining that magnification (Kodak, 1969). In photomicroscopy, the camera is attached to and uses the microscope optics. Most microscope and camera manufacturers supply adapters that attach your camera to the microscope. Magnification ranges from about 2:1 to 50:1 or more. Generally, the lighting used in photomicroscopy is limited due to shorter working distances, the nature of the microscope, and the high magnifications.

Magnification is calculated by dividing the size of the image by the size of the subject, and can be expressed as a deci mal (.5x is one-half lile size) or a ratio (1/2 size or 1:2). A magnification of 5 times would be 5:1.

In photomacrography, you can choose from a number of lenses, accessories, and techniques to achieve the needed magnification. Magnification ranges from 1:1 to about 50:1 and usable light sources are less restricted than in photomicroscopy.

One major difference, obviously, is that of magnification capabilities. Microscopes have a definite advantage in that arca, but you pay a price for it. As the magnification increases, the depth-of-field decreases. *Depth-of-field is* the distance in front of and beyond the point at which the lens is focused that the subject appears to be in focus (Behnke, 1991). When photographing a mountain scene, the depth-of-field is nearly infinite, but at high magnification it may be a fraction of a millimeter.

Although photomacrography does not provide very high magnification, its advantage is greater depth-of-field. This capability is possible because photographic lenses contain an iris diaphragm to control the amount of light passed on to the film. As the lens is "stopped down," and the diaphragm opening becomes smaller, the depth-of-field increases. Because of this feature, photomacrography is the preferred method for obtaining magnifications. Some microscopes have iris diaphragms, but they are expensive and hard to obtain.

PHOTOMACROGRAPHIC EQUIPMENT

MACRO LENSES

Magnification of a subject is increased by extending the lens from the camera. A normal lens typically will take you no closer than 18 inches with a magnification of 1:5. A macro lens is designed to extend further and attain a 1:2 or 1:1 magnification. The optics in such a lens

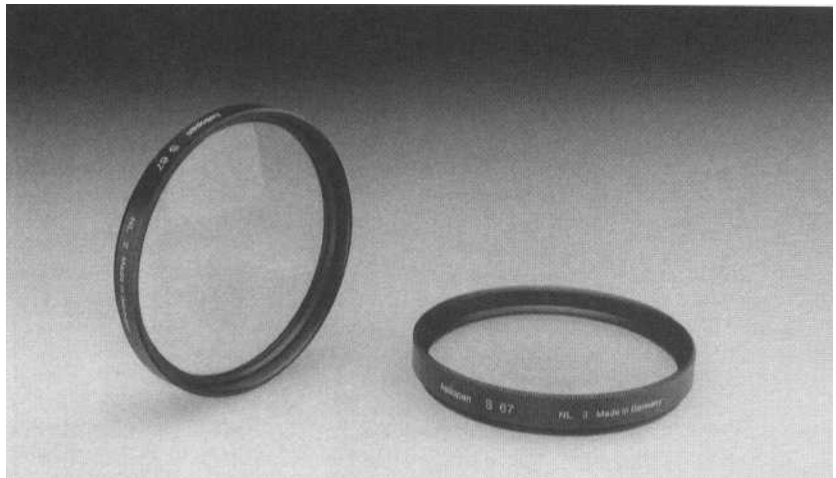


Figure 12-1 Supplementary close-up lenses (Courtesy of Photomark)

are also designed for such close-up work. Because of the decreased depth-of-field with magnification, you are essentially doing flat-field photography. Normal lenses are not designed for that job, but macro lenses are. Macro lenses are generally available in two focal lengths: 50 mm and 100 mm. A 50-mm lens will attain a given magnification with less extension and light loss. The 100-mm lens gives you more working room and better perspective. Macro lenses are also capable of smaller apertures, thus providing greater depth-of-field. A minimum aperture of f22 is standard for macro lenses, while f16 is standard for a normal lens.

Some camera manufacturers supply lenses that go beyond ordinary macro lenses in their ability to deal with higher magnifications and shallower depth-of-field. Such lenses include Zeiss Micro Tessars, Canon Macrophoto lenses, Olympus Zuiko Macros (in focal lengths of 20 mm, 80 mm, and 135 mm), and the Leica Photar series ranging from 12.5 mm to 120 mm. Focusing must be done by moving the whole camera assembly and/or the specimen because these lenses are nonfocusing. Such lenses are superior for the high-magnification work necessary in micromount photography. A 20-mm macro, for instance, easily obtains a magnification of 14 times on a bellows. Dan Behnke, well-known micromineral photographer (*Plate* 21), uses the Olympus Zuiko macro lenses for his work.

CLOSE-UP LENSES

Macro lenses are not inexpensive, but there are alternatives that vary greatly in the quality of image attainable. Supplementary close-up lenses are one of the options (Fig. 12-1). They work essentially like a magnifying glass and screw onto the front of your normal lens like a filter does. Their magnification strength is rated in *diopters:* +1 diopters, +2

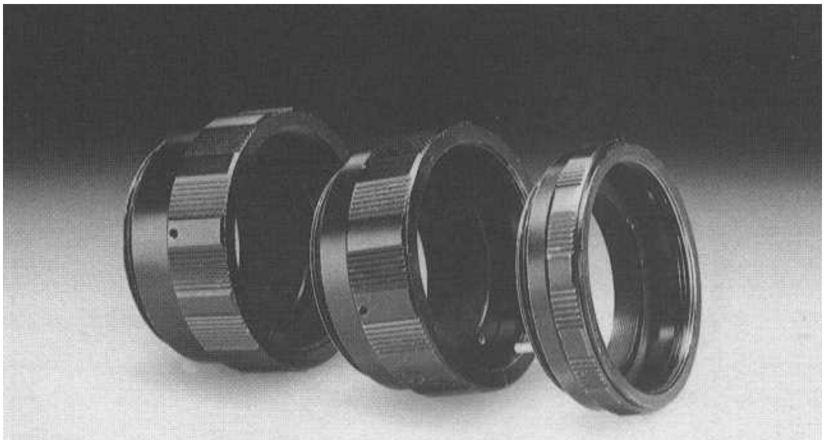


Figure 12-2 Extension tubes for Glose-up photography.

diopters, and so on. They can be purchased individually or in sets of three to four, and can be used individually or in combination to attain different magnifications. Generally, the best magnification you can attain using diopters is 4:1. Aside from their limited magnification, their use degrades image quality by the addition of too much glass in front of your lens.

Yoshida Industry Co. Ltd., of Japan, has recently introduced a product that is a great improvement on the old Glose-up lens systems. Their Raynox Model CM-3500 MicroExplorer is a series of three Glose-up lens assemblies that thread into an adapter that snaps into the front of your lens. Instead of being simple single lenses, each assembly consists of from three to four separate lenses of high-quality optical glass. The lenses are not designed for use on the standard 50-mm lens, but on a 200-mm or 300-mm focal-length lens. For greater versatility, a zoom in the range of 70-210 mm or 100-300 mm works best. Depending on which lens you mount the assemblies on, you can reach magnifications of up to 8x. Because of the high quality of the optics, the images are far superior to those obtained with normal Glose-up lenses.

EXTENSION TuBES AND BELLOWS

Another option is the use of extension tubes that are inserted between the lens and camera body (Fig. 12-2). They are usually available in sets of three, each of a different length. As with the diopters, they can be used individually or in combinations. They have the advantage of being relatively inexpensive and add no more glass surfaces to degrade the image. With a standard set of tubes and your normal lens you can easily reach a 1:1 magnification.

To achieve greater magnification, you can use a bellows, which is an accor-

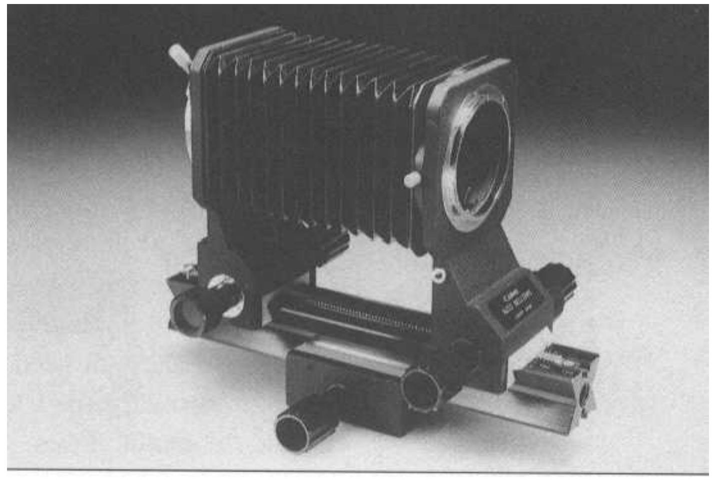


Figure 12-3 Bellows for greater magnification than can be achieved with extension tubes.

dionfke expandable device attached to a set of rails (Fig. *12-3).* The lens is attached on one end and the camera on the other. The front and rear standards are both movable and can be locked in place. Bellows are usually substantially longer than extension tube sets, and so higher magnifications can be achieved. Between the two extremes of full extension and retraction, the magnification range is continuously adjustable as opposed to the three set lengths of extension tubes.

The best Bellows are those with a double rail system. One set of rails allows for magnification adjustment, while the other focuses by moving the whole camera-Bellows-lens assembly.

You can combine Bellows and extension tubes for even greater magnification. If you are mechanically inclined, much larger extension tubes can be made from such things as plastic pipe or the heavy cardboard tubes on which carpet comes rolled (see Fig. *A-3* in *Appendix A). You* must be careful to line the inside of the tube with black, nonreflective material such as cotton flocking or flocked paper. This lining eliminates light scattered by bouncing around in the tube, which can create washed out "hot spots" on the photographs. Also, make sure that the image the lens projects covers the full frame at such an extension. If it doesn't, the corners will be cut off and the photograph "vignetted."

REVERSING RINGS

Bellows and extension tubes will give you the magnification you want, but you still have the problem of using lenses that were not designed for such close-up work. The average lens is designed to work with a greater distance in front of the lens than behind it (towards the film plane). As you extend the lens for greater magnification, this conjugate relationship is reversed, with a shorter distance in front

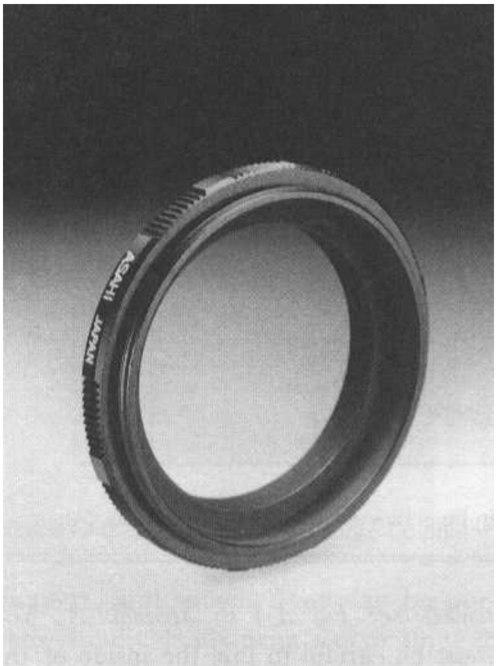


Figure 12-4 Reversing ring for mounting lens backwards in order to improve image sharpness when the lens is extended beyond intended limits.

of **the lens** than behind. **lf the lens is mounted backwards, the proper ratio is restored** and image quality dramatically improved. Reversal can be accomplished by **the use** of an inexpensive reversing ring that screws onto the front of a lens like a filter *(Fig. 12-4)*. You then mount the lens backwards and proceed with your photography *(Fig. 12-5)*. Keep in mind that in using a reversing ring you lose all of your automatic lens functions that must then be done manually. Lens reversal also benefits macro lenses and increases magnification slightly without additional extension. Some bellows are designed so the lens can be reversed without having to use a reversing ring.

OTHER LENSES

In photomacrography, we are trying to record an essentially flat object (remember the shallow depth-of-field) on a flat frame of film. Darkroom enlarger lenses are designed to do just that, so they are ideal for use in photomacrography. You may be able to buy a used enlarger lens through a used photographic equipment dealer. You also will need an adapter or two to attach the lens to your bellows/extension tubes. Such adapters are usually available through a good camera dealer. They can also sometimes be made by modifying a camera body cap by boring a hole in its center to allow for mounting of the lens. These lenses generally do not Nave to be reversed in use. Another option is a ciné lens, which can also be bought used, often inexpensively. Such lenses should be used reversed because their optics are very close to the rear of the lens. This setup makes it easier to get close to a specimen at higher magnification and not interfere with the lighting.

OBTAINING KNOWN MAGNIFICATIONS

There are times when a specific magnification of a subject must be obtained, usually to fulfill publication requirements. There is a simple formula that can be used to determine magnification with any lens. Magnification (M) is equal to the distance (d) between the lens and the film plane divided by the focal length (F), minus one.

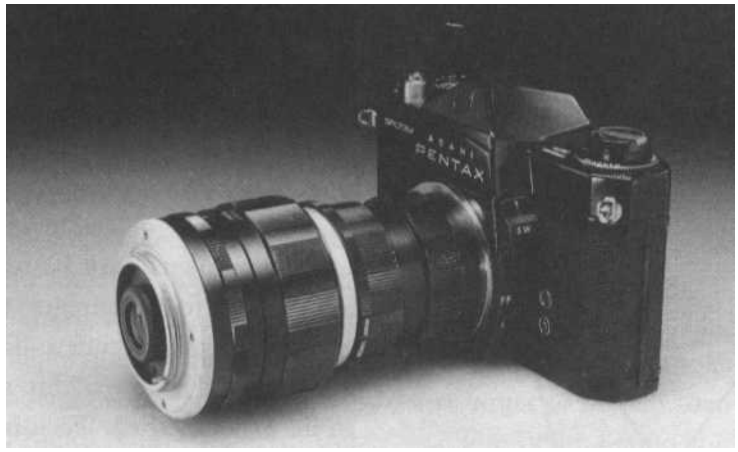


Figure 12-5 Lens mounted reversed on extension tubes.

$$\text{Magnification} = \frac{\text{Lens-to-film- distance}}{\text{Focal length}} - 1$$

$$M = \frac{d}{F} - 1$$

The point from which you measure on the lens is the diaphragm. Since this varíes from lens to lens and is hard to determine accurately, another technique can be used. Place a scale in the subject position and adjust the lens-to-film distance until the required magnification is reached. You might logically assume that with 35-mm equipment, you could just divide the reading off the scale into 35 mm, that being the length of the frame as viewed through the viewfinder. Unfortunately, very few viewfinders show the complete field-of-view, and are under by a few percent. The most accurate method would be to measure the length of the image on a small ground glass placed on the focal plane of the camera (ground side toward the lens) with the back open (and no film in it).

You may wish to know the final magnification. If the subject is large enough, you measure it, and divide it into the final measured image size. You can also place a scale in the photograph in the primary plane of focus that is then divided into the measured length of the scale in the final photograph.

Keep in mind that in using a reversing ring you lose all of your automatie lens functions that must then be done manually. Lens reversal also benefits macro lenses and increases magnification slightly without additional extension.

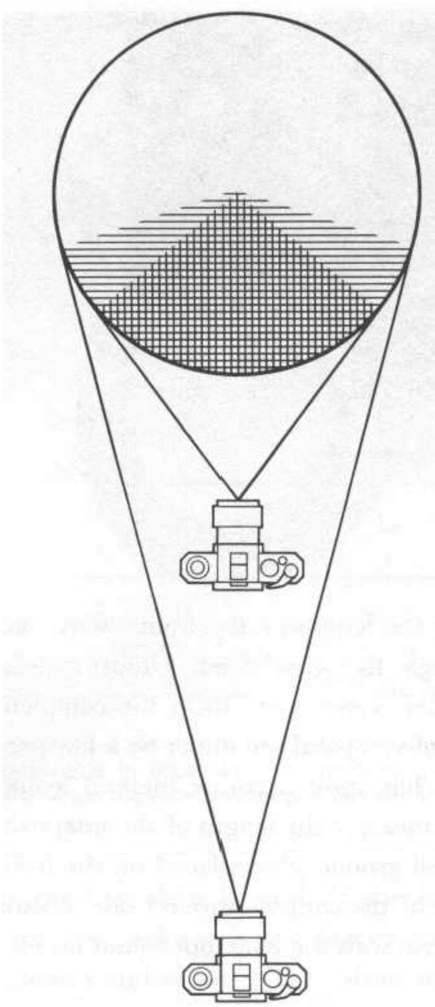


Figure 12-6 Perspective with different focal length lenses. Short focal length lenses give distorted perspective, foreshortening the subject. Longer focal length lenses (ca. 100 mm) give more accurate perspective.

To make magnification determinations easier, many manufacturers of bellows mark the rails in centimeters and with degree of magnification based on the use of a specific macro lens. Most lens manufacturers also provide data on degree of magnification for different lens-to-film plane distances as well as field-of-view at different magnifications.

MAINTAINING MAGNIFICATION DURING ADJUSTMENTS

Once the desired magnification is obtained, any adjustment of the focusing ring, bellows, or extension tubes will change the magnification. Therefore, all such adjustments must be made by moving either the complete camera-lens assembly or the specimen. If you're using a double-rail bellows, this movement is easily accomplished. Focusing rails that operate in the same manner, with a geared track, can be bought from the larger photo supply houses.

In some copy-stand arrangements, there is a gear or friction drive that makes adjustments easy. An old enlarger stand can be used for the same purpose, especially if it has a gear or good friction drive.

Since the specimen is often much smaller and lighter than the camera and its attendant paraphernalia, it is easier to move the specimen. This may be best accomplished by the use of lab jacks. Lab jacks are adjustable platforms that operate on the principle of a car's screw operated jack. Lab jacks can be bought through laboratory supply houses and scientific suppliers such as Edmund Scientific in a variety of sizes and prices.

There are numerous ways to create a focusing stage out of found items. The lens board of an inverted enlarger head can be used to hold the specimen, with the focusing mechanism adjusting the height of the subject. See *Appendix A*, Gadgets and Gizmos, for further discussion and plans for focusing stages.

IMPORTANT CONSIDERATIONS

DEPTH-OF-FIELD AND DEPTH-OF-DETAIL

Depth-of-field is a subjective phenomenon, as it is the arca in a photograph that appears to be sharp. As stated earlier, the smaller the diaphragm opening (the higher the f number), the greater the apparent depth-of-field. Unfortunately, this gain is attended by a loss of overall sharpness or "depth-of-detail" due to diffraction of light from the smaller diaphragm opening. Depth-of-detail is " . . . a depth range over which detail of a given fineness or separation is delincated satisfactorily" (Kodak, 1969).

While depth-of-field increases indefinitely, depth-of-detail increases to a point, then decreases dramatically. The photographer must decide whether to (a) maximize depth-of-field with a loss of sharpness or (b) compromise and not stop down all the way to retain some sharpness or depth-of-detail. Most lenses are designed for optimal sharpness when stopped down two to three stops from their largest opening. Most people choose maximum depth-of-field, because the human eye more readily discerns a lack of focus than a lack of fine detail.

PRINCIPAL PLANE-OF-FOCUS AND DEPTH-OF-FIELD

When you focus on a subject, there is actually only one very thin plane that is in focus. The location of this plane can be critical for two reasons. If you are trying to obtain a specific subject size in the final photo, the principal plane-of-focus must coincide with the subject's greatest width. If it does not, the subject will measure larger or smaller than desired.

The other reason for critical placement of the principal plane of focus is for optimal use of depth-of-field. As a gener al rule, when you stop the lens down to obtain maximum depth-of-field, the distance that comes more into focus is twice as far beyond the principal plane-of-focus as in front of it. This condition is why it's often said that you should focus one-third of the way into your specimen. This approach does not take into account the possibility that your total depth-of-field may not equal the depth of the specimen. Also, at magnifications greater than 1:1, the arca in focus on either side of the principal plane-of-focus is about equal.

The best way to deal with this problem is to establish your principal plane-of-focus, then stop the lens down to the taking aperture. While stopped down, carefully examine the subject through the lens and make sure that all critical details

To increase your depth-of-field, you have two choices: either Glose down the diaphragm or decrease the image magnification. To decrease depth-of-field, open the diaphragm or increase image magnification.

are in focus. lf not, adjust the camera or specimen for the best results. You may have to make compromises, remembering that major crystals should remain sharp and that lack of focus on profiled arcas near the top of the specimen will be more noticeable than arcas near the bottom or even the center. You will quickly find that focusing with the lens stopped down is difficult because the viewfinder will be fairly dark.

A common misconception in photography is that shorter focal length lenses provide greater depth-of-field. "Depth of field is a function of the relationship between the diaphragm opening and the image magnification" (Blaker, 1989). To increase your depth-of-field, you have two choices: either close down the diaphragm or decrease the image magnification. To decrease depth-of-field, open the diaphragm or increase image magnification. The misconception arises from the fact that a shorter focal length lens has less image magnification, and therefore greater depth-of-field. lf you were to obtain the same image size using two different focal length lenses, you would find the depth-of-field for each to be the same. An interesting point here is that for a given extension, the shorter focal length lens will give you greater magnification. So if you have come to the limit of your extension capability and still not achieved the desired magnification, switch to a shorter focal length lens.

WORKING DISTANCE

Working distance is another important factor in photomacrography. The greater the magnification, the shorter the distance between the camera lens and the subject. At high magnifications, the working distance may be so short as to interfere with the lighting of the specimen. lf you find this to be a problem, try using a longer focal length lens and greater extension to achieve the same magnification with greater working distance.

Short working distances also make it hard to predetermine the proper distance of the camera from the subject to start the focusing and framing process. At a 1:1 magnification, the working distance is approximately the lens-to-film distance. By the time you reach a 3:1 magnification, the working distance is about equal to the focal length of the lens. These approximations should be used as rough guidelines for initially setting up your camera-subject distance. lt's always a good idea, especially at high magnifications, to start a little closer to the specimen than estimated, and then back off until focus is achieved. lf you work the other way around, you run the chance of grinding an expensive lens into a rare or expensive specimen.

PERSPECTIVE

lt is preferable to use the longest focal length lens possible for a given setup because it minimizes image distortion. While the use of shorter focal length lenses means less extension and greater possible magnification, they produce inaccurate perspective of the subject. As you can see in *Figure* 12-6, short focal length lenses cannot "see around" the contours of three-dimensional objects, and so they exaggerate the portion of the subject closest to the lens. This distortion is exemplified by portraits we have all seen that were taken with a wide-angle (short focal length) lens. The lens greatly distorts the features and makes the nose disproportionately large. As mentioned before, a longer focal length lens gives us a longer working distance, making the use of lights, reflectors, and diffusers easier.

SPECIMEN ORIENTATION AND HIGHLIGHTS

Considering the lack of depth-of-field, orientation of the specimen is very important. Major crystals should be oriented as nearly as possible in a plane parallel to the film plane. Use the preview button on your camera to manually stop down the lens to be sure all important features and crystals are in focus before shooting. On the other hand, selective focus and minimal depth-of-field can be used to isolate a subject, such as a single crystal, that would be lost in a "forest" of other crystals.

Use of the preview button is also important to examine details of the high lights. A highlight that is of the perfect intensity with the lens wide open, may nearly disappear at the stopped-down taking aperture. The same holds true for background lighting treatments such as spodighting. That diffused spotlight effect may be reduced drastically in size and become too sharp-edged as it comes more into focus.

PHOTOMICROSCOPY

Here are a few helpful tips concerning photomicroscopy: You should make sure that the tension on the microscope's focusing mechanism is adjusted so that the weight of the camera will not cause it to creep out of focus. Microscope eyepiece tubes were not designed to hold the weight of a camera. If the eyepieces are at an angle, you should make a platform angled to hold the microscope, so that the eyepiece tubes are vertical. Some microscopes (binocular microscopes) come with a third tube specifically designed as a camera mount. This is a great feature because otherwise you must mount the camera on an eyepiece and lose the use of that eyepiece. Photomicroscopy is further discussed in *Chapter 13*.

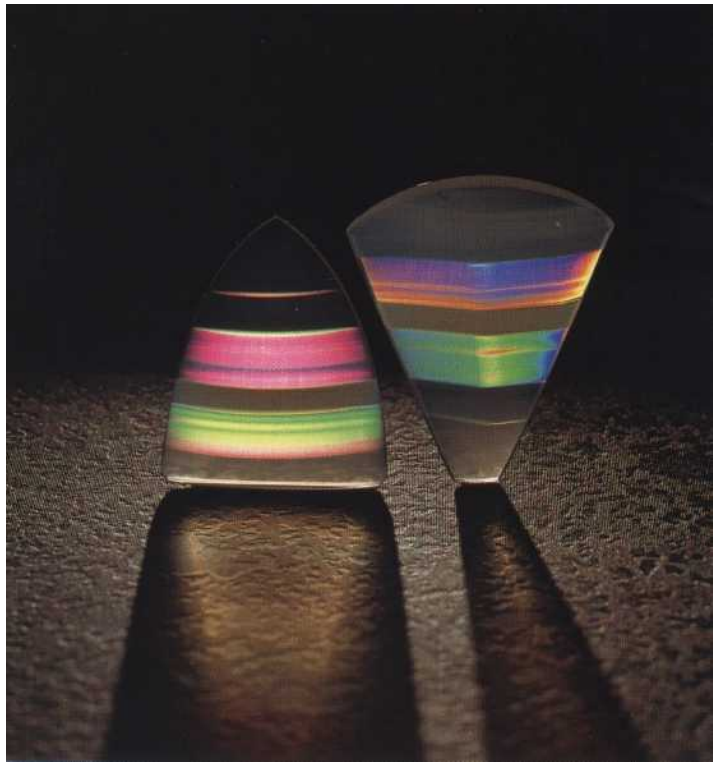
on left, incandescent light and (b) fluorescing with ultraviolet light.

[PLATE 2,5] Calcite from DaFNegorsk, Primorskiy Kray, Russia (19.5 cm high). lleliodor specimen. Photo by Jeff Scovil on glass with double exposure, using quartz halogen light for the background and ultraviolet for the calcite.

[PLATE 26] Carvings in agate and chalcedony by Glenn Lehrer. Photo by Lee-Carraher.

shown approximately life size.

[PLATE 281 Opal and diamond ring. Photo by Michael Havstad on Lusterboard.



[PLATE 29] Iris agate: Crystal Reflections. Photo bv Robert Weldon using backlighting to bring out the iris phenomenon in the agate.

[PLATE 30] The Hope Diamond (National Museum of Natural History). Photo by Tino Hammid.

[PLATE 31] Grossular garnets. Photo © by Joel E. Arem.

[PLATE 32] Jewelry designed by Martin Gruber for Nova. Photo by Sky llall.

CHAPTER 13

Photomicrography

There is a great deal of satisfaction in dealing with the microscopic aspects of mineralogy, gemology, and paleontology. However, when this minuscule world must be shared with a larger audience, and there just aren't enough microscopes to go around, the photography of such tiny objects must be accomplished. In *Chapter* 12 1 discussed how such photography is done using more or less standard photographic equipment. In this chapter, I cover how it is done with the microscope.

But first F11 point out the advantages and disadvantages of photography through the microscope as opposed to the photomacrographic techniques already discussed in *Chapter* 12. The major advantage is the greater magnification that can be attained. In photomacrography, the theoretical top magnification is 50x, while in photomicrography it can be hundreds or thousands of times that. For our purposes, though, a magnification of around 150x is the limit. We are limited because of dealing with three-dimensional subjects, and the higher your magnification, the shallower your depth-of-field, which limits your ability to satisfactorily encompass a three-dimensional object.

Chapter 12, one way to increase depth-of-field is to "stop down" the lens's

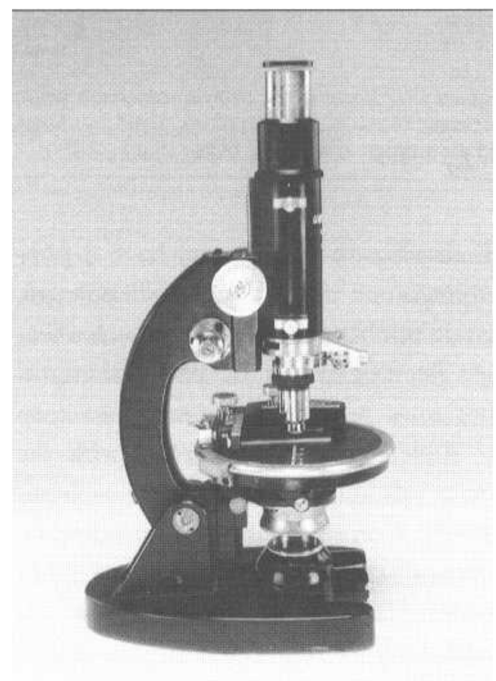


Figure 13-1 Monocular petrographic microscope. (Courtesy of Bill Hunt)

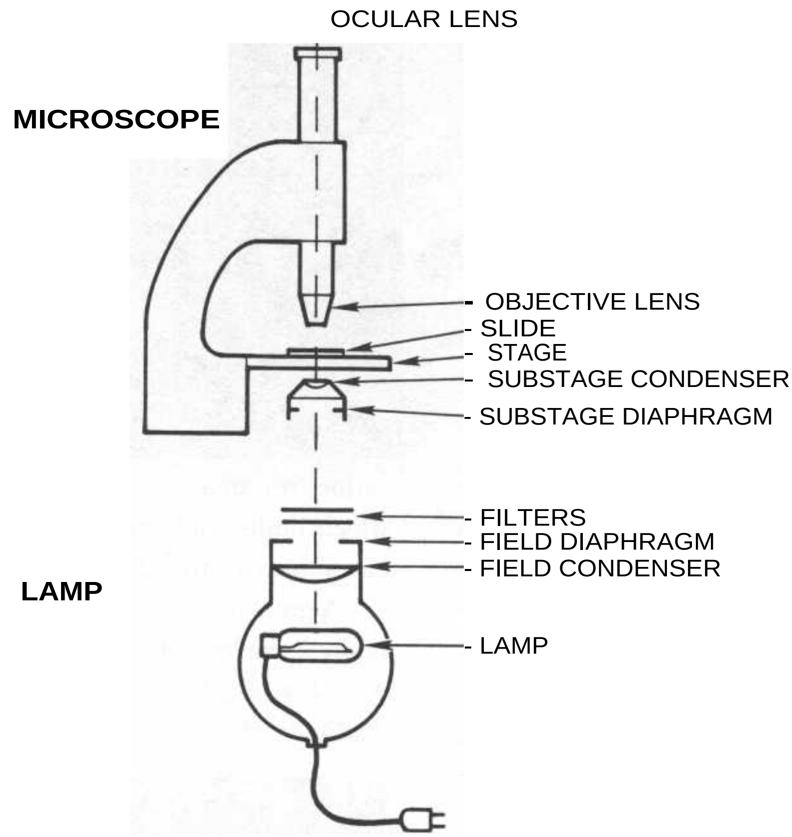


Figure 13-2 Basic monocular microscope setup. Beneath the stage is the substage condenser, then the substage diaphragm, then filters, field condenser, and, finally, the light source. Al¡ elements are aligned on a common optic axis. (After Blaker, 1989)

iris diaphragm. Unless you have a photomicroscope that features a diaphragm, you do not have the control of such a feature. Because of this, the photomicrographer must be especially careful to keep the subject in a plane parallel with the film to minimize depth-of-field problems. The question you must ask yourself when deciding which system to choose (photomacrography vs. photomicrography) is, which is more important to you, depth-of-field or magnification? If you deal primarily with very small subjects beyond the range of photomacrography, the answer is obvious. Of course, if finances permit, having both is the answer.

TYPES OF MICROSCOPES

COMPOUND MICROSCOPES

Nearly all microscopes used today are compound microscopes. They basically consist of a tube with lenses at either end that produce a magnified image. The lens closest to the subject that does the initial magnification is called the *objective.* The lens, or eyepiece, that you look

Figure 13-3 Antique Bausch & Lomb monocular microscope. (Courtesy John Lucking)

through is called the *ocular.* It produces a secondary magnification and corrects any minor optical problems of the objective. For best photographic results, both the oculars and objectives should be the same brand and designed for use with each other. They should also be flat-field lenses so that all will be in focus on the film plane. Many lenses are not flat field and, while suitable for direct viewing, are not good for photography.

MONOCULAR MICROSCOPES

Most of the higher powered biological microscopes are monocular, meaning that there is only one tube, one objective, and one ocular. Petrographic microscopes, used for the examination of thin sections by transmitted light, are also of this design (Fig. 13-1).

Figure 13-2 illustrates the basic monocular microscope setup. Below the stage is a light source with a field con denser and iris diaphragm, both of which are used to control the field illumination. Immediately below the stage is a substage condenser and substage diaphragm that control image contrast,

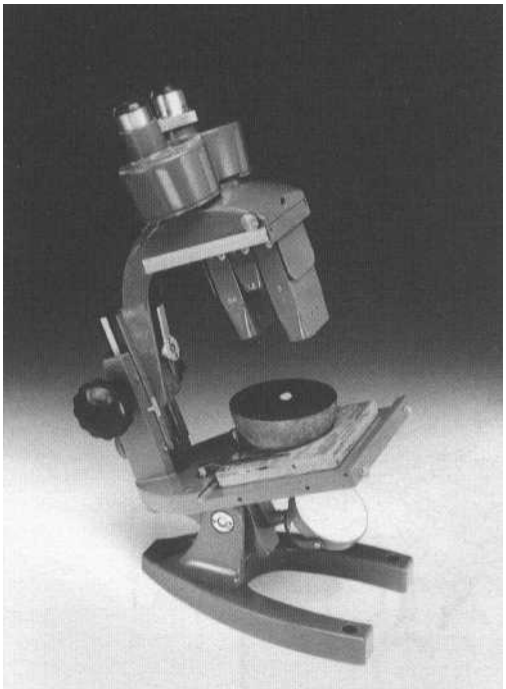


Figure 13-4 Binocular Greenough microscope by Bausch & Lomb. (jeff Scovil Collection)

image diffraction, and depth-of-field. *Figure 13-3* shows an antique monocular microscope.

Except for petrographic microscopes, monocular microscopes are of little use in the fields covered in this book. There are several reasons for this: (1) they are too high powered for most of our purposes, (2) they are designed primarily for transmitted light viewing of transparent subjects, and (3) they are designed primarily for viewing what are essentially "flat" objects, while we are interested primarily in three-dimensional objects.

BINOCULAR/ STEREOMICROSCOPES

The simplest stereomicroscopes have two tubes, each with its own ocular and objective. They are essentially two monoculars mounted side-by-side at an angle of 12-14°. They are angled so that they focus on the same subject, albeit each with a slightly different view. The result of this configuration is a threedimensional view of the subject. Such microscopes are called Greenough Microscopes and are relatively low powered (usually less than 100x). They are used primarily for viewing threedimensional subjects that may be opaque *(Figs. 13-4* and *13-5).* The wide-field microscope has separate oculars, but uses only one objective *(Fig. 13-6).* For a more detailed discussion on these two types of microscopes, see Wight (1993). Gemological microscopes are stereo microscopes fitted with forceps for holding cut stones, plus substage condensers, iris diaphragms, and dark-field, reflected, and transmitted lighting *(Fig. 13-7).*

For best photographie results, both the oculars and objectives should be the same brand and designed for use with each other. They should also be fíat-field lenses so that all will be in focus on the film plane. Many lenses are not fíat field and, while suitable for direct viewing, are not good for photography.

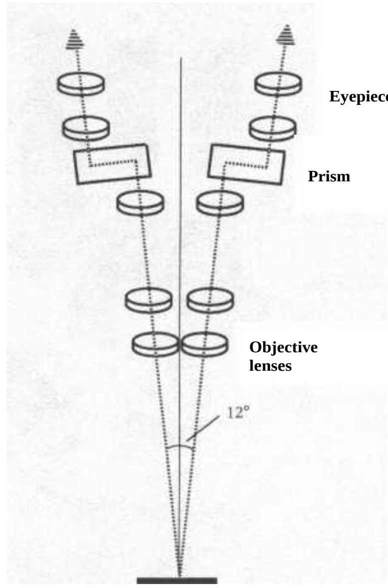


Figure 13-5 **The Greenough binocular microscope is essentially two joined monocular microscopes. (Wight, 1993)**

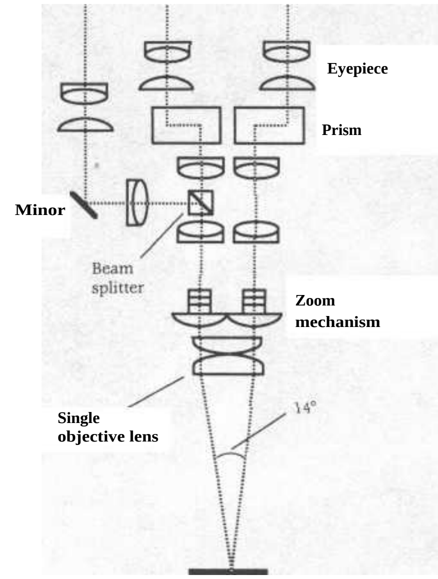


Figure 13-6 **The wide-field microscope uses a single large objective lens. (Wight, 1993)**

TRINOCULAR PHOTOMICROSCOPES

This type of microscope has the two standard tubes, as well as a third designed solely for use in photography (Fig. 13-8). There are several advantages to the use of such a microscope. (1) The third tube allows viewing with both eyes while the camera is mounted. (2) The photo tube is usually of a larger diameter, reducing potential reflections from the use of smaller diameter viewing tubes. (3) The photo tube is a straight line to the objective, without the prisms in the viewing tubes that can degrade the photographic image. (4) If the objective for the photo tube is separate from the viewing tubes, they are probably optimized for photographic work, producing a superior image.

There are several ways that light is channeled into the photo tubes:

1. The photo tube has its own separate, complete optical system. This arrangement is simple but fairly expensive. It has, howcver, the advantage of always being available and has the same brightness as the oculars. Besides the added expense, a disadvantage is its slightly different view than the viewing tubes.

2. A beam-splitter can be used in one tube to divert the light from one ocular. The light is always available and has the same view as the oculars, but there is a reduced amount of light to each (Fig. 13-6).

3. A slide mirror or prism diverts the light from one of the oculars. This method affords the same orientation and amount of light, but when in use, the ocular from which the light is diverted cannot be used. The mirrors that must be used are front surfaced to minimize distortion. The coating on such mirrors is delicate and subject to discolorization after a few years.

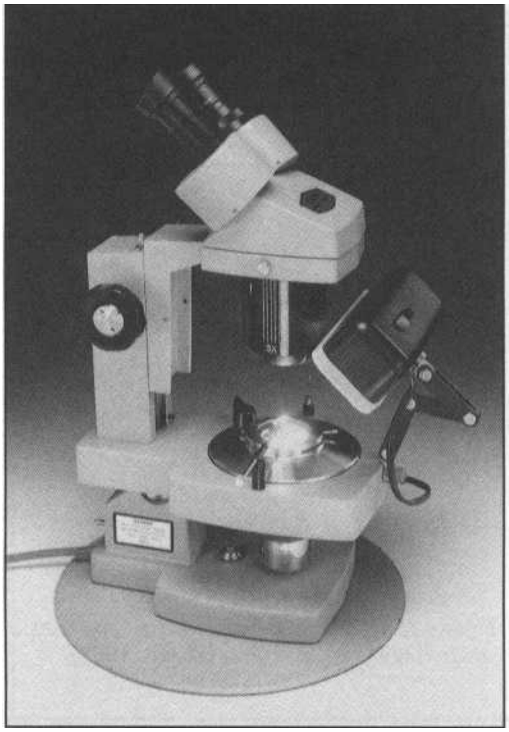


Figure 13-7 Gemological microscope with both transmitted and reflected illumination, and dark-field lighting (Courtesy of Michael's Creative Jewelry)

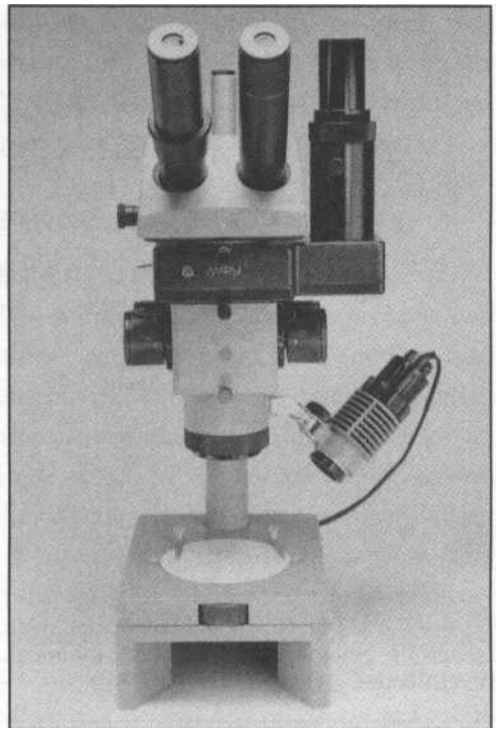


Figure 13-8 Russian MBS-10 trinocular microscope with photo tube on right. The light beam is diverted by beam-splitters that are placed in the light path by means of a lever. (Courtesy of *C & N* Minerals)

Many trinocular microscopes have an iris diaphragm built into the photo tube for depth-of-field control, and the tube can be extended for aid in focusing. Some have a right-angle eyepiece built into the tube for viewing with the camera mounted. Another advantage of the photo tube is that you can make the camera parfocal with the oculars, that is, in focus in the same plane of the subject at the same time.

Higher powered monocular photomicroscopes have some advantages over trinocular photomicroscopes because of the following additional accessories to aid in photography: mechanical stages for precise manipulation of the subject; substage condensers that can be focused, centered, and rotated; iris diaphragms; and provisions for mounting filters, center stops, and other light modifiers.

Although trinocular microscopes do not have all of these accessories, they still are the best means of doing photomicrography, although relatively expensive. Most of the microscopes in use today are of the standard stereo variety. There are few people willing to invest in a second, more expensive microscope just for the sake of photography. While using a standard stereo microscope for photography is not as convenient or up to the same standards of quality, very good

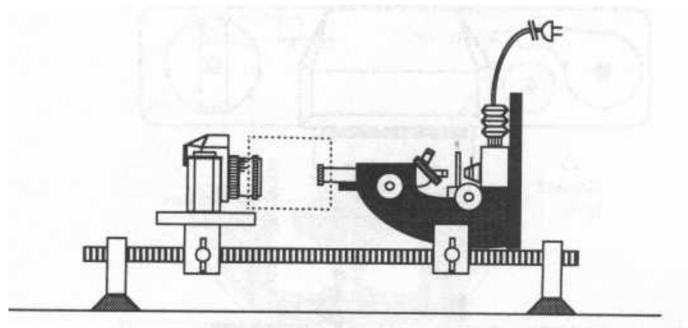


Figure 13-9 Setup for photomicrography on an optic bench with lens on camera. (Wight, 1993)

results can be obtained. It is, of course, true that the higher the quality of the instrument, especially the optics, the better the quality of the photomicrograph.

THE CAMERA-MICROSCOPE COMBINATION

There are three basic ways to use a camera with a microscope.

A camera with its own lens used with the microscope ocular (Fig. 13-9). This method is fairly simple in concept, but can be difficult to do and works best with monocular microscopes. After focusing on the subject, you place a white card above the ocular and move it back and forth until you locate the point at which the cone of light is at its mínimum diameter. Place the camera so that the front surface of the lens is at that point. Have the lens focused for infinity and the diaphragm wide open to minimize the possibility of vignetting. Enclose the gap between the camera and microscope to keep out stray light. Use a material that will not transmit vibration. This method is best done on an optical bench (essentially a horizontal rail) to ensure alignment of the components. It is difficult to locate the proper camera-microscope distance and to maintain alignment. The use of a binocular microscope compounds the problems dramatically.

2 A camera without a lens, but with microscope ocular. This method is the most commonly used because it is the simplest. As in the preceding method, the camera and microscope can be mounted on an optical bench to ensure alignment, and the gap between the two made lighttight. The distance between the two is not critical, but will change the magnification that varies with the distance. The quality of the image does not vary significantly with varying distances. Most commonly, an optical bench is not used, and the camera is mounted directly on the microscope by

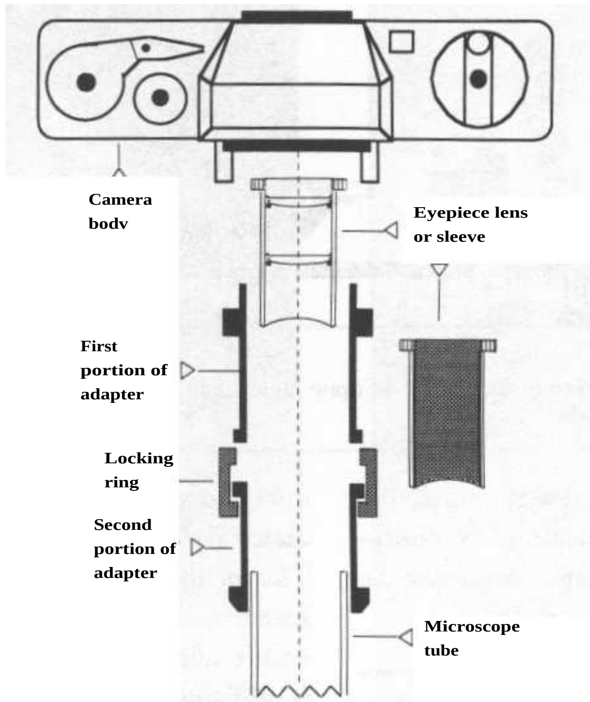


Figure 13-10 Schematic of a camera with a microscope adaptor.

means of an adapter that screws on in place of the camera lens (Fig. 13-10).

These adaptors usually come in thece parts: one attaches to the camera, another to the microscope, and another that joins the two. The ocular may have to be removed to attach the microscope-mounted portion and then inserted before camera attachment. Many adaptors are made so you can vary the distance and therefore the magnification. Unfortunately, most adaptors are designed for use on the larger diameter tubes of monocular microscopes and must be modified for use on a binocular microscope. Consequently, you may have to saw off the portion that fits the microscope and replace it with a smaller diameter tube made from PVC pipe or some other tubing. To make it fit snug, you may have to cut slots lengthwise in the tube (about 3/4 inch, 2 cm, deep) so that it can be snugged down with a hose clamp.

Another problem is that there is usually little arca for the adaptor to grip. You don't have the long unobstructed tube you have on a monocular microscope. So the camera can fall off if jarred. Also, you may not be able to take advantage of the tubc's focusing ability to bring the camera parfocal with the other tube. As a result, you must focus through the camera and not the other ocular, which is more difficult.

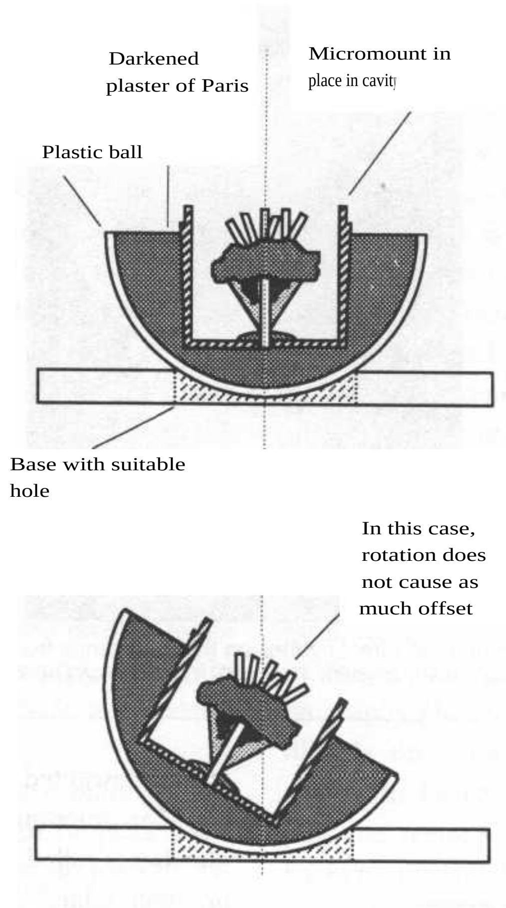


Figure 13-11 Ball table for holding a micromount for viewing and photography. Minimal angular displacement of the specimen is achieved by placing it as close to the center of the sphere as possible.

Another disadvantage with this setup is that the microscope heads are not designed to hold the weight of a camera. The eyepieces and the head are usually at an angle that puts a strain on the microscope. To deal with this problem, build an angled base to mount the microscope on so the tube on which the camera is mounted is vertical. You may also find that You must tighten the tension on the focusing knob so that it doesn't creep under the added weight of the camera.

3 A camera without a lens and without an ocular. This method is basically the same as the preceding, but is not recommended. The lack of the ocular means a decrease in magnification and a lack of correction of the objective's optical faults.

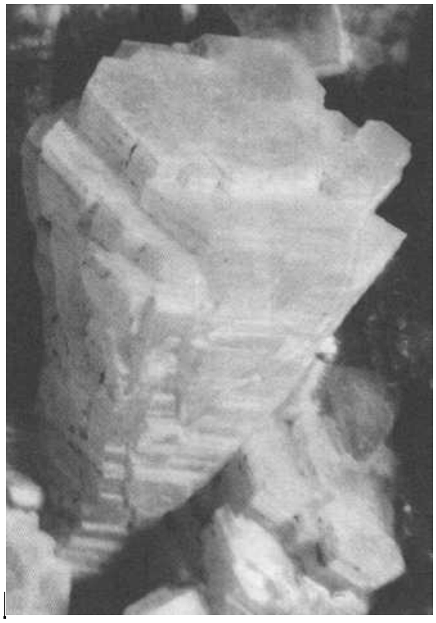


Figure 13-12 Violet Anderson used direct lighting on this weloganite from the Francon Quarry, Montreal, Quebec, Canada, which is about 1 cm tal¡. (Courtesy of The Roya¡ Ontario Museum, Toronto, Canada)

THE SPECIMEN SETUP

SUPPORT

To photograph a small object, it must be held in the proper position. The means can be as simple or complicated as you want. A wad of putty is a good start as it can be molded to whatever shape necessary, and it allows the subject to be placed at the proper angle. Another possibility is the use of a small container of sand or uncooked rice into which the subject is placed. The subject can be placed at the proper angle and pressed partially into the granular medium. Needless to say, rice and sand can get messy, and rice can attract unwanted insect pests.

Most micromounters use a variation on what is called in German, Kugeltisch, or "ball table." The simplest swiveling holder is made from half of a rubber ball. Fill the half ball with plaster of paris, then press a greased micromount box partially into it. When the plaster has dried, remove the box, sand the surface of the plaster smooth if necessary, and paint it matte black. The half ball is then placed in a hole, somewhat smaller than its diameter, that has been bored into a piece of wood, plastic, or metal (see Figs. 13-4 and 13-11). For photography, the device is placed on the microscope stage with a micromount box inserted into the recess. The half ball is easily rotated or angled for optimum viewing. Another variation on this theme would be to take a solid ball, such as a wooden croquet or bocci ball, cut it in half and caree a recess into the flat surface. Instead of making a recess in the hemisphere, you can attach a holder to the flat surface of the hemisphere. The holder can be a slightly larger box, or one fashioned from sheet metal. A set screw on one side or a spring clip holds the box in place.

Another variation of a ball table makes use of a ring magnet. A steel ball has the box holder attached to it by one of several means. A hole can be drilled into the ball, and a machine bolt inserted that has been welded to the metal holder. The holder can be welded directly to the ball also. The ball is then placed on the ring magnet that holds it at whatever angle you wish.

Magnetic holders are more reliable when the specimen must be placed at a steep angle because they do not slip. On the other hand, the hemisphere with the recess is easier to make and creates less angular displacement of the subject during adjustments (see Fig. 13-11). The closer the mounted subject is to what would have been the center of the whole sphere, the less the displacement and the easier the adjustments will be. With most of the circular magnet designs, the specimen sits relatively high above the ball and the center of rotation. Consequently, slight adjustments in angle throw the subject out of the line of sight.

BACKGROUNDS

Often the matrix of the specimen serves as the background, and so there are no background considerations. When photographing specimens with little or no matrix, you're stuck with the inside of the micromount box, which is usually painted black. This background is usually acceptable, but is poor for dark subjects. If you are photographing a dark specimen against a black box, a small piece of white paper can be slipped inside the box behind the specimen. lf you are adventurous, use colored paper.

Mounted specimens are usually easier to photograph because they can be easily handled and the mounting pedestal keeps them away from the background, minimizing its impact. Because of the magnifications used in photomicrography, placing an unmounted subject directly on a background usually does not work. Every scratch and dust mote plus the texture of the paper or cloth background will be emphasized to distraction. You can, however, use the technique of photographing on glass as outlined in *Chapter* 11. Instead of a large sheet of glass, substitute a cover slide for really small specimens, or a piece of the glass used for glass mounting 35-mm slides. Suspend the glass with the subject above the background of choice. To get a black background, place the glass on top of an empty film canister, the inside of which has been painted matte black or lined with black flocked paper or velvet.

SCALE

lt is very difficult to place a scale in a photomicrograph. Any ruler you could use, no matter how well made, will look quite crude under magnification. It is best to determine your magnification and record it in your notes, as well as on the slide mount or print. Determining the magnification is most easily done by viewing a millimeter scale in the place of focus after the subject has been removed. Count off the number of millimeters in view, and divide that number into 36 (the length of the negative or slide). If the field of view is 6 mm, then the magnification is 6x.

LIGHTING

SOURCES

Many of the light sources used for illumination during viewing are inadequate for photography. High-intensity desk lamps are not concentrated or controlled enough, and are most likely not the proper color temperature (see *Chapter 6).* Ringlights provide a very flat light that is not good for adequately defining the three-dimensional nature of most subjects. Ringlights are also usually fluorescent lights that are notorious for the difficulty in matching their color temperature with the proper film.

The light should be of sufficient intensity that long exposures with their attendant reciprocity failure problems are unnecessary. Yes, you can deal with reciprocity failure, but if you can avoid it in the first place, it will make your life and work a lot easier.

The use of a high-quality light is a must. The light source should have a variable intensity, focusing capability, and a color temperature easily matched to an appropriate film. Additional handy features include an iris diaphragm and a filter holder. There are a number of light sources available that meet these requirements, most made by the major microscope makers. The variable intensity is not to be used to control the light during photography. As explained previously (in *Chapter 6),* doing so would change the color temperature and give inaccurate colors. The variable intensity should be used primarily as a means of prolonging the life of your light source. With the high intensity of most fiber optics today, it is rarely necessary to do all your viewing, composing, focusing, and so on at full power. Use a lower setting for those tasks, and use full power for metering and the actual exposure. Even a small decrease in intensity significantly prolongs the lile of expensive light bulbs.

Your light source should be stable relative to maintaining its color temperature. As discussed in *Chapter 6,* the color temperature of incandescent bulbs changes as they age. The color temperature of quartz halogen lights does not, and thus they make a better light source.

The introduction of fiber-optic light sources was a boon to both microscopists and photomicrographers. They are discussed in some detail in *Chapter 6,* but a few more things can be said about them here. Many of them come with flexible, armored guides. These guides are handy in that they stay where you position them with no other help. They do have a little spring to them, and when positioning them, must be positioned a bit past where you actually want them to be. On release, they spring back slightly, which can be a bother with critical positioning. The stiff probe also conducts and maintains any vibration. This vibration is not transmitted to the specimen, but it does cause the light to vibrate, which can cause image degradation. Ideally, it is best to have flexible probes that must be held in position with clamps, possibly attached to the microscope. If three is vibration, it is preferable to have everything vibrate in sync, instead of only one item in the system, which would ruin the photograph. Be aware that most fiber-optic light sources are fan cooled and the vibration from a poor quality fan can ruin your photographs.

TECHNIQUES

DIRECT LIGHTING

The methods for lighting microscopic specimens are basically the same as for macro specimens. The scale of the subject, however, does require a comparable downscaling of the lighting equipment and the use of appropriate microscope illuminators as just discussed. You'll also find that the comfortable working distances and room for maneuvering you had with larger specimens disappear, and the dramatically reduced distances in photomicrography become a test of patience and dexterity. The smaller beam of light, which may also be focused to a very small size, does not give you much, if any, room to place reflectors. One way of dealing with this problem is to use a fiber-optic light source with multiple probes. Most come with only two probes, and some with three. 1 have seen fiber-optic lights with as many as eight, small-diameter probes. The probes are not focusable and must be held in place by means of electrician's helping hands. Using such a light source, the photographer can precisely place fill light or highlights wherever he or she wishes. Violet Anderson (Fig. 13-12) was a well-known mineral photomicrographer who commonly used direct lighting.

Because most specimens will be

In short, the same main concerns about light sources exist for photomicrography as for any other photography:

- You must know the color temperature.
- You must have sufficient intensity to avoid reciprocity failure.
- You must have a means of varying the intensity.
- You must have color stability.
- You must have a setup that is vibration-free.

mounted in some sort of holder, you don't have convenient surfaces on which to rest reflectors. Electrician's helping hands, which have been mentioned before, can be used to hold reflectors in place, as can flexible pieces of wire. A number of types of wire can be used. The wire must be stiff enough that it will not sag under its own weight or that of the reflector. It must be soft enough to be easily bent, but not so springy that it won't stay where you position it. The lower end of the wire can be attached to a weight that rests on the tabletop. A magnet works well for this purpose because you can attach it to the side of the microscope base, or to any vertical or angled surface made of a ferrous metal. Reflectors cut from small scraps of foil or paper can be attached to the wire with bits of putty or tape.

You'll find that specular reflections will be a problem with microscopic subjects just as they are with larger subjects. Instead of diffusiog the light at its source, it is better to diffuse at the subject position. A piece of diffusion material (e.g., double matte drafting Mylar) can be positioned close to the specimen, in the light path. You may wish to have a diffused main light, but slightly more specular fill. If so, either angle the main light or spread the beam (by defocusing with the light's focusing lens) so that some of it passes over the diffuser, striking a specular reflector on the opposite side of the specimen. The use of this technique with either a specular or matte reflector will, in any case, produce a better modeling effect than will total diffusion, which tends to make three-dimensional objects appear flatter.

For highly reflective subjects such as gold, make a cone or cylinder of the diffusing material and place it around the subject. Half of a translucent plastic sphere, such as a ping pong ball, also works well. The use of one light with such a setup will give you a directional diffused light. To make the lighting more even, aim two or three lights at the diffuser from points equidistant around its perimeter. Be sure no light passes over the diffuser walls and falls directly on the subject.

BRIGHT-FIELD LIGHTING

Bright-field lighting is the standard method for illuminating transparent subjects under the microscope. The light originating from a substage illuminator travels up through a field condenser and field diaphragm, through a substage diaphragm and substage condenser, through the subject, and, finally, into the microscope. As mentioned previously, the primary function of the field condenser and diaphragm is to control the field of illumination. The primary purpose of the substage condenser and diaphragm is to control depth-of-field, image contrast, and image difraction. Bright-field lighting is primarily used for the study of inclusions and internal features of transparent minerals and gems.

DARK-FIELD LIGHTING

In this method, a center stop (an opaque disc) is positioned at the plane of the substage. The stop intersects the light beam such that the result is a hollow cone of light. The stop allows only the peripheral rays to pass. When the center stop is of the right size, none of the light enters the microscope objective unless the subject refracts or scatters the light. The result is a brightly lit subject on a black field.

The technique is especially useful in the study of inclusions, producing superior results to that of bright-field lighting. Dark-field lighting has its greatest use in the study of inclusions in gemstones (see Fig. 16-7 and *Plate* 34). In biological work, the method is especially helpful in defining fine hairs on the edges of a subject. Earth-science subjects seldom have fine hairs that need to be defined, but microcrystals coating a larger crystals surface, or attached byssolite and similar finely acicular minerals, would benefit from the same lighting.

SHADOWING

To use the shadowing technique, you purposely create uneven lighting by introducing an opaque object partially into the light path, beneath the transparent subject. The result is an increase in contrast, and, thus, greater definition of the subject. The technique is particularly useful in the study of inclusions, zoning, and similar phenomenon in gemstones (*Plate* 36).

The shadow-coating material can be pieces of cut paper, black masking tape, or pieces of cut sheet metal. The size, shape, and placement of the opaque light shield all affect the results. This technique is discussed in greater detail in *Chapter* 16.

POLARIZED LIGHTING

The use of polarized light in photomicrography is a common technique in both petrography and gemology, and is well documented (McCrone et al., 1979; Phillips, 1971). The basic principles are covered in *Chapter* 10, under the topic of polarizing filters in the section on "Color Filters."

EXPOSURE DETERMINATION

Metering for photomicrography can be tricky, but not much more so than for close-up or photomacrography. The principles are the same (see *Chapter 9).*

Some manufacturers have light meters with probes that are designed to be inserted into the microscope tube for the measurement of light. 1 am not going to give these meters any further consideration because they are expensive and can be difficult to use.

The best meter to use is the through-the-lens metering in your camera. Once the subject and lighting are set up, meter the subject as you would a larger subject. Keep in mind all of the metering tips from *Chapter 9* concerning light subjects against dark backgrounds and vice versa. Background can be a problem because many micromounts are mounted in black painted boxes. Spot metering or a heavily center-weighted metering system will help with this problem. Another solution is to take your reading off a piece of 18 percent gray card cut about 1 inch square resting on top of the micromount box. (Be careful that you do not damage a specimen that projects above the edge of the box.)

If your camera has autoexposure, be sure it is on the aperture priority setting. If you haven't removed the camera lens, keep its aperture wide open. If you are using the lens-off technique, there is nothing for the camera to stop down in shutter speed priority.

A handy feature to have is a viewfinder blind. Some cameras today are designed with a built-in blind that blocks out stray lighting entering the eyepiece that could throw off your metering. This feature is especially important if you are auto-metering without your eye at the viewfinder. Your head blocks out a lot of the light that would otherwise interfere with the metering. For those who do not have a built-in viewfinder blind, block stray light during metering with a spare hand, or place a screen between the light source and the eyepiece.

You may find that your meter is not sensitive enough to read the light. Whether you are using the lens-on method or the lens-off method, use the following technique. First set the shutter at its longest setting, and then change the ISO setting on the meter until the meter registers. The next step is where a handheld meter comes in handy. Adjust its settings until the ISO and the shutter speed match those of the camera. Then adjust the ISO dial to the actual ISO of the film you are using. Read off the exposure time that is now indicated next to the aperture setting that matched with the incorrect ISO. What you are doing is pretending there is a more sensitive film in the camera, and using the handheld meter to convert that to what the reading would be for the less sensitive film you are actually using.

It's always wise to bracket your exposures, that is, take several exposures at different settings using your metered reading as a base. You will be bracketing using the shutter speed and not aperture, since the latter will remain constant to maintain the wide-open setting necessary for use with the lens-on technique. If you are using the lens-off technique, you don't have an aperture to worry about.

If the subject is dark, 1 bracket toward longer exposures, and shorter for lighter subjects. It's better to waste a little film than have to reshoot, especially since you are not always able to do so.

A problem with the long exposures necessary with photomicrography is reciprocity failure. As explained in *Chapter* 10, this problem can be dealt with by use of the proper filters and increases in exposure time. Another way of dealing with the problem is to avoid it completely. You can do this by using a film designed for longer exposures. As an example, Kodachrome 25 runs into reciprocity failure at exposures longer than one second, whereas Ektachrome Professional 64 is good for up to 10 seconds, and Ektachrome 160T is good for exposures up to 100 seconds.

When actually making the exposure, it is critical to eliminate vibration. Make sure you are working on a solid table away from vibration sources such as furnaces and air conditioners. A cable release is a must, the best being an air bulb release because it transmits less vibration. If your camera has a delayed release switch, it can be used instead. It is best if the camera has a mirror lock so that the camera itself is not a source of vibration. The best way to make the exposure is to turn off all the lights in the room, lock open the shutter while set on B or T with a locking cable release, turn the lights on and off the proper length of time, close the shutter and turn the room lights on again. To minimize vibration and be able to control several lights at once, plug all the microscope lights into a switch-operated multiple outlet that is not located on the same surface as the microscope. Even better is the use of a darkroom enlarger timer into which you plug your lights. You can set the exposure time on its dial (which is luminescent), and let it accurately time your exposure.

CHAPTER 14

Stereophotography

When we look at an object, we get a sense of its shape and these-dimensional form due to our stereoscopic vision. Because our eyes are separated by a short distance (65 mm on the average), they each have a slightly different view of an object. The brain puts these slightly different views together and we get a perception of the depth of the object.

Stereophotography simulates this perception by the use of two photographs of an object taken at slightly different angles. When the two photographs are viewed simultaneously but separately by each eye, the brain is tricked into sensing a three dimensionality that is not really there.

Some of you may remember that stereo was an amusing part of 1950s monster movies, but ask of what use it is in mineralogy. As beautiful and accurate as some photographs may be, they are still limited two-dimensional renderings of these-dimensional objects. Some objects may be adequately represented by normal photographs, but some, due to complexity of form, intimate intergrowth, or subde surface detail are not adequately rendered in a two-dimensional photograph. Stereophotography communicates spatial relations, minimizing the misinterpretation of images. It makes complicated forms, aggregates, and internal and surface details much clearer.

I´m sure that you Nave all looked at a photograph at some time and had difficulty determining if certain features were pits or protrusions. Stereophotography eliminates this confusion. For accurate and critical analysis of some subjects, Stereophotography is a necessity. Its value in scanning electron microscopy (SEM) has long been recognized. The use of stereo pairs in aerial photography is the basis *of* photogrammetry and for making accurate maps, especially topographic maps. Anyone who has taken an introductory course in geology is familiar with the use *of* stereophotographs for the study of geological features.

Because there is nothing like actually holding a specimen in your hands to truly appreciate it, the simplest reason for

Stereophotography communicates spatial relations, minimizing the misinterpretation of images. It makes complicated forms, aggregates, and internal and surface details much clearer.

using stereophotography is that takes you one step closer to that experience when you cannot actually hold the specimen.

PHOTOGRAPHIC EQuIPMENT

In the late nineteenth century, stereophotography was very much in vogue. Every fashionable parlor had a stereo viewer handy and a stack of stereophotography to peruse. Unfortunately, stereophotography experienced a decline in interest in the early twentieth century, but interest renewed in the 1950s. There are a number of stereo camera models available on the market now. Probably of greatest interest to mineral photographers is the old Stereo Realist that could be adapted for mounting on a stereomicroscope. In 1971, the Realist Macro Stereo Camera was introduced. This camera had a fixed focus distance of 10 cm. Metal rods projecting from the sides of the lenses helped you establish the proper distance from the subject. The area covered was approximately 1 916 inches wide by 1'3/6 inches high.

Probably the stereocamera familiar to most people is the Stereo-Realist manufactured by the David White Company (later Realist, Inc.). Other brands available are the Nimslo and Nishika. A normal camera can be turned into a stereocamera with the addition of a beam-splitter attachment to the lens. The attachment uses mirrors to place the two slightly different images on one frame of film. Several models are available at different prices.

TEGHNIQUES

Stereophotography can be accomplished several ways, none of which require special equipment. Stereocameras have two lenses and take two photographs simultaneously. You can approximate this setup by mounting two cameras side-by-side and firing them simultaneously by the use of a dual cable release.

LATERAL TRANSLATION

A simpler method is to use one camera and take two photographs, moving the camera laterally between exposures. It's a good idea to always take the left photo first, and then the right, because that's the sequence in which the finished photographs must be viewed. This method is known as the lateral translation technique, and the distance moved should approximately equal the distance between your eyes-65 mm. To determine your personal "interocular" distance, just look in a mirror and measure the distance between your pupils. For distant scenic shots, 65 mm may be too short to give a good stereoscopic effect, and so the base distance can be increased.

A simple way to make a lateral movement to create stereo pairs of subjects at intermediate distantes is to use the "Kodak two-step" (Walden, 1989). Take the first exposure with your weight on the left foot, and then the second exposure with your weight on the right foot. Be sure to keep the camera level and the framing the same.

As you get closer to a subject, the amount of lateral movement needed for attaining a natural stereoscopic rendering of the subject decreases. This distance, which is also known as *base separation,* can be calculated using the following formula:

$$\frac{\textbf{Normal eye separation}}{\textbf{Apparent subject distance}} = \frac{\textbf{Base separation}}{\textbf{Lens-to-subject distance}}$$

OR:

$$\frac{N}{D} = \frac{B}{d}$$

Any of the four variables can be calculated if the other three are known by multiplying diagonally the knowws and then dividing the product by the third known.

The formula can also be expressed as:

$$B = \frac{N \times d}{D}$$

Normal eye separation, *N,* is 65 mm (or your personal interocular distance), and *d* is easily measured. The variable *D* is explained thus: for normal viewing you would want distantes and sizes to appear the same as with the unaided eye, so *D* would equal *d. If* we were to photograph a subject at a distance of 5 feet, or 1,524 mm, the base separation, *B,* would equal 65 mm. So for normal viewing, *B* is the same as *N.* A problem arises when doing very Glose-range photography of small subjects. You don't normally view those subjects at such Glose range. lt's best to imagine "blowing up" the subject and viewing it at a comfortable distance, say 16 inches (400 mm). This theoretical viewing distance then becomes *D* in the equation. If our lens-to-subject distance, *d,* equals 2 inches (51 mm), then the base separation, *B,* equals 8.3 mm.

As the lens-to-subject distance decreases, so does the base separation. It then becomes easier to move the subject rather than the camera to attain the required base separation. This movement can be done by the use of a microscope stage that has finely geared movements in the X and Y axes.

Such stages can be bought through scientific supply houses such as Edmund Scientific and Wards. Simpler and much cheaper stages can be devised by mounting a simple scale in a track so that it slides laterally along with the subject past a stationary marker. A more accurate stage could be made incorporating a micrometer.

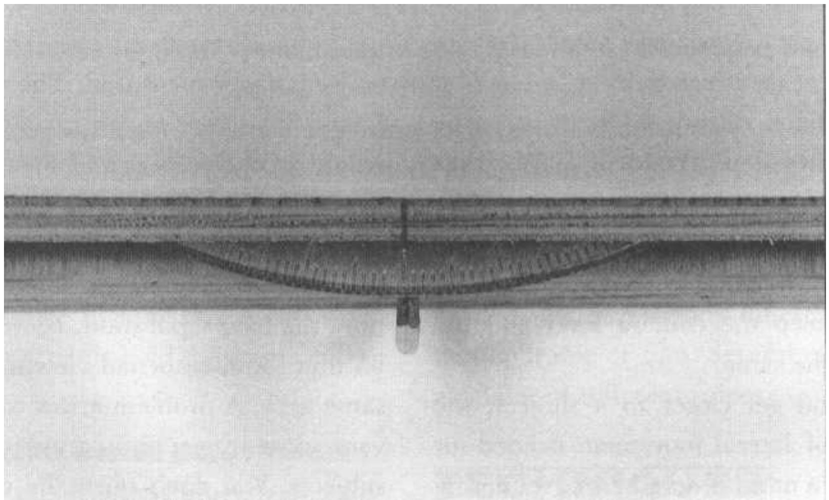


Figure 14-1 Detail of a stereophotography platform. The specimen alignment mark is visible below the Plexiglas surface and above the protractor and indicator.

ROTATION METHOD

The lateral translation technique is simple, but is of limited use in photomacrography and photomicrography. In these situations, the subject is so close that the lateral movement seriously changes the position of the subject in the frame.

An alternative to lateral translation is the rotation method where the subject is rotated instead of moving it or the camera laterally. The rotation method requires that the subject and background material be placed on a rotating stage. A lazy Susan mounted between two pieces of plywood works well. The lazy Susan should not be mounted in the middle of the board, but near one edge with the center of rotation marked on the plywood. Draw a line through this center point parallel with the edge of the board it is nearest to, marking the edges of the board too. Mark the edge of the board at right angles to the first line through this center point. These marks will aid you in the placement of the specimen on the stage, as the subject must be centered above the point of rotation. Attach a protractor to one of the boards and a pointer to the other so that you can accurately measure the rotation. The center point of the protractor must be the same as the rotation point of the stage (Fig. 14-1).

The first step in centering is to align the camera with the axis of rotation. Stand a thin cylindrical object at the rotation point using the lines you marked on the edge of the board. A small T square or drafting triangle may help you with this step. Place the camera and tripod so that the lens axis is nearly parallel with the board surface (a slight angle to the board will not effect results much), then center the cylinder in the frame. You know the camera and **cylinder are centered** when the latter does not appear to move when the stage is rotated. Replace the cylinder with the subject, centering the main point of interest in the viewfinder.

Wilson and Chamberlain (1987) suggest 5° as the proper amount of rotation, while Moyd (1949) suggests 10 °. 1 calculated the base separations for a series of distances using Blaker's formula (1989) and plotted the results. Using the values *N* = 65 and D = 400, the plot gave an angle of 9°. Changing the values of *N* and D slightly to allow for different viewing-distance preferences and interocular distances only changed the angle plus or minus about 1 ° *(Plate 22).*

Just as with the lateral translation method, take the left image exposure first. Then rotate the stage clockwise the required amount and take the second image. Both Moyd (1949) and Walden (1989) **suggest that you rotate the stage counterclockwise half the required distance first.** Then for the second exposure, rotate the stage clockwise the full required distance. This procedure assures you of a more symmetrical view of the specimen relative to your initial setup, minimizing lighting angle changes and variation from your chosen specimen orientation.

1 suggest that you take a series of stereo pairs varying the angle of rotation. After viewing the results you can deter mine what gives the most realistic degree of there dimensionality. Keep in mind that too much rotation can cause a hyperstereoscopic effect, distorting the subject and giving it too much apparent depth. Too little rotation can create a hypostereoscopic effect with too little relief For some applications such as aerial stereophotography, hyperstereoscopy is the norm so that features can be seen more clearly.

LIGHTING

Lighting a specimen for stereophotography is no different than for any other kind of photography. However, there are a few things to keep in mind. First, to avoid the possibility of critical changes in lighting details on rotation, the lights should be mounted on the stage so that they rotate with the subject. Mounting the lights on the stage is generally only possible if the lights are small, such as the high-intensity desk lamps suggested in *Chapter 6,* or when using microscope lights. Many photographers don't mount the lights on the stage and still get good results. If it's not possible to place the lights on the stage, examine the lighting after the required rotation to be sure it is satisfactory. Even

Even when the lights are rotated with the stage,
it is wise to check the lighting.
A subtle highlight in the first image may become
a glaring burn-out in the second.

when the lights are rotated with the stage, it is wise to check the lighting. A subtle highlight in the first image may become a glaring burn-out in the second.

Should rotation of the lights be impractical, and light shifts unacceptable, you can rotate the camera. The camera is mounted on an arm that has a pivot point directly under the specimen. The arm should be devised so that the camera can move along its length for focusing. The camera should also be adjustable in height and mounted on a ball head for leveling adjustment. Obviously, such an arm must be as rigid as possible to minimize vibration.

DEPTH-OF-FIELD

While the subject of a stereo pair does appear to be three dimensional, the photos have no more depth-of-field than a normal photograph. Blaker (1989) suggests a method for increasing apparent depth-of-field. He proposes that for the second photo in a stereo pair, you change your focal plane slightly-preferably further into the subject. This change of focus should be minimal and approached with care, because a focal shift changes the subject's magnification. A series of experimental shots with different focal shifts is suggested to determine acceptable limits to the shift and whether the increased depth-of-field is significant.

LARGE-FORMAT STEREOPHOTOGRAPHY

There is little difference in stereophotography with different format cameras. The advantage with larger format is that the greater size of the image allows direct viewing without enlargement. Because of the greater case of taking double exposures, you can put a stereo pair on a single sheet of film.

You never have to worry about getting the stereo pair out of sequence or losing half of the pair. You also eliminate all alignment problems.

The technique is quite simple. Photograph the image on one half of the frame, rotate the subject, then expose it on the other half of the frame. For this to work, the background must be black so as not to expose the other half of the frame. If you do not use a black background the image can be masked in the camera or in front of the lens.

Obviously, the camera must be shifted laterally between exposures. This movement can be accomplished one of two ways. The first exposure can be made with both the front and rear standards shifted laterally, and the second with them shifted in the opposite direction. The second method is to shift the whole camera laterally by means of a track or a geared horizontal arm such as is found on a studio camera stand. Since the image is reversed in a studio, shift to the right for the first exposure, and then to the left for the second exposure.

HIGH-MAGNIFICATION STEREOPHOTOGRAPHY

The principles of stereophotography at high magnification are the same as for more "normal" distances. The difference is in the equipment requirements and the smaller tolerances for error.

The two arcas of critical concern are (1) the precise rotation of the subject within the axis of rotation and (2) accu rate focus at the center of the axis of rotation. lt must be remembered that the greater the magnification, the shallower the depth-of-field. As the subject rotates, it must stay within a narrowly defined "vertical cylindrical space with a diameter equal to the depth-of-field" at that magnification (Betz, 1990). Betz gives the following example: with a field of view of 1.2 x 1.8 mm, the depth-of-field is less than 0.05 mm. With such small working distances it is obvious why accuracy is critical.

SPECIMEN POSITIONING EQUIPMENT

HORIZONTAL METHOD

We first consider the requirements for shooting in a horizontal plane because it is much easier than working vertically as in a copy-stand arrangement.

To accurately position your subject, you'll need equipment that fills the following needs: (1) the ability to move accurately in two directions (X and Y axes) in a horizontal plane, (2) the ability to move vertically, and (3) the ability to rotate in the horizontal plane. The ultímate instruments for accomplishing these movements precisely are optical positioning devices used for testing and experimenting with optics. Such devices can be bought through scientific supply houses such as Edmund Scientific, or optical suppliers such as Melles Griot. They are, however, fairly expensive. Most, if not all of the components, or less expensive substitutes for, can be found at surplus supply houses.

The best horizontal positioners are microscope stages, but some camera accessory manufacturers make focusing racks for cameras that have the required movements. They are much bulkier than microscope stages since they are made to hold a camera. For vertical adjustment, a lab jack, which works on the basis of a car's scissors jack, works best. For rotational positioning, a good quality photographic panoramic head works well.

There are of course substitutes for all of these items. Scrounging through mechanical and electrical surplus outlets will reveal a wealth of items usable as positioning devices. You may even have usable items in your own honre-the focusing rack off an old microscope or projector works well for vertical positioning. lf you are handy in the shop, many of these devices can be made. (See *Appendix A*, Gadgets and Gizmos, for more ideas.)

When photographing micromounts horizontally, the camera and focusing track must be mounted on a sturdy, level platform such as an optical bench. A good substitute for the optical bench is a flat sheet of ¾-inch plywood. lf you have an extremely long bellows be sure that it is adequately supported to elimínate vibration.

SYSTEM ADJUSTMENT

The specimen apparatus should be mounted on the same piece of plywood as the camera, with the addition of a small platform to hold the light source that rotates with the specimen. A protractor and pointer should be devised to measure the rotation.

The first step is to center the optic axis on the rotation axis, as described in the discussion of the rotational method under "Techniques." Since the working distances are much smaller, the cylinder is replaced with a needle. First adjust the needle so that it is precisely on axis, and then adjust the camera so that it is centered on the needle and perpendicular to it. Minor adjustments may be necessary when the needle is replaced by the specimen. For the reasons mentioned earlier, the light should rotate with the specimen. This is much easier with photomacrography, since you usually use a single, smaller light source.

Should you decide to do stereophotography with a vertical setup, your axis of rotation will have to be in the horizontal instead of the vertical plane. A very expensive universal microscope stabe can accomplish this orientation, or you can devise a much simpler, cheaper one. Some sort of horizontally mounted rod tensioned so as not to move when positioned can be used. To this rod must be attached the required protractor and pointer. For fine adjustments, you may be able to find a box with reducing gears attached to a usable axle at a surplus supply.

VERTICAL METHOD

Mounting the camera so that it points downward at the specimen in a copy-stand arrangement can also be done. The arrangement is more difficult to work with for a number of reasons:

Stability. The system is inherently less stable because there is less support for the camera in particular. The greater mass and length of the setup due to the addition of bellows and extended lenses is subject to more vibration. The unsupported copy stand is also a source of greater vibration. Of course, vibration can be minimized by bracing the copy stand against a solid wall and making the stand as massive and rigid as possible. The camera and bellows can also be braced against the stand.

2. Difficulty of viewing. With the long extensions necessary, the camera may be quite elevated and be difficult to reach for viewing. You may need to use a step stool to reach the viewfinder, and may find it necessary to use a right-angle viewfmder attachment to make viewing easier.

. Difficulty of adjustment. The weight of the camera/bellows assembly can be substantial and can be diflicult to adjust because its full weight is on the adjustment device. Unless you Nave a geared track or properly adjusted counterbalance, once you release the vertical lock, you could have the whole assembly come smashing down on your specimen.

STEREOPHOTOMICROGRAPHY

Stereophotography through the microscope can be done one of three ways:

- With the use of a microscope designed for stereophotography. Such microscopes are available but are quite expensive. The separate images are supplied to the camera by means of a beam-splitter or mirror arrangement that switches from one objective to the other. Steve Chamberlain uses a Nikon SMZ-10 stereomicroscope with a trinocular head for his stereomicrography (Plate 23). With a flip of a lever, the two images are switched.

- Photographing through both eyepieces. Mount the camera on one eyepiece and then the other to get the stereo pair.

- Photographing through one eyepiece. Mount the camera on one eyepiece and rotate the specimen just as in the vertical method previously discussed.

Figure 14-2 Stereo viewers. Standard adjustable metal and plastic-lensed viewer on the left, and inexpensive cardboard viewer with plastic lenses on the right.

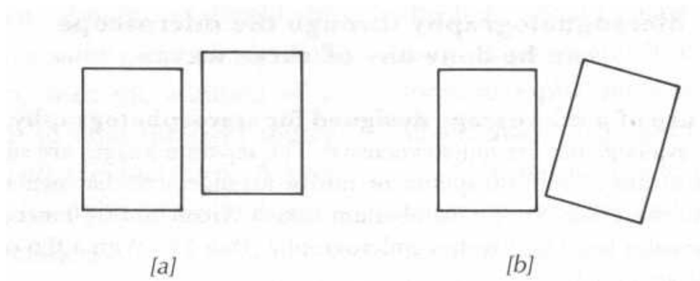


Figure 14-3 Misalignment of stereo pairs: (a) vertical misalignment and (b) rotational misalignment (After Blaker, 1989)

Some of the problems with stereophotography through the microscope are that the optics in most micro scopes, while adequate for viewing, are less than optimal for photography; there is a lack of control of depth-of-field due to the absence of a diaphragm; and the light source is unable to be rotated along with specimen.

VIEWING STEREO PAIRS

There are basically three methods of viewing stereo pairs: (1) handheld transparencies, (2) handheld prints, and (3) slide projection. Transparencies can be viewed on a light table or held up to a light source. Using a light source for viewing is more difficult unless the transparencies are mounted side-by-side in their proper positions. A printed stereo pair can just lie side-by-side for viewing, but it is best if they are permanently mounted so as to maintain proper sequence and orientation.

Viewing slides or print stereo pairs generally requires the use of a stereo viewer, which is a simple device that resembles a pair of glasses. Two magnifying lenses are mounted in a frame that is supported above the stereo pair. Looking through the viewer both magnifies the images and forces the eyes to view them separately. A simple viewer can be made using two cardboard tubes held to the eyes. Empty toilet paper tubes work well for this purpose. There is no magnification, but the tubes force the eyes to see the images separately (Fig. 14-2).

Viewing handheld slides and prints can only be done with the stereo pair separated no more than your interocular distance. There are some viewwes available that allow you to view pairs that have a greater separation. Such a reflecting type stereoscope is manufactured by Verlagsgesellschaft, Weinheim, Germany, and can be used with any size prints as well as with projected slides. The KMQ System views vertically paired prints using

The first step in learning to view stereo pairs without a viewer is to look at a distant object. While keeping this object in view, raise a stereo pair up into your field of view. Try to maintain the parallel alignment of your eyes as you focus on the stereo pair. At first, your eyes will immediately converge as you change your focus. But with practice you will master the technique.

a prism stereoscope but is not good for prints smaller than 5 x 7 inches (13 x 18 cm).

The projection method has the advantage of allowing many people to see the stereo image at the same time. The projected images must be polarized, and the audience must wear inexpensive polarizing glasses. Two projectors are required, preferably mounted one above the other. A polarizing filter is placed over each projector lens, and the images lined up so that they overlap precisely. While wearing the glasses, just the projector with the right image is turned on and the filter is rotated until the image in the left eye is dark. The procedure is repeated for the left image and right eye. The polarizers will then be at 90° to one another and when both projectors are on, the image will be in stereo. An aluminized metal screen must be used for this method, as other types of screens will depolarize the images. There are commercially made stereo projectors, but they are hard to find and are fairly expensive.

The mounting of stereo pairs must be done carefully, as misalignment may make it impossible to combine the two images properly. At the very least, improper alignment will cause uncomfortable eye strain. There are basically two kinds of alignment error: vertical and rotational. Vertical misalignment means that the two images are not level with each other, as in *Figure 14-3.* In rotational misalignment, one of the photos is rotated relative to the other one.

lt's possible to learn to view stereo pairs without the use of viewwes of any kind. The great advantage of this ability is that you never have to remember where you left the stereo viewer.

As you look at an object that is fairly close, your eyes converge so that they are both looking at the same thing. When viewing a stereo pair, the viewing axes of the eyes must remain parallel with one another. They naturally do this when focused on infinity.

The first step in learning to view stereo pairs without a viewer is to look at a distant object. While keeping this object in view, raise a stereo pair up into your field of view. Try to maintain the parallel alignment of your eyes as you focus on the stereo pair. At first, your eyes will immediately converge as you change your focus. But with practice you will master the technique. Eventually you will reach a point where you can just look at a stereo pair, relax your eyes, and combine the two images. When you do, you will actually see three images, with the one in the center being in stereo and the other two out of focus at the periphery of your vision. Just as with stereo viewers, the method only works with stereo pairs no further apart than your interocular distance. There is a small percentage of people who can't see stereo pairs three dimensionally even with the aid of a viewer, and some who can't master the technique of viewing them without aid.

Stereo photography will literally add a new dimension to your photography, increasing your enjoyment and under standing of your subjects. If you wish to pursue stereo photography further, obtain a copy of the Reel-3D catalog (see *Appendix B).* It lists many gadgets, cameras, projectors, and books for the stereo enthusiast.

CHAPTER 15

Fluorescence Photography

When certain substances are exposed to ultraviolet radiation, they emit visible light. This phenomenon is known as *fluorescence.* The colors emitted by fluorescent materials such as minerals are usually quite different than their colors under visible light and are often quite spectacular. The collecting of mineral specimens solely for their fluorescence is a widespread and popular activity (see Robbins, 1983). Approximately 15 percent of the known mineral species fluoresce, which includes more than 500 different minerals. (*Plate 24).*

Fluorescence has more than just aesthetic value in the earth sciences. Fluorescence can indicate composition, growth history, and structure, and can be important for identification. This last capability is especially true in the field of gemology, where many of the identifying characteristics have been removed due to cutting. In addition, physical tests on cut stones are limited so as not to damage and, therefore, devalue the stone.

THE PHYSICS OF FLUORESCENCE

To understand fluorescence we must understand a little something about the electromagnetic spectrum. The human eye detects only visible light, which is but a small part of this spectrum. All electromagnetic radiation travels in "waves" exemplified by holding one end of a rope that is attached at the other end. As the rope is moved rhythmically up and down, a series of waves is produced. The distance between waves is the *frequency.* The frequency of visible light ranges from violet at 400 nanometers (nm) to deep red at about 750 nm (a nanometer is 1 / 10 of an angstrom, which is 10^{-10} meters). Above 750 nm is infrared radiation, and below 400 nm is the ultraviolet region (Fig. 15-1).

Ultraviolet (UV) radiation is divided into four regions of the spectrum: (1) vacuum ultraviolet, extending from 180 nm down to 10 nm, which is the boundary with soft X rays, (2) short wave, from about 180 nm to 280 nm, (3) mid-range UV, at 280-320 nm, and (4) long wave, from 320 nm to 400 nm.

Fig. 1 **THE VISIBLE SPECTRUM AND A PORTION OF THE ULTRAVIOLET SPECTRUM**

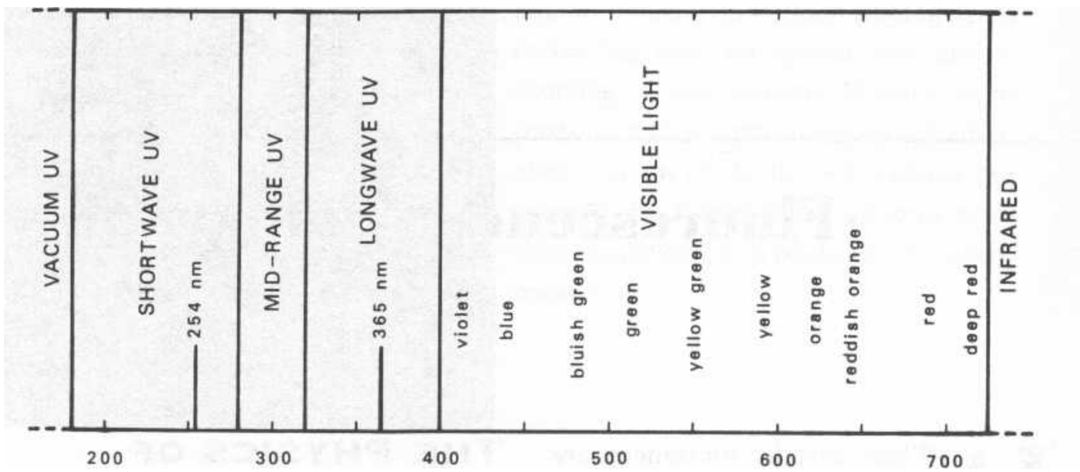


Figure 15-1 The visible spectrum and a portion of the ultraviolet spectrum. (From Modreski, 1989)

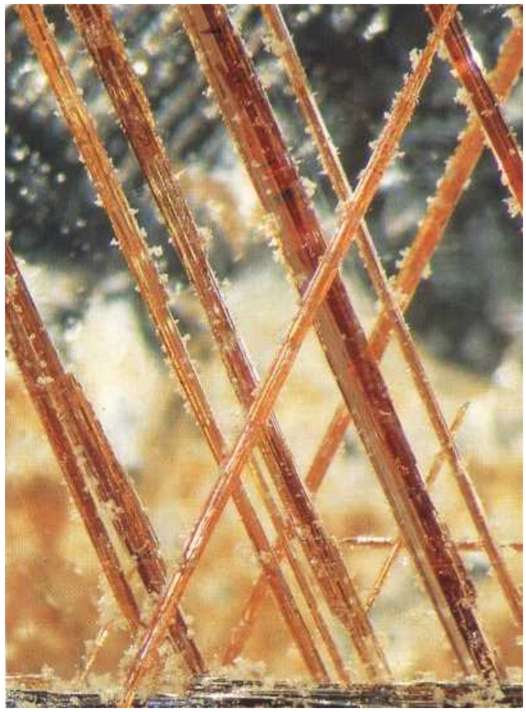
Long-wave UV is transmitted by most optical glass and is the most commonly used in fluorescence photography. Mid-range UV is the component of sunlight that causes tanning. It is not transmitted by regular lenses. Short-wave UV also causes tanning and is used as a germicide. It is not transmitted by normal glass lenses, but is by special "quartz" lenses. Vacuum UV has no use in photography and is only transmitted through a Vacuum.

When ultraviolet radiation strikes certain materials, the energy is absorbed, resulting in electrons jumping to higher energy levels. They then return to their original levels, giving off the absorbed energy as visible light. The light is emitted, in part, because the ` jump" to their original levels is actually done in a series of jumps, each releasing a lower amount of energy (longer wavelength) than was absorbed. In some minerals, the ability to fluoresce is intrinsic, but in many minerals it is caused by the addition of trace amounts of metals called activators.

Fluorescence is actually a part of a larger phenomenon known as *luminescence,* which is the emission of electromagnetic radiation after excitation by another source of higher energy radiation. The exciting source may be any of the following: X rays, gamma rays, electron beams, or ultraviolet radiation.

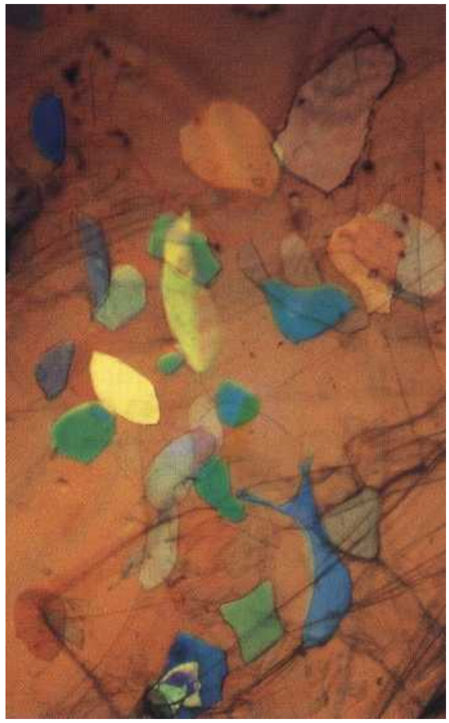
The types of luminescence of greatest concern to us are: (1) fluorescence, where the luminescence ceases after a very short time (10-8 seconds) after exciter removal, and (2) phosphorescence, where the luminescence continues for a long time after removal of the exciting radiation, sometimes for hours. Some materials actually phosphoresce in the infrared, which can be recorded on infrared film.

[PLATE 33] Jewelry from Frank Goodman & Sons: burmese rubies and sapphire with diamonds. Photo by Shane F. McClure. (Copyright © Gemological Institute of America).



[PLATE 34] Rutile in quartz from Minas Gerais, Brazil (magnification 5 x; Gemological Institute of America). Photo by John Koivula using a Nikon SMZ-10 stereomicroscope and dark-field and fiber-optic illumination.

[PLATE 35] Bytownite feldspar from New Mexico (magnification 20 x; Gemological Institute of America). Photo by John Koivula using a Nikon SMZ-10 microscope and crossed polarizers to bring out the twin lamellae and carbon dioxide inclusion.



Gemological Institute of America). Photo by John Koivula with (a) at left, crossed polarizers, and with (b) shadowing added.

[PLATE 371 Assorted cut stones from Ralph Mueller and Associates. Photo by Jeff Scovil taken on black glass with light reflecting off the glass from behind.

[PLATE 38] Seaphites sp. from the Fox Hills Formation, Fall River county, South Dakota (top shell is 5.2 cm wide; Ron Stebler collection). Photo by Jeff Scovil with direct undiffused light from above.

[PLATE 39] Insect in amber from the Dominican Republic (Breck P. Kent collection). Photo by Breck P. Kent.

Other types of luminescence are:

- Thermoluminescence: caused by heating the substance (but not to red heat). A type of fluorite called collophane is well known for exhibiting this phenomenon.

- Triboluminescence: caused by crushing or grinding. Sphalerite is well known for this effect. Translucent cobbles of quartz when rubbed briskly together will glow and were used in ceremonies by Native Americans of the Southwest.

- Cathodoluminescence: caused by the bombardment of a material by a high-voltage electron beam. This technique is an important analytical tool for studying zoning, growth, and origins of minerals and gemstones.

SOURCES OF ULTRAVIOLET LIGHT

There are a number of sources of ultraviolet light, each varying in output and usability.

Sunlight is a major source of long-wave and some midrange UY The sun also produces short-wave UV, but most of it is scattered by the Earth's atmosphere and so does not reach its surface. It is difficult to use sunlight in fluorescence photography because the visible light will totally mask any fluorescence. To use sunlight, you would have to build a light-tight box with one wall being a large exciter filter (see the later section in this chapter on filtration) that admits only ultraviolet radiation. Another drawback to using sunlight is that its UV output is quite variable depending on the position of the sun in the sky, as well as on atmospheric conditions.

Ultraviolet-producing fluorescent tubes (low-pressure mercury lamps) are the most commonly used sources of UY They work by means of an electrical discharge through a gas such as argon. The argon gas is ionized, giving off light and enough heat to vaporize mercury in the tube, which becomes ionized and gives off light. Most of the light is in the Breen to blue range, plus long- and short-wave UY The inside of such tubes is coated with a phosphor that absorbs short-wave UV and is opaque to most visible light. These "black light" tubes are relatively inexpensive, fit standard light fixtures up to 48 inches in length, and can illuminate large arcas.

High-pressure mercury vapor lights are high quartz content glass tubes holding pressurized mercury vapor. They require a strong electric current and transformers, and can take several minutes to warm up. High-pressure lights have a strong long-wave UV output with some mid-range and short-wave UV emissions. They are useful for illuminating small arcas with high-intensity UY

Mercury vapor lamps are often available with either an integral or separate filter. The latter is preferable because it allows you a choice of filters to better deal with particular shooting situations.

Arc lames produce intense radiation in mid-range and long-wave UY An electric current is passed from one electrode to Another across a small gap in the air. The best-known arc lames use carbon electrodes that are slowly consumed in the process, requiring a means of moving the electrodes toward each other to compensate. Cadmium electrodes can also be used and are longer lasting. Xenon arc lamps use metal electrodes enclosed in a glass tube with xenon gas. They put out more visible light than UY

Electronic flash units vary gready in UV output depending on the gas in the tube and their power. Electronic flash has the same problem as sunlight in that the fluorescence is obscured by the visible light from the flash. This light can be removed using the proper barrier filter, but you're left with the problem of the very short duration of the flash. It's better to have a continuous source of UV so as to judge fluorescent colors of the subject, light distribution, contrast, and so on. There are basically the same problems encountered when using flash for visible light photography (assuming you are not using studio flash with modeling lights). Electronic flash could have some use in the field, when shooting at night at a locality, especially if a large arca needs to be illuminated and a power source for UV lights is not practical.

Old-fashioned wire-filled flash bulbs put out some long-wave UV and have problems similar to those encountered when using electronic flash.

CAMERAS

Most SLRs are usable for fluorescence photography, as are medium- and large-format cameras. If the camera has auto-exposure, there should be a complete manual override, because it will most likely not be able to deal accurately with the subject. The great advantage to medium- and large-format fluorescence photography is the use of Polaroids to determine proper exposure, thereby saving time and film.

TECHNIQUE

There are there fundamental considerations in setting up for fluorescence photography:

1. Illumination with a UV light source using a suitable filter to remove visible light.
2. Filtration at the camera to remove UV light.
3. Use of a suitable film.

Other elements to be considered include determining the exposure and selecting suitable backgrounds.

ILLUMINATION

Lights should be kept as close to the subject as possible, for while distance of the camera from the subject has little effect on exposure, distance of the lights from the subject seriously affects exposure length. The size of the lights should be kept in proportion to the size of the subject-large lights are used with large subjects to ensure even illumination. Small lights of greater intensity are used with small subjects to minimize exposure time.

It's best to use two lamps, about 45° either side of the subject to ensure even illumination. Some photographers use a third, handheld light that can be moved around during the exposure. This third light can be used for more even illumination, or to highlight certain arcas.

To capture the full range of fluorescent colors, especially in a mixed group of specimens, both long- and short-wave lights can be used at the same time for photography. If you are seeking to capture just one response due to a particular wavelength of exciting radiation, then use just that one source.

The lens must be shielded from the lights so as to eliminate flare and possible fluorescence of the lens or filters that would result in a degraded image. Place black paper or cardboard Bobos between the lights and the camera, making sure that the Bobos are not in the field of view.

FILTRATION

An ***exciter filter*** must be used over the light source to eliminate all visible light that the lamp produces. If this is not done, the small amount of visible light produced will pollute the fluorescence of the subject and may completely mask any weak fluorescence. Most UV lights come with a suitable exciter filter. However, exciter filters used on order model UV lights degrade through time and must be replaced.

A ***barrier filter*** must be used over the lens to remove all UV light. Barrier filters transmit only visible light and remove all the UV radiation transmitted by the exciter filter. Ultraviolet light can reflect off the specimen and enter the camera resulting in a fogging of the film and masking of the fluorescence. All films are especially sensitive to the blue and violet end of the spectrum. Ultraviolet light can also enter the camera directly from the light sources if they are not suitably screened from the camera. Another source of trouble is that the lens glass or filter materials may fluoresce. If this is a problem, be sure that the barrier filter is the outermost of any group of filters you may be using (you may also be using color-compensating filters to deal with reciprocity failure). You may be able to find a filter by another manufacturer that does not fluoresce, or another with a similar absorption range that does not fluoresce.

A simple UV ***or haze filter will*** remove most long-wave UV but little short-wave UY These filters are available as standard screw-in glass filters. A more efficient choice is the Kodak Wratten barrier filter, available most commonly as 3 x 3 inch gels. Gels must be used in a special holder that screws onto the front of the lens. In order of decreasing transmission they are numbered 2B, 2A, and 2E. The most commonly used is the 2A.

The selection of a barrier filter may depend on what visible wavelengths are produced by the fluorescence. Blue may be an important color, but might be removed by the barrier filter. If this is a problem, you must choose a barrier filter that will transmit the fluorescent blue. Kodak (1968) shows the transmittance curves of a number of barrier filters and should be a help in finding the proper filter. Ultraviolet Products, Inc., recommends use of a yellow K2 filter to eliminate blue reflections. Grigsby (1969) notes that the K2 filter works better with long-wave UV than with short-wave because the former emits more blue and violet light. Standfast (1980) recommends that a Breen G15 can also be used to remove all blue reflections. The K2 and G15 should only be used if these is no blue fluorescence. Exciter filters may also contribute to the problem by transmitting visible light in the same range as the fluorescence you wish to record.

Because of the reciprocity failure that occurs with the long exposures necessary for fluorescence photography, you may wish to use color-correction filters to compensate for color shifts. Unfortunately, these filters were designed for use with normal lighting, and so the corrections may not be as accurate with fluorescence photography but still may be of some value. lf exact color rendition is critical, view a series of test shots on a color-corrected light box, using CC filters over the transparencies until acceptable results are achieved. The next time you photograph that particular subject, use the CC filter you found to have the best correction.

FILM SELECTION

Since color is the main reason for photographing fluorescence, the following discussion is limited to the use of color films.

All films are inherently very sensitive to the blue end of the visible light spectrum and to UV Since tungsten films are especially blue to compensate for the lack of that end of the spectrum in tungsten lighting, they are of little use in fluorescence photography. Daylight films are the most commonly used, and transparency (slide) films in particular. With transparency film, what you see is what you get (within the capabilities of the film). Color prints from negative film rely on a processor for proper color, and most machines and operators are calibrated to deal with "normal" light and color situations. Fluorescence photography do not usually fall within any of the normal parameters and, so, seldom provide satisfactory results. Although it is more expensive to do so, prints can always be made from slides. lf it's necessary to use print film, it would be wise to provide the printer with a standard for color guidance. Photograph the subject both in color slide and print film. Once you have the accurate slide, use it as the standard.

Although low ISO films provide finer grain and more accurate color, reciprocity failure and the resultant color shift can be a problem. To avoid this problem, a medium-speed film is recommended in the range of a ISO 100 to 200. The most frequently used film is Ektachrome 160 daylight. As always, it's best to experiment to determine what film fits your needs best.

lf your subjects are not too small, and don't require long extensions and small f-stops for maximum depth-of field, you may be able to use a slower, finer grained film such as Kodachrome 25 or 64. The use of brighter lights will also allow you to use slower, finer grained films.

With transparency film, what you see is what you get (within the capabilities of the film). Color prints from negative film rely on a processor for proper color, and most machines and operators are calibrated to deal with "normal" light and color situations.

EXPOSURE DETERMINATION

It is very difficult to meter the fluorescence of minerals due to the very low light levels produced. Some very sensitive light meters can read this light, but must be used with a barrier filter over the sensor so the UV radiation will not throw off the reading. But even if you can get a meter sensitive enough, the reading will still not be accurate. Meters are designed for use under "normal" conditions, generally not for materials that emit their own light under excitation from other radiation sources. At best, the meter reading will only give you a rough starting place to bracket your exposures.

Bracketing is the key to correct exposure with fluorescence photography. Some authors such as DeMenna (1983) and Modreski (1989) have published tables of exposure times for different minerals using different barrier filters and specific light sources. Such tables are of limited usefulness because of all the variables from one photographer to the next. These variables include light source, distance of light from subject, subject brightness and size, degree of magnification, fluorescence color and brightness, film type, aperture, and type of barrier filter. lt's best to make a series of test shots keeping track of the variables, and keeping them to a minimum. For example, light-to-subject distance should be standardized. Once such a table is compiled, it will be very useful in future shoots to narrow down the bracketing range. When using medium- and large-format cameras, bracketing can be kept to a minimum by the use of Polaroid film for test exposures.

Just as with normal photography, depth-of-field is important, but it can be more of a problem with fluorescence photography. Since exposures are substantially longer, a small f-stop for maximum depth-of-field can cause serious reciprocity failure. It may be best to compromise and use f 8 or fl 1 in order to minimize the problem and the need for compensation with longer exposure time and filtration.

If you're using electronic flash as a UV source, you can bracket with the following method. In the darkened room, lock the shutter open on B with a locking cable release, and bracket by varying the number of flashes per exposure. Reciprocity failure can also be a problem with multiple flashes. The number of flashes that a film can tolerate varies depending on the film. lf that information isn't published on the information sheet that comes with the film, it can be obtained through the Kodak information line (1-800-242-2424).

Fluorescence photography must be done in a very dark room so that stray light does not mask the fluorescence. If such a room is not available, wait until nightfall and cover all of the windows. A tripod or copy stand is a necessity, as is a locking cable release. Compose the photograph using whatever lights you would use for a normal photograph, then turn them off. Lock the shutter open on B, and time the exposure using a watch with a sweep second hand or a digital watch in stopwatch mode, then close the shutter. An alternative to using a watch for timing is to plug all your lights into a dark-room enlarger timer that is set for the proper exposure time. This method eliminates potential vibration from the cable release, shutter, and mirror flop, and relieves you of the task of staring at a watch face for long periods. Such a timer would not work well with lights that take some time to warm up.

BACKGROUND SELECTION

Typically, a black, nonfluorescent background is used so as not to distract from the subject. Black velvet is most often used, but lint on the cloth can be a serious problem. The lint fluoresces a strong blue/white and can be difficult to completely remove from the background. Clean the background thoroughly using tape to dab off the lint, or use a commercial rolling lint remover such as can be bought at the supermarket. You can also minimize the lint problem by elevating the subject off of the background (in a copy-stand arrangement) by means of a hidden pedestal. Another problem with black backgrounds is that if the fluorescent mineral is in a dark, nonfluorescent matrix, there will be no outline of the specimen-the fluorescent mineral will appear to be a disconnected series of lights in a sea of black. Some photographers deal with this situation by placing the subject on a colored paper or cardboard background that fluoresces a subtle but contrasting color. Experiment with different materials under the UV light to find a pleasing background. White papers are not used because they nearly all fluoresce a very strong blue/white due to added brighteners.

Modreski (1989) suggests another technique to separate the subject from the background. Briefly light the subject with white light after the fluorescent exposure. The result will be fluorescent patches on a dimly lighted matrix. You must be careful when doing this because the white light exposure will subdue the fluorescence and reduce contrast.

I have found that a double exposure technique works well for producing contrasting backgrounds. I place the speci men on a sheet or raised glass as shown in Plate 25. The background paper is illuminated with a spodight or microscope light as 1 would normally illuminate a shot. The first exposure is taken with just the background light on, and the second with the background light off but the UV lights on instead. Some experimentation will have to be done to determine the proper relative exposures of the two lights, along with a lot of bracketing.

A tripod or copy stand is a necessity, as is a locking cable release. Compose the photograph using whatever lights you would use for a normal photograph, then turn them off. Lock the shutter open on B, and time the exposure using a watch with a sweep second hand or a digital watch in stopwatch mode, then Glose the shutter.

OTHER **CONSIDERATIONS**

Different materials have dramatically different levels of fluorescence. These differences can be a problem when shooting several specimens at once, or when several different fluorescent minerals are present in the same specimen. If not compensated for, you will find that some of the colors are overexposed and washed out, and others too dark and underexposed. The simplest way to deal with this problem is to compromise on the exposure and choose the one that is inbetween the two extremes, while the best way to deal with the situation is to mask the brighter arcas if possible, placing black cardboard cut-outs over them. The cutouts are removed part way through the exposure to achieve a more even exposure. It's best to learn the relative exposures by making trial exposures of the subjects individually.

You will also find that some fluorescent colors do not record accurately, even with proper barrier filters and no reci procity failure. Film emulsions don't "see" things exactly the way our eyes do, and are also designed for use under more averáge conditions. Most films are balanced for common colors such as rich greens, skin tones, black, gray, and white. They deal less accurately with pastels, pinks, purples, and oranges. To learn more about this problem, see Kodak's publication number E-73 (1987). If you run finto a film sensitivity problem, you can deal with it by using color-compensating filters in the procedure described in *Chapter* 10. This method doesn't work well if you have more than one fluorescent color in the shot, as other colors will be inaccurately changed due to use of the CC filten

If you're going to work for prolonged periods with UV radiation, use protective eye wean Sunglasses that block UV can be used, but a better choice would be contrast goggles designed specifically for the purpose. They are available through a number of UV equipment supply houses. In blocking stray UV radiation, they also serve to increase contrast when viewing fluorescent materials. Never look directly into UV lamps, as they can permanently damage your eyes. You should also keep your skin covered when working with UV for long periods to avoid sunburn.

It's often handy to photograph a subject in normal light as well as UV for comparative purposes. If you use the same daylight film for both, you must consider the color balance for the normal shot. There are several options for dealing with the different requirements for the two shots. You can use blue daylight photo flood bulbs, daylight studio flash, or a conversion filter over the lens. If you have two camera bodies, you can use tungsten film for the normal shot and daylight for the UV shot.

CHAPTER

16

Lapidary Arts

In many ways, the photography of lapidary materials is the same as that of minerals. There are, however, some major differences. The peed for accurate, detailed photography is the same, but the subject in lapidary photography demands different treatment. Minerals are essentially viewed by themselves and stand or fall on their own merits. Most mineral collectors tend to be purists and insist that specimens be portrayed without a lot of window dressing. Lapidary materials seldom stand alone. Many pieces are functional and are used within specific contexts. The person on the street may not know exactly what the stones in a piece of jewelry are, but he or she knows the beauty, aura, mystique, and, perhaps, the history of a piece. Therefore, lapidary materials are seldom presented without window dressing.

The use of photography to promote a piece demands that the subject be placed in a setting that entices the viewer and creates a mood of elegance, mystery, or beauty. Although the photography of minerals is very rewarding and creative, photographing lapidary materials is much more challenging and demands more of the photographer's creative and design talents. If you're doing advertising photography, the work you do must be constantly fresh and creative. In the highly competitive jewelry business, clients don't want to see their ads look like someone else's, or not stand out on the pape.

This chapter deals with the specific requirements of photographing lapidary materials. Many of the general techniques discussed in previous chapters-such as those pertaining to equipment, film, light sources, metering, magnifications, and medium- and large-format photography-apply as well and the reader is referred to those chapters for the basics.

(See also *Chapier 18* on location shooting.)

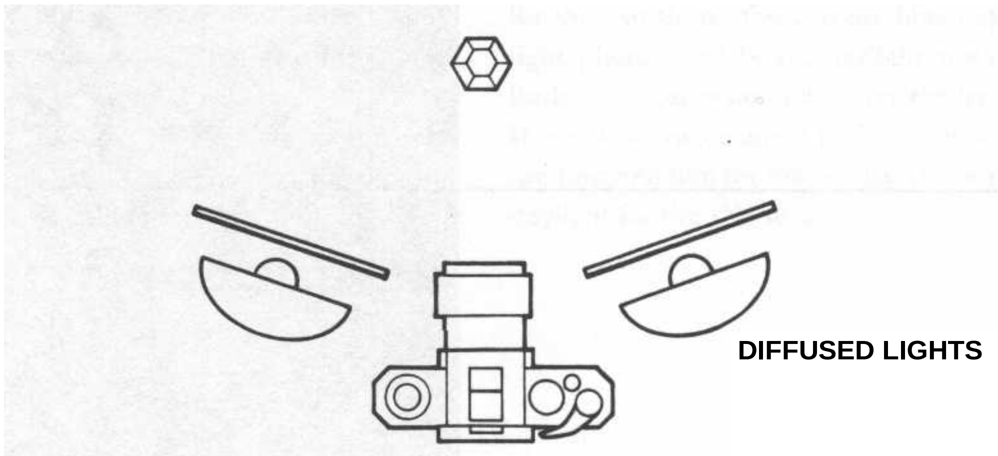


Figure 16-1 Setup for photographing cut stones with diffused lights on either side of the lens.

LIGHTING SPECIFIC SUBJECTS

CARVINGS, CABOCHONS, AND FLAT OBJECTS

In the photography of both minerals and lapidary materials we're dealing with similar problems of high luster, transparency, and varied forms. Because of the high luster of the subjects, it is rare that lights are not diffused.

Lighting is most often above and slightly in front of the subject, especially for objects such as carvings where the form must be brought out by careful modeling with the lights. Carvings often have fine and varied surface details that must be shown. Because diffused lighting reduces reflections and contrast, it can create a "flatter" image with little "kick." Once you have finished setting up the basic diffused lighting, you may find that adding a single pinpoint light source or reflector with high specularity (such as a mirror or metallic surface), will add "punch" to the picture, bringing it to life. Don't forget that if the carving is of a transparent or translucent material, that some backlighting in addition to the diffused direct lighting will enhance the subject *(Plates 26* and *27).*

Working with cabochons and spheres can be troublesome. They will reflect everything around them, especially the lights. Reflections of the lights will obscure the color and transparency of the subject and will also be distracting. The problem can be minimized by keeping the lights as diffused and broad as possible. Such lighting will keep detail in those otherwise obscuring highlights *(Plate 28).* It may also help not to have the lights as far to the front of the subject as you would normally. Position them more directly above the subject to keep the

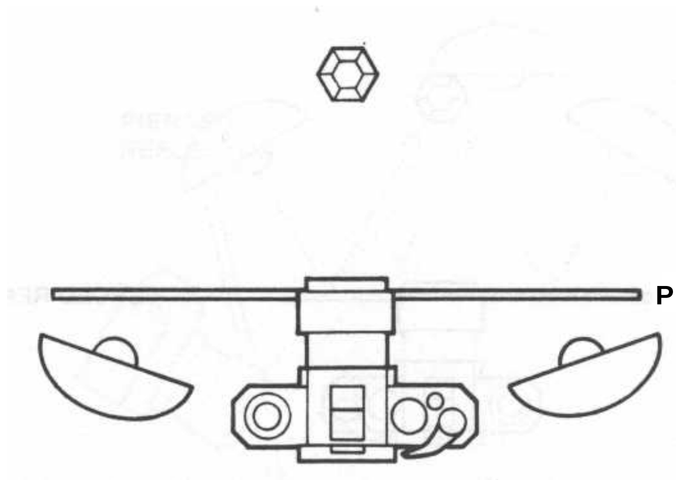


Figure 16-2 Setup for photographing cut stones with lights on either side of the lens, with a large diffuser pierced by lens. A larger area of diffuser illuminates the stone better than in Figure 16-1, especially if more than two lights are used, spaced equally around the lens.

highlights very close to the top edge of the cabochon or sphere, where they are less objectionable. Another possibility is the use of pinpoint light sources. Their reflections will be quite intense, but small. Their use can, however, create dense shadows on the background. Focused fiber optics are best for shooting many phenomenal stones such as star stones, cat's-eyes, and even opals *(Plate 29).*

Photographing flat objects such as slabs is like copy work (i.e., photographing flat art). Lights should be placed at 45°, left and right of the subject so that there are no reflections and lighting is even. If the subject is dark and very reflective, it may act as a mirror and reflect an image of the camera or lens. This problem can be eliminated by the use of a sheet of black cardboard that is pierced for insertion of the lens and is used in conjunction with a lens hood.

CUT STONES

The photography of cut stones is a challenge. Most people make the mistake of lighting them as they would any other subject, then they try backlighting them when they run into problems. Neither method works. If you stop to think about it, a faceted stone is designed so that the light enters through the top table facet, reflects off the pavilion facets on the back of the stone, and then exits out the table to the viewer's eye. Lighting for photography must follow the same path. This objective can be accomplished one of several ways.

If your light sources are small enough, as with the high-intensity desk lamps discussed in *Chapter 6,* they can be placed on either side of the lens, aimed at the stone. The film plane of the camera should be as nearly parallel with the table of the stone as possible (Fig. 16-1). This setup maximizes the effect and keeps the

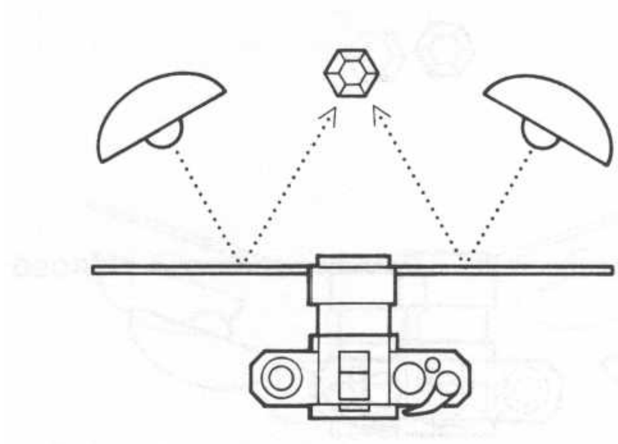


Figure 16-3 Setup for photographing gemstones with the lights aimed at reflectors place around lens. Effects are improved if more than two lights are used, equally spaced around the lens. A deep lens shade should be used so that light does not fa¡¡ on the lens causing fiare.

stone from looking distorted or the culet (the apex formed by the junction of the pavilion facets) from appearing off center. The lights must be diffused and nearly touching the lens. This technique works well with some stones, but the lighting is uneven and all the pavilion facets may not be illuminated. A better method would be to use a sheet of diffusing material with a hole in it for the lens to fit through *(Fig. 16-2).* The lights are on either side of the camera as before, but further back so as to illuminate all of the diffusing material (the lights themselves need not be diffused for this technique).

Another method is to have the lights on either side of, and aimed at, the camera *(Fig. 16-3).* Instead of diffusing mate rial with a hole in it placed around the lens, an opaque, white reflective material is used, such as Foam Core or cardboard. Care must be taken not to let light spill onto the lens itself. A long lens shade must be used to prevent this spillage. Cut the shade from a sheet of black construction paper or, preferably, black flocked paper. Form it into a tube that fits snugly around the lens and tape it te hold the shape. Cut it down in length se that when looking through the viewfinder, you no longer see it vignetting the image.

If your light source is too large and must remain above the subject, an alternative method can be used. The camera is set up in the proper angle as before with a reflector fitted around the lens. This time, the hole in the reflector is larger than before so that the reflector can be angled to reflect the light along the axil of view and into the table of the stone (see *Fig. 16-4).*

The master of loose, cut-stone photography is Tino Hammid (Plate *30),* who gets incredible brilliance from his sub-

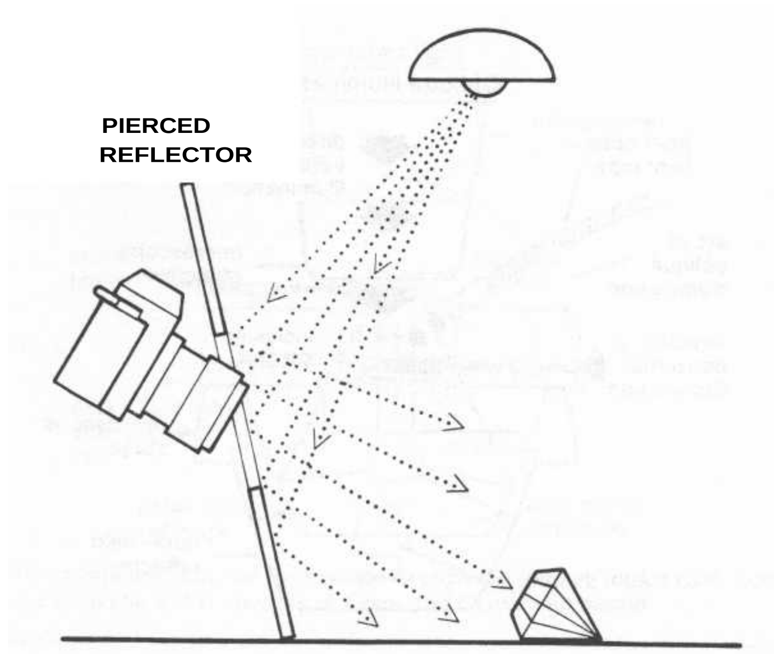


Figure 16-4 If a single large light is used, it may not be possible to use the methods shown in Figures 16-1, 16-2, and 16-3. A pierced reflector can be angled so that the light is reflected along the lens axis to the stone.

jects. Joel Arem is known for his group shots of faceted stones (Plate 31).

When using any of these techniques, it is important to keep all reflections off of the table facet so as not to obscure the interior of the stone. A few subtle reflections off crown facets are good to show that they are there and their quality. Additional useful highlights can sometimes be added with small reflectors on either side of the stone. Instead of using a white reflector around the lens, it may sometimes be possible to use a matte aluminum reflector when a little more punch is needed.

One of the main objects in photographing cut stones is to bring out therr brilliancy. This effect is achieved by getting as many of the pavilion facets to reflect the light as possible. Pavilion facets that do not reflect light may be completely black and create a disturbing "window" Such windows may be hard to avoid especially with emerald and similar cuts. You may find with such stones that orientating the table parallel with the film plane won't produce the best results. While viewing the stone, carefully change its angle until the optimum one is found. Occasionally you'll run finto a stone that is impossible to get any color out of because it is too dark, or that you can get no reflections off the pavilion facets because they are cut too deep. In such cases, you can cheat a little by covering the back of the stone with foil, or just placing a small foil reflector behind it. You may sacrifice some detail of the pavilion facets, but you'll get color and brilliance.

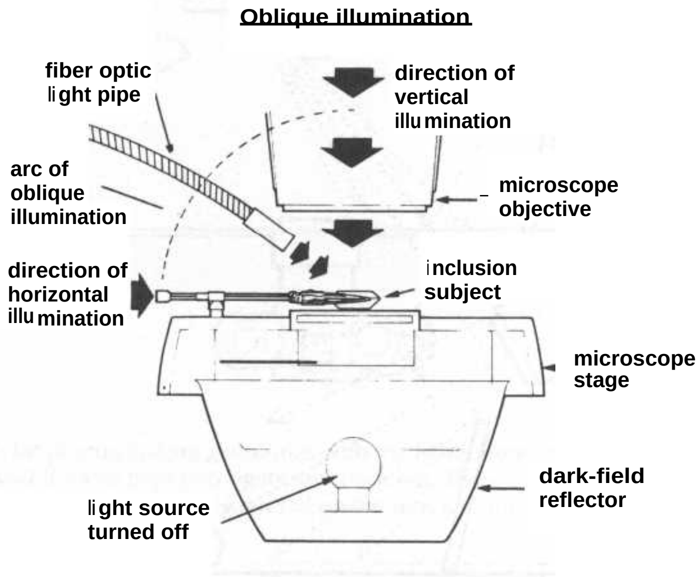


Figure 16-5 Oblique illumination requires that the light be transmitted anywhere from 0° to close to 90° to the subject. (Koivula, 1981; courtesy of Gems *and* **Gemology)**

Not all the stones you shoot will be flawless. Examine the stone carefully before shooting to locate imperfections. Orient the stone for shooting so that any flaws are minimized.

JEWELRY

jewelry presents the additional problem of highly polished metal (*Plates 32* and 33). In addition to its reflecting everything around it (including you and the camera), any portion of the metal not reflecting a white reflector will go black. The secret of jewelry photography is *tent lighting.* The subject has to be totally surrounded by white reflectors.

Start with a large diffused light source such as a soft box, then lean sheets of Foam Core right up against the soft box. The camera will have to look through a hole in a reflector, and all reflectors will have to butt up against each other. Any gaps between reflectors will appear as black lines in the polished metal of the jewelry. Even if the reflectors butt up against each other, there may still be lines reflected. This problem can be dealt with by using white painter's masking tape to join the sheets together on the inside of the setup, facing the jewelry.

An alternative to reflectors is to literally "tent" the subject. Create a conical form of diffusion material to place around the subject. A hole is cut in the material for the lens, and several lights are placed evenly around the diffuser. There are several companies that make cloth cones for this purpose, but you can

Transmitted light

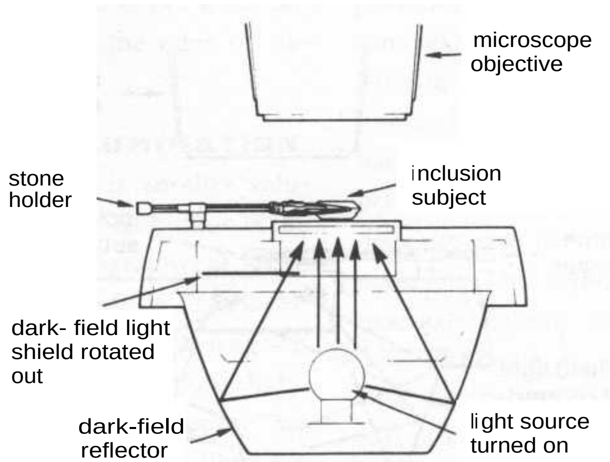


Figure 16-6 With transmitted light, the light passes through the subject, in this case, from the sub-stage light source. (Koivula, 1981; courtesy of Gems *and* Gemology)

easily make your own. When using cloth as a diffuser, you can use white Velcro as the seam closer. This seam can be opened anywhere necessary to allow access for the lens.

Some photographers have also experimented successfully with hemispheres of translucent white plastic as diffusers for jewelry photography. The hemispheres can be plastic storage bowls or the large spheres used as diffusers for domestic and public lights. Look in the lighting department of your local variety store for usable diffusers, but be sure they are neutral in color.

Sometimes reflectors are not needed on the far side of the subject and can be left out. This may be necessary so that the background grades to black or is just shaded. Be careful, however, that the highlights that define the top edge of the subject and separate it from the background are not lost. You may be able to create such a highlight by suspending a small reflector above and behind the subject and not interfere with background lighting.

INCLUSIONS

Inclusions in gemstones are of great interest to gemologists because their patterns "fingerprint" a stone, thus making it identifiable. They also aid in determining mineralogical origins and whether or not the stone is synthetic. Direct or oblique illumination is seldom used in inclusion studies but is useful for opaque gems. According to Koivula (1981), direct illumination is good for defining some fractures and ultrathin liquid fingerprints. It is also good for bringing out interference colors. The best lights for such purposes are fiber optics, sometimes used in combination with other techniques, such as dark-field and polarized lighting (Fig. 16-5). Koivula also recom

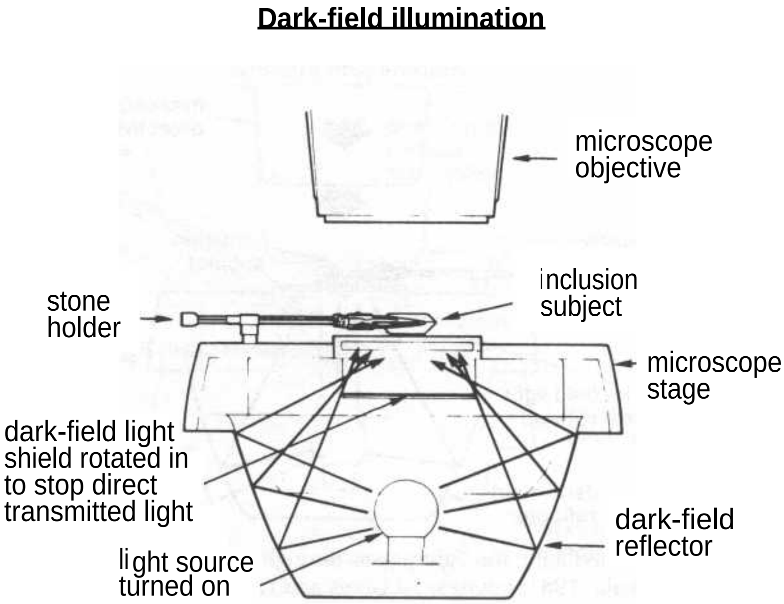


Figure 16-7 With dark-field illumination, a dark shield is placed between the subject and the light source below it, so that the only light to reach the camera is that refracted by the stone. (Koivula, 1981; courtesy of Gems *and* Gemology)

mends that gemologists create a file of slides illustrating inclusion characteristics for easy reference.

LIGHTING TECHNIQUES

TRANSMITTED LIGHT

The use of transmitted light is standard in the microscopic examination and photography of gemstones, and especially of their inclusions. Transmitted light is good for revealing large fluid-filled inclusions and color zoning, but it is not good for revealing fine detail (Fig. 16-6).

As already mentioned, fiber optics are the light source of choice with some units being very specialized and particularly suitable for gem-inclusion photography. GEM Instruments Corporation makes a fiber optic with six separate, interchangeable light wands or probes. The probes are plastic-coated stainless steel with a fiber-optic core ranging in diameter from .5 mm to 3 mm. Each probe can be attached to a 175-cm long rubber-sheathed optic bundle (2.5 mm in diameter) that can be attached to any standard fiber-optic light source. Because the fiber optics are not self-supporting, they must be held in position with a holder or stand. The advantage of the system is its extreme controllability and choice of pinpoint probes. The probes can be put right at the edge of a stone at precisely the needed angle. This positioning can be very important for the examination of mounted stones where illumination is very difficult. Such precise placement also brings out the separation planes of assembled stones when the light is placed right at the edge of the plane at a slight angle.

DARK-FIELD ILLUMINATION

Dark-field illumination is another valuable and commonly used technique in the examination and photography of gemstones. The detail it reveals in fluid inclusions, healing fractures, and cleavages is superior to that of transmitted light. Most gemological microscopes are designed to provide dark-field Alumination and some can also be used for photomicrography

(Fig. 16-7; Plate 34).

POLARIZED LIGHT

The use of polarized light is another valuable tool in inclusion photography. It reveals strain around included crystals, strain induced by crystal intergrowth, and twinning *(Fig. 16-8; Plate 35).*

FLUORESCENCE

The fluorescence of some gem minerals is characteristic and useful in their identification. Ultraviolet light is of limited use in inclusion photography because the host material must be nonfluorescent and transparent to ultraviolet light. Some included organic fluids and solids will fluoresce but are difficult to photograph due to long exposure times and vibration problems.

AXIAL LIGHTING

In thinking about the requirements for lighting gemstones, with the light needing to be axial or near axial, I considered the possibility of using coaxial lighting. After some experimentation, I found that axial lighting does not work very well on cut stones. I was expecting to get great brilliance out of the stones, but did not. I believe the light beam is too confined and does not give the pavilion facets enough coverage. The slightly wider coverage of near-axial lighting does a much better job. The technique is worth experimenting with, as it may prove useful with certain cuts or types of stones.

You must be careful that the table is not exactly perpendicular to the beam or you will get a total "burn out" of the table obscuring all internal detail. On the other hand, what will be revealed is the quality of polish on the table. This capability in itself could be useful in judging the quality of the faceting and an additional aid in fingerprinting the stone by the pattern of grinding striae on the facet.

The technique would also be handy in the examination of jewelry. The interiors of castings, deep settings, and the like would be revealed by the use of axial lighting.

FILTRATION

With the exception of a few specialized applications, filters are seldom used in lapidary photography. Neutral-density filters can come in handy if your light source is as powered down as it can go but is still too bright. I run finto this problem when switching from large-format, to

Polarized light

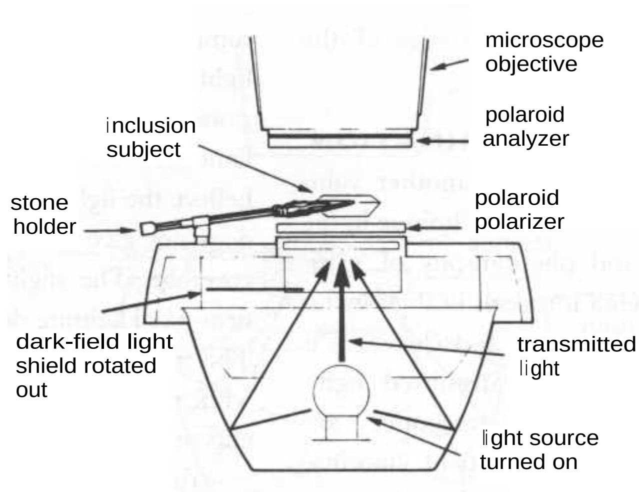


Figure 16-8 Polarized lighting requires that polarizing materials be placed above and below the subject. (Koivula, 1981; courtesy of *Gems and Gemology)*

a 35-mm shot of the same subject using the studio flash for both. Most 35-mm lenses do not go down to f45 or f64, and so the lights must be moved away from the subject. This repositioning can be difficult with all the reflectors set up in critical positions, plus it can change the angle of the lights and thus change the effect you are trying to achieve. This situation brings up the use of neutral density filters. They can be used in the same way already discussed in *Chapter 10.*

Polarizing filters can come in handy to deal with problem reflections. They do, however, cut out a lot of light and so require the use of longer exposures. I prefer to control reflections by diffusion of the light sources (of course, the more diffusion, the longer the exposure also).

Since lapidary photography often tries for "glitz," special effects filters can be very useful. There are an amazing variety available, but it is best to stick with the simpler effects such as those produced by using a star filter.

A specialized filter of great use is the first-order red compensator made by the Polaroid Corporation. It is used by gemologists, crystallographers, chemical microscopists, petrologists, and mineralogists to help determine the optical character of unknown crystalline compounds and define arcas of strain.

Koivula (1984) goes into detail on the usefulness of the red compensator. It is inserted into a field of polarized light where it enhances the image by addition or subtraction of optically retarded wavelengths as they pass through the compensator into an optically anisotropic solid. The filter enhances interference colors that brighten as you near the optic axis. Because the filter enhances and brightens the image, it reduces

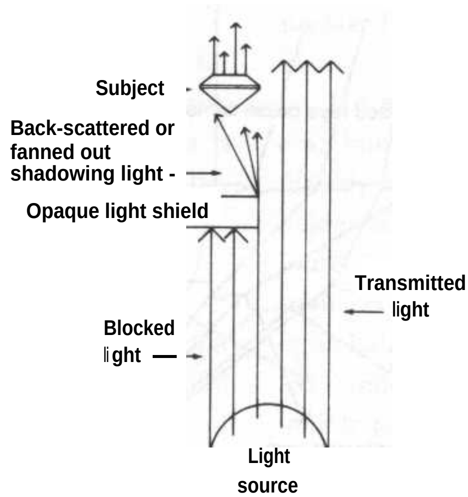


Figure **16-9 An exaggerated diagram showing the backscattering of light as the opaque light shield is gradually inserted into the transmitted light path. (Koivula, 1982b; courtesy of Gems** *and* **Gemology)**

exposure time, which in turn reduces potential vibration problems.

SPECIAL TECHNIQUES

SHADOWING

Shadowing is a technique used in microscopy where the cone of light produced by a substage condenser is purposely interrupted so as to create uneven lighting. An object such as a pie-shaped piece of black paper is inserted into the light path to achieve the effect. The shape of the opaque "shield" varies depending on the subject and the results desired. The technique works particularly well with inclusions (Plate 36).

"As the edge of the opaque light shield is slowly inserted into the light path, it interferes with the direct upward passage of light, causing it to be diffracted and scattered at the edge. This fanning out of the light literally causes a transmission of light in certain portions of the inclusion subject while other arcas . . . appear to be darkened or shadowed, gready increasing contrast in and around the inclusion" (Koivula, 1982b; also see Figs. 16-9 and 16-10). A similar but more limited effect can be achieved by just closing down the substage diaphragm. Use of the diaphragm causes excessive diffraction and its effects cannot be controlled by position and shape as with the introduction of an opaque light shield.

The first step in the procedure is to remove the dark-field stop from the gemological microscopc while it is in the transmitted-light mode. Slowly insert the shield while looking at the feature in the stone being examined. A dark region, which is the shield, will appear at the edge of the field of view. The contrast in

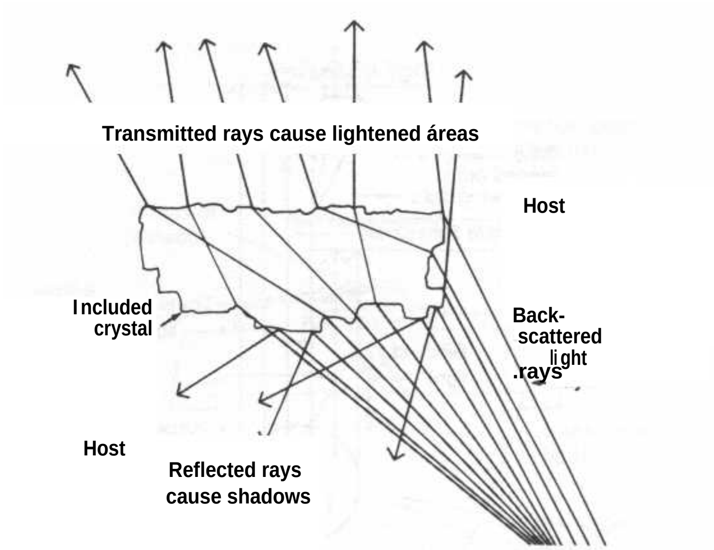


Figure 16-10 A simplified theoretical situation illustrating the effect of both reflection and reflection transmission of the backscattered light as it contacts an included crystal with a refractive index different from that of its host. (Koivula, 1982b; courtesy of Gems *and* Gemology)

the subject will slowly change until the feature seems to suddenly leap out three dimensionally. Try inserting the shield from different directions and change its shape until optimum results are achieved. The distance of the shield between the subject and the light seems to have little effect on the results.

IMMERSION

lt is sometimes useful to photograph a stone in refractive index fluids so as to make it easier to see inside it. It's generally inadvisable to use full-immersion techniques for several reasons. Immersion liquids are very dense and toxic organic compounds that are usually colored. Any time you put something between the camera and the subject, the image quality is going to suffer.

Immersion liquids are sensitive to light and heat, and they tend to darken with age and exposure to lights. They must be frequently filtered to remove dust that builds up during use. Another problem is that convection currents in the liquids will show up in photographs and distort the subject.

There are advantages to using immersion liquids with the same refractive index as the stone you are examining. Surface scratches and blemishes nearly disappear as well as distracting facets. Because of these advantages, Koivula (1981) suggests a modified technique. Instead of totally immersing the stone in the liquid, just place a droplet on its surface. The very thin film produced by the droplet produces fewer toxic vapors, creates less distortion, and affords little opportunity for convection currents to form. Cleanup is much easier, and the facets on the other side of the stone are still exposed and can be used for lighting the inclusion.

The technique is especially good for examining crystals with rough faces and for badly scratched faceted stones. It is also useful as an aid in locating optic figures in anisotropic stones.

STEREOPHOTOGRAPHY

Little needs to be said here except that the use of stereophotography would enhance the imaging and definition of lapidary materials. Inclusion studies would benefit especially from a threedimensional rendition making their characteristics much more readily discernible. Spatial relationships would be much more obvious and useful.

STRIAE IN CORUNDUM

Jenkins (1974) wrote about an interesting technique for observing and photographing growth striae in corundum. One of the ways of telling the differenly between synthetic and natural corundum is by the growth striae. In natural corundum the striae are linear, while in synthetics they are curved. It can be difficult to see the striae without special techniques.

Jenkins states that corundum absorbs light differently at the growth boundaries, which are hard to see with visible light. He says that the phenomenon is more visible with the use of light that is more in the dark-blue and long-wave ultraviolet range. The human eye is not very sensitive in this range, so he recommends the use of a film that is, (below 4000 angstroms). At the time, he used Kodak Plus X Pan Professional sheet film.

His technique was not to use a camera, but to lay the stone table down directly on the sheet film in a cut film holder in a dark room, with a point light source suspended about 6 feet above the stone. He used a pen light, but a fiber-optic light would probably be much better. Some experimentation is required both to get the proper exposure as well as best orientation of the stone. The reason for use of a pen light or fiber optic is so that the light rays are as close to parallel as possible. With the technique, the striae are easily visible.

BACKGROUNDS

It is the use of backgrounds and attendant props that really sets lapidary photography apart from mineral photography. Nearly anything can be, and has been, used as a background for shooting jewelry. The sky is the limit. Just look at any good quality magazine with jewelry ads and youll see what I mean. The materials used are no longer just backgrounds, but props that set the mood just as in a movie or play. Among the materials used I have seen feathers, flowers, bricks, tiles, marbles, pencils, Plexiglas rods, paper, fabrics of all types, books, wood, coins, plants, and on and on. Your imagination is the only limitation on background choice. But remember, it isn't just what you use for a background, but what you do with it. Study those ads and see how the materials have been used. See if the materials all contribute to a theme. Examine the lighting and the use of depth-of-field.

Don't get too carried away with the backgrounds; remember that they are to set off the subject, not detract from it. Simpler is often better. Remember also to keep your background materials clean and free of putty smudges, fingerprints, and lint.

A popular background for the photography of stones is one that is finely textured, neutral and dark in color, and reflective. 1 like to use a piece of nonglare glass. It can be suspended above a black background, or, better yet, you can paint the smooth, untextured surface black. This painted side will be facing down during photography. With normal lighting for a stone, the background will appear black, with a slight reflection of the stone. When you add a diffused light source behind the setup (as explained in *Chapter 11,* Backgrounds), a halo effect is created around the stone. This halo also picks up the subtle texture of the nonglare surface of the glass *(Plate 37).*

Any finely textured, reflective material can be used as a background, including plastics and papers. You must be very careful when using plastics because they scratch very easily, attract dust, and drive you crazy. A popular material for photographing cut stones on is Luster Board, which is a textured, heavy paper stock with a coated glossy surface.

SPECIMEN CONSIDERATIONS

PREPARATION AND HANDLING

Considering their relatively high value, lapidary materials must be handled with great care. The work arca should not be over a concrete or tile floor where the subject would be destroyed or irreparably damaged should it be dropped. If you are photographing in a room with such a hard floor surface, have it covered with an arca rug. Always handle subjects over a table, and not the floor.

Subjects must be well cleaned before photography. Lapidary materials present numerous highly polished and reflective surfaces that show the smallest amounts of dirt, lint, and fingerprints. If you aren't familiar with the cleaning of lapidary materials, learn how from a jeweler or have the owner clean the items before he or she gives them to you. Lens tissue works well for the removal of minor fingerprints. A polishing cloth is handy for the removal of minor tarnish and fingerprints from polished metal surfaces. Before you use it though, you should consult with the owner or jeweler. Small brushes, air bulbs, and tweezers should be handy for the removal of lint, as well as putty to "touch off" lint. Cotton gloves should be worn when handling lapidary items to avoid fingerprints.

Lapidary materials present numerous highly polished and reflective surfaces that show the smallest amounts of dirt, lint, and fingerprints. Lens tissue works well for the removal of minor fingerprints. A polishing cloth is handy for the removal of minor tarnish and fingerprints from polished metal surfaces.

SUPPORT

Propping of Lpdary materials can be done in the same manner as for mineral specimens, using putty, blocks of wood, and whatever is at hand. Because of the variety of shapes and the greater variety of backgrounds, you may have to be much more creative about propping. Sometimes propping materials can be a visible part of the background-a true "prop"-or, more likely, it will be hidden. 1 have found that beeswax is excellent for holding up items such as rings. It has more holding power than most putties and is translucent and nearly colorless, making it less visible if some of it shows (which it should not). It is best used on nonporous surfaces because it will stain and is hard to remove.

Hot melt glues can also be very useful for propping hard-to-hold objects such as top-heavy rings. 1 recently used some to hold a carved bird on the end of a horizontal dowel for a sequence of multiple exposures. No putty or wax would have been strong enough to do the job. Hot melt glues must also be used with caution. They cannot be used on anything that is heat sensitive, porous, or rough surfaced because it would be very difficult to remove from the latter.

Sometimes it may be necessary to suspend an item and not have the means of accomplishing this show. CPM, Inc., sells a kit containing a variety of black, tungsten-alloy wires, adhesives, and hooks for this purpose.

SCALE

A **scale is rarely used in the** photography of Lpdary materials for the same reason it is seldom used with minerals aesthetics. If a scale must be used, you can take two pictures, one with and one without the scale, or place the scale at the edge of the frame so that it can be cropped out. As with everything 1 photograph, I record measurements of the subject that are later noted on the slide mount or back of the print. If stones are involved, I record carat weights.

CHAPTER 17

Fossils

For the most parí, the photography of fossils is quite unfke that of minerals and lapidary materials. Most fossils do not Nave highly lustrous, planar surfaces, and, with the exception of some shells, few have the range of colors minerals and gems do. Thus the photographer's task is simplified in some ways. Diffusion of light sources is not so critical and you don't have colors that are incompatible with a film's color sensitivity.

The photography of fossils also generally has a different philosophy than that of minerals and lapidary materials. While fossils certainly can be photographed aesthetically, the approach is usually a simpler, cleaner, more scientific one. The majority of fossil photography is done for scientific publication, and since color is not usually a critical factor, most work is done in black and white. Backgrounds are either white or black, depending on how light or dark the fossil is. Whenever possible, white is preferred because it reproduces better than black and these is less chance that dark arcas of the subject will fade into the background. Very accurate rendition of the subject is required in fossil photography. There should be no ambiguity as to the form, texture, or important details. No window dressing is needed, and so backgrounds are usually uniformly lighted, nondistracting, and shadowless. Given these requirements, most fossil photography is done on a light table. When using a light table you must be careful to mask off all portions of the table with opaque black paper so as to avoid flair. Be careful that the light table is not overilluminated or the edges of the subject will burn out. To achieve a pure white background, it should be no more than four stops brighter than the subject.

GENERAL TECHNIQUES

Fossils come in a wide variety of forms and so require a variety of photography techniques. Stony fossils, such as bones and shells, are very three dimensional and

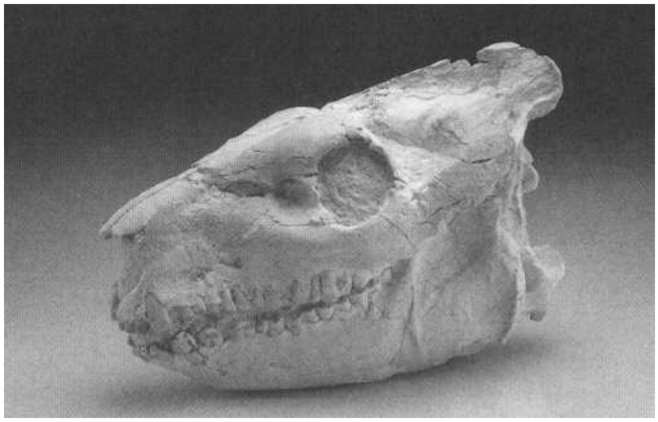


Figure 17-1 Direct lighting of an oreodon skull *(Merycoidodon culbertsoni,* **Oligoncene, White River Formation, Douglas, Wyoming; 21.3 cm long). (Ron Stebler Collection)**

should be shot like any three-dimensional object. The light should be undiffused (unless the subject is very reflective) and from above, with adequate fill to provide detail in the shadow arcas but not so strong as to negate the modeling effect of the main light *(Fig. 17-1* and *Plate 38).*

Relief impressions in matrix, such as leaf and fish imprints, must be lighted with a single flood or spot at a low grazing angle to bring out the low relief. The angle will depend on the amount of relief in the specimen. The less the relief, the lower the angle and the less the fill illumination. Be sure that your lighting is consistently from above or to the left. If it comes from another angle, the relief may be reversed; that is, hollows may seem to be raised arcas instead and vice versa *(Fig. 17-2).*

Fossils as *stains on rock surfaces* require low contrast, nondirectional lighting. The problem with such fossils is their low con trast and nearly complete lack of relief *(Fig. 17-3).* For black-and-white photography, Sometimes a color filter will help separate the fossil from the matrix. For instance, if the fossil is a reddish tint on a matrix with a similar tonal value, a red filter will make it appear lighter in a black-and-white photo. Using a green filter will make it appear darker relative to the matrix.

Sometimes wetting the specimen helps to bring out contrast. A spray bottle with distilled water may be all that is needed. You must work fast though, so that the water doesn't evaporate under the hot lights. You must also be careful that the water won't damage the specimen. Sometimes total immersion is necessary. Again, use distilled water and wait for all bubbles to stop rising to the surface. Use as little water as possible so as not to have problems with convection currents and excessive image degradation due to adding another material through

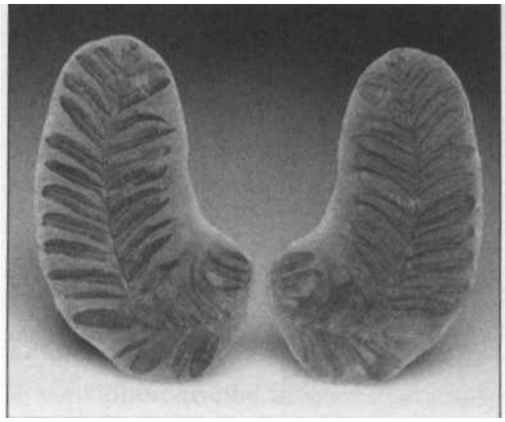


Figure 17-2a Illumination of a low-relief fossil with the light axis nearly at right angles to the surface. (Neuropteris sp., Pennsylvanian, Mazon Creek Flora, Grundy County, Illinois; 19.1 cm high) (Ron Stebler Collection)

Figure 17-26 Same specimen as shown in Figure 17-2a lighted at grazing angle from above

which the light must travel. If bubbles adhere to the subject they can be "touched off" with a fine artist's watercolor brush.

Carbonaceous or highly refective low-relief fossils can be dealt with several ways. High-angle diffused lights will yield "normal" looking photographs, and axial or near-axial lighting will provide very detailed light objects against a dark background.

Inclusions in amber are photographed like a three-dimensional object. The difficulty with such inclusions is that the surface of the amber can cause distortions and reflections, and swirls within the amber can also distort the image. The surface of the amber should be as clean as possible and well polished. The thinner the amber is over the inclusion, the better *(Plate 39).* Some inclusions can be photographed by immersiog the amber in a fluid of the same refractive index. Refer to the discussion in *Chapter* 16 on the problems of using immersion liquids. Another problem with immersion liquids is that they may damage the amber. If you must use such liquids, first test them on a scrap of amber.

The fact that many fossils *fuoresce* can be used to advantage. If there is little contrast between the fossil and its matrix, photography under ultraviolet light can visually separate it from its matrix. Whereas the fluorescent colors of many minerals are not within the range of sensitivity of color films and so cannot be recorded accurately, fossils don't fluoresce in so wide a range of colors and are thus easier to work with.

Figure 17-3 Diffused, high-angle lighting on a low-relief, high-contrast fossil. (Eurypteris remipes, Late Silurian, Passage Gulf, New York) (Breck P. Kent collection and photo)

SPECIAL TECHNIQUES

SMOKING

One technique occasionally used in photographing fossils is "smoking." lt is used for highly reflective objects, or for those whose transparency interferes with the definition of fine surface features. Ammonium chloride comes as a powder that vaporizes when heated above a flame. The subject is held over the ammonium chloride with the surface to be coated facing downward. lt becomes coated with a thin, opaque, white layer of ammonium chloride that easily washes or rubs off. See Weide and Webster (1967) for a more sophisticated method of applying larger amounts of ammonium chloride to larger subjects.

After coating, the object can easily be photographed to reveal surface features. A similar effect can be achieved by coat ing the subject with finely powdered aluminum. lf at all possible, it's preferable not to coat subjects because they lose all trace of color and, for black-and-white work, their true tonality.

STEREOPHOTOGRAPHY

Stereophotography can be júst as valuable a tool with fossils as with other subjects. The there-dimensional nature of the fossils is more easily appreciated than with standard photography, especially for low-relief fossils. Just as with aerial stereophotography, the there dimensionality can be exaggerated to more clearly see spatial relationships and form.

PROCEDURES AND DOCUMENTATION

lf your photography is for research purposes, then you should establish a standardized procedure for the sequence of photographs taken of specimens and record that procedure. This is done so that there is no confusion as to the sequence of and logic of the procedure should someone else be using your photographs for research some time in the future and you are not there to interpret for them.

A sample sequence for the photography of bones might be (1) dorsal, (2) ventral (and/or medial and lateral), (3) distal, (4) proximal, and (5) close-ups of details.

A scale should also be included in each shot, located so that it can be cropped out if necessary. Be sure that the scale is in the same plane as the subject. If the scale is farther than the subject, the subject will appear to be larger than it actually is, and vice versa. lt's also a good idea to include a label in the shot with such information as the catalog number, site identification, and location. You can use a small slip of paper placed next to the scale. Should your notes ever be lost, this ensures that the photograph will not become worthless.

Accurate records of the photographs should be kept with frame numbers for each subject, catalog numbers, location data, and the date the object was photographed. The notes should be neatly typed so that other researchers can use them, and copies made and kept in a different location as a precaution against loss or damage.

FILM

The choice of film for fossil photography is the same as for minerals and lapidary. Slow, fine-grained films that are properly balanced to the light sources work best.

Although for most purposes black-and-white film will do the job for fossils, color film is sometimes used because slides are often needed for lecturing and teaching purposes, as well as for publication. Should the need rise, two cameras can be used, one locaed with black-and-white film and the other with color slide or print film. The complete standardized shooting sequence need not be duplicated with the color film unless deemed necessary.

CHAPTER 18

Location Photography

Photography in your own homo or studio may be the most convenient and desirable, but it is not always possible. Often the subject cannot leave its location to travel to yours for a number of reasons. These may include security because of rarity or value; the need for temporary secrecy before the release of a new ítem on the market; size or weight problems; fragility; or impracticality as when a whole collection must be photographed. In any case, location photography, as it is called, is frequendy a necessary part of a photographer's life.

There are three key words to keep in mind when doing location work: portability, versatility, and preparation. Portability means you must be able to transport and set up your equipment quickly. Time is of the essence, and to facilítate speed and case of transport you must get the process of equipment choice, packing, transportation, setting up and tearing down down to a science.

Versatility of you and your equipment is a must because of the unpredictable nature of location shooting. You must be quick on your feet to deal with situations as they arise, or the shots and/or client are lost. The equipment chosen must be able to deal with a variety of situations. The solution may sound like you should bring everything but the kitchen sink, but that would conflict with the need for portability.

Having equipment that is multifunctional, light in weight, and well chosen based on what your research has revealed about the job is the way to deal with the situation. If you have a lightweight set of light stands, bring them instead of the heavier ones. The same goes for your tripod. Your ability to deal creatively with unforeseen circumstances and to improvise on the spot will also be very valuable.

Renting equipment is a solution to some problems. If you're planning to make use of rented gear, call ahead to make sure there is a rental store in the town you will be shooting in and that the equipment will be available when you get there. Whenever possible, rent only equipment with which you are familiar. A shoot far away from home is no time to experiment with unfamiliar equipment.

And no less important to location photography is preparation. Find out ahead of time what sort of facilities are available-the room location and size; number and size of windows; availability of electricity; location of outlets; whether or not they are grounded; and the amperage on the circuits. What are the subjects? How big are they, how many are there, will there be group shots? What are the colors and lusters you'll be dealing with? Let the client/owner know what your needs are and see if he or she can reasonably accommodate you. Make sure that the subjects are ready ahead of time and that they are cleaned and mounted or unmounted as necessary. A lot of time is wasted removing lint, glue, or silicone from specimens before they can be photographed.

Be sure you know the purpose of the shoot so you can bring the right kind of film and equipment. For publication, you'll need color transparency (slide) film. Print film will be needed if prints are to be distributed to sales reps. For a full-page ad, a large-format camera would be best. Have the client/owner check with the publisher or printer as to their requirements.

YouT find that compromise occasionally plays a role in location photography (hopefully, a very small one). Preparation is the key to minimizing compromise, which can not only compromise the quality of the photography, but of your relationship with the client/owner.

K N

Photographic equipment is delicate and must be adequately protected against the rigors of travel. Strong, well-padded carrying cases that are easy to carry are essential. There is an incredible variety of cases on the market, from individual lens ponches, to multicompartment cases for complete studio lighting systems. They are made of cloth, metal, wood, or plastic. The best cases cost a lot of money but will last a lifetime.

Choose cases that will fit your equipment, budget, and needs. If cases are to be shipped, they may peed to be tougher than if you were to be carrying them. They should also have good locks on them to eliminate pilferage. Your address and phone number should be permanently attached to the case, inside and outside. Since airlines have weight restrictions, it's a good idea to choose cases that are as light as possible, but still durable.

Don't get cases that are so large that when fully loaded they will give someone a hernia. YouT regret having to haul around such a case, and baggage handlers will curse you, maybe taking it out on the case. If you do have heavy cases, affix warning labels to that effect on the case. Such labels are usually available where you check your baggage in at the airline's counter.

The interiors of the cases must be well padded to protect your equipment. The contents should also be in individual padded bags or boxes to protect them from rubbing against one another.

Camera shops will occasionally have used carrying cases for sale, as will the camera shows and flea markets that are held in most major cities. Also look in the want ads in your local paper under Photography for bargains. Surplus stores will sometimes have suitable heavy duty cases designed for other kinds of equipment that can be used. If the cases are not padded, you can easily add padding yourself. Upholstery supply shops are a good source of foam rubber and spray adhesive. If you are good in the shop, you can build your own cases to custom fit your needs. I make my own cases of quarter-inch white polypropylene, standard extruded aluminum stock, piano hinges, flush folding handles, and draw catches from the hardware store. The $80 1 spend on materials for a large case is a lar cry from the $250 or so 1 would have to spend for a readymade case, not built to my specifications.

It's a good idea to make a checklist of all of your equipment. Every time you go on a trip, go over the list and be sure all that you peed has been packed. You won't need every item on that list for every trip, but it will ensure that you forget nothing that you do need. It's very frustrating to get somewhere only to find that something was forgotten, and cannot be replaced on location.

It's wise to bring more than one camera body. Aside from the need for two bodies if you must shoot a subject with more than one kind of film, a second body assures you of having at least one that works if the other breaks down. Spare light bulbs and batteries for meters and flash units are also a must.

TRANSPORTATION

If you're traveling in your own vehicle, you'll have to work out a system for efficiently loading your gear. 1 drive a pickup truck with a camper shell and make sure that most of the load is up against the back of the cab for proper weight distribution. If possibly, be sure that the load does not block the view from the rear view mirror. If it does, you should have a mirror on the passenger door to allow for sale passing. Load your equipment so that it can't shift while driving, possibly causing damage to the vehicle or equipment. Bring along a hand truck that converts to horizontal four-wheel use. It will be invaluable for transporting your gear from the vehicle once you have reached your destination.

Film, especially once it has been exposed, is very sensitive to heat. Carry all your film in plastic refrigerator-type containers, in an ice filled cooler. 1 don't advise using Zip-lock type bags because they don't seal that well and can leak if the ice in the cooler melts. On reaching your location, remove the plastic containers from the cooler to allow the film to reach room temperature before use. This must be done so that condensation on the cold film doesn't ruin it.

SECURITY

Camera equipment is expensive, and the shots you have taken may be irreplaceable. Keeping your vehicle and the gear in it secure is imperative. The first step is to be sure that all of your equipment is insured against theft, loss, and damage.

Install an alarm system on your vehicle if possible. If you must stop for the night at a motel, park in a well-lit spot that is very visible, especially from your room. If there are windows on your van or truck, cover them with curtains to keep the contents from prying eyes. Add extra padlocks on camper doors. You might also wish to being critical items, such as cameras and exposed film, into the motel with you at night.

Mineral shows are particularly dangerous locations. Thieves know that the people attending may have valuable goods with them, and target vehicles in show and hotel parking lots. If you are going to be at a show for several days, leave nothing in your vehicle overnight. Many people are robbed when they stop for gas or a bite to eat after leaving a show. Gas up before hand and don't stop anywhere near the show. Thieves have been known to follow someone from a show and hit them when they make a stop.

ROOM CHOICE

There are a number of important requirements for the room in which you'll be shooting:

- There shouldn't be too many windows, especially if you're shooting with tungsten film. Control of light is the basis of a photographer's work. 1 always carry sheets of opaque black plastic for covering windows. If possible, use clips to attach the plastic, or use photographer's tape so as not to mar walls or woodwork. Tacks should never be used.
- The room should be large enough to work in without being so cramped that you are tripping over your gear. If there is furniture in the room, move it carefully, with the owner's permission, and put it back where it was when you are done.
- lf possible, the room should be near the subjects you will be photographing. Carrying delicate and valuable items long distances is not only dangerous but time consuming.
- Adequate electrical outlets should be in the room. 1 always carry with me a couple of extension cords of different lengths, as well as an adapter or two in case 1 encounter ungrounded outlets.
- The best floor is concrete covered with a thin unpadded carpet so as to minimize vibration while shooting. The thin carpet keeps tripod legs from slipping and is some insurance against breakage of dropped subjects. Thick, heavily padded carpet is to be avoided because it does not provide a firm surface. If thick carpet is unavoidable, a sheet of plywood laid on top of it will help. A slick hard surface can also be difficult to work on. Unless they are equipped with locking leg braces, tripod legs will slip if they are not fully spread. A nonsfp, office-type floor pad is a good surface to work on if slippery floors are present.
- Be sure there is Adequate headroom. If you are using studio lights on stands or booms, there must be enough room between them and the subject.

Once you have decided on a room, unload your equipment, being careful not to mar walls or doorways with your cases. Locate cases where they are convenient for use, but not in the way. Don't bring in the subjects until you have finished setting up, to avoid the risk of damaging them or adding to the clutter and confusion.

You'll most likely need a table on which to work. I have worked on end tables, card tables, dining tables, and pool tables, among others. It's best if you bring your own table so that there are no surprises. The table should be portable and light, yet stable, plus large enough to work on. Leg braces should not interfere with tripod legs.

Passeneau (1984) uses a metal projector stand for a shooting table. A light stand is set up behind, fitted with a wooden crossbar. Attached to the crossbar is a sheaf of different colored background papers, somewhat like a large pad of paper. The lower portion of the papers rests on the projection table. You flip back the colors that don't complement the subject, and the ones left lying on the table are held down with magnets. Such tables are light, collapsible, and relatively inexpensive. They are, however, rather small, leaving little room for lights, accessories, or other items you may wish to have within easy reach.

INTERNATIONAL TRAVEL

Traveling to other countries can be a trying experience but can be made less painful with a little planning. Before leaving the country, prepare a complete inventory of your equipment by case. To simplify things, identify your cases by numbers or letters that are large and clear (e.g., Case # 1, 2 and 3, or A, B, and C). Assign a value to each item in the case, based on what you could get for it used, and total the amounts. Make note of model and serial numbers of items. Before leaving, register the inventory with your home country's customs agents. Upon entering another country, you may be asked not only what you are carrying and for what purpose (business or pleasure), but also how much the gear is worth. The concern is usually whether you will be trying to sell your equipment and avoid paying taxes or duties. Check *ahead of time* for the policies of the country to which you'll be traveling. You may still have to pay sales tax on your equipment. In some countries, such as Canada, the tax is refunded after leaving the country and you have proved to customs agents that you are bringing back everything you brought in. Be sure that all cases are locked and properly identified with both your flight and baggage numbers as well as your home address.

Passing film through airport X-ray machines is supposed to be safe for all films up to ISO 1600. I still have my doubts, and so do many other photographers. There are several lead-shielded film carrying packs available that will protect your film from X-rays. I carry my film by hand through security and ask for a hand inspection. If your film is in opaque canisters, they'll have to be opened individually by the guard. To save yourself, the guard, and the people behind you time, take all of your film out of the cardboard boxes, and be sure they are all in clear plastic film canisters. All Kodak 35-mm film comes in opaque, black canisters, but Fuji film comes in clear canisters. Most film processing labs recycle film canisters and can supply you with clear ones to transfer your film to if you don't have any. I also make it a point to go through security with my cameras unloaded so that they don't have to be hand inspected. If Fin in the middle of a roll, I make note of what frame I'm on, rewind the film leaving the leader out, and mark the frame number on the outside of the film canister. If you have a camera that automatically rewinds, you may not be able to use this procedure. Some won't rewind in the middle of a roll, and most will rewind it all the way in without leaving a leader for reloading the film. If that's the case with your camera, leave the film in and have it hand inspected. There is another option. Several companies make a film leader retriever, which is a good item to keep in your camera bag anyway in case of an accidental rewind.

I always keep my camera bag with me on the plane as carry-on luggage. The bag carries my cameras, lenses, and most important accessories. If the rest of the luggage is delayed or lost, you aren't at a total loss and can still do some shooting.

Another important consideration abroad is electricity. Many other countries don't operate on the same voltage or number of cycles, or have the same plug configurations as in your home country. There are kits available that contain a small transformer as well as a variety of adapter plugs that should be able to deal with most electrical situations. Check your equipment to be sure that none of it will be adversely affected by a change in the number of cycles per second. In the United States, the standard is 60 cycles per second, but in other countries it may be 50 or less. Many types of equipment are designed to operate within a range of 50 to 60 cycles and will not be harmed by a 10 cycle drop. Some equipment, however, can be very sensitive to slight changes in the number of cycles per second. Check the information panel on the equipment for its requirements. If none is provided, write or call the manufacturer and get their advice.

It's wise to save all your processing until you reach home, whether you are in an industrialized nation or not. The quality of processing of your lab at home is a known quantity, and it's best not to take chances-you may never be able to come back for a reshoot. Likewise, you should buy all of the film you'll need on the trip ahead of time if there is any doubt as to availability at your destination.

CHAPTER

19

Better Slide Presentations

minerals will be used in slide shows, I thought it fitting to include a chapter on producing better slide presentations. Having sat through many such presentations at mineral shows, symposia, and mineral and gem club meetings, I've noticed an appalling lack of anything approaching professionalism. 1'm not just nit-picking because of my profession. You all have seen the following types of slides: folded, wrinkled, ¡Ilegible maps; a tiny specimen sitting in a sea of fabric; caption and title slides (if they exist at all) that are amateurish; and illustrations copied out of books that are cockeyed and with text on the back side of the page visible. I have seen such slides in presentations by both amateurs and professionals. Such problems don't give the audience a good impression of either type of speaker. They also don't get their message across very well and they are not very enjoyable.

There has been much written on production and presentation of good slide programs (see, for instance, Close, 1984), so I'11 just review some basic techniques for improving the quality of your slides.

EQUIPMENT

If you have been photographing your own minerals, gems, or fossils, you probably Nave most of the equipment needed for sude production, such as the following:

- A good quality 35-mm SLR camera.
- Macro lens or extension tubes and enlarging lens.
- A light meter. The one in the camera will do for most work, but a handheld meter with incident light capability may also be necessary.
- Two lights with reflectors, 3200 K (or daylight-balanced blue photo floods).
- Two light stands.
- Color slide film, balanced to your lights.
- A copy stand (a tripod can be substituted but is difficult to use for copy work).

- A sheet of clean glass about 9 x 12 inches (the size will vary depending on the size of the material you are copying).
- Thinner glass is preferred to minimize distortion and the green tint that thick glass has.
- Lens shade.
- Black cardboard.
- Sheets of black construction paper.
- 18 percent gray card.
- Paperweights and shims.
- Miscellaneous artist's supplies: colored pencils, markers, typewriter correction fluid, ruler, technical pens, scissors, T-square, and drafting triangles.
- Access to a copy machine with enlarging and reducing capability.

FILM

Since our purpose is to produce slides, obviously color slide film must be used. Either its color temperature must match your lights, or a color-correction filter must be used as explained in Chapter 10. A fine-grained, low ISO film is best for smallest grain and best color rendition. I generally use the same film that I use for the rest of my studio work-Kodak Ektachrome Professional Tungsten (EPY 64T).

STANDARD TECHNIQUES OF COPY WORK

Besides the camera, your most important and basic piece of equipment for creating slides is the copy stand. It's basically a horizontal board to which is attached a vertical column with a movable platform, to which you attach the camera. The camera is aimed downward at the flat artwork resting on the copy-stand base (Fig. 19-1).

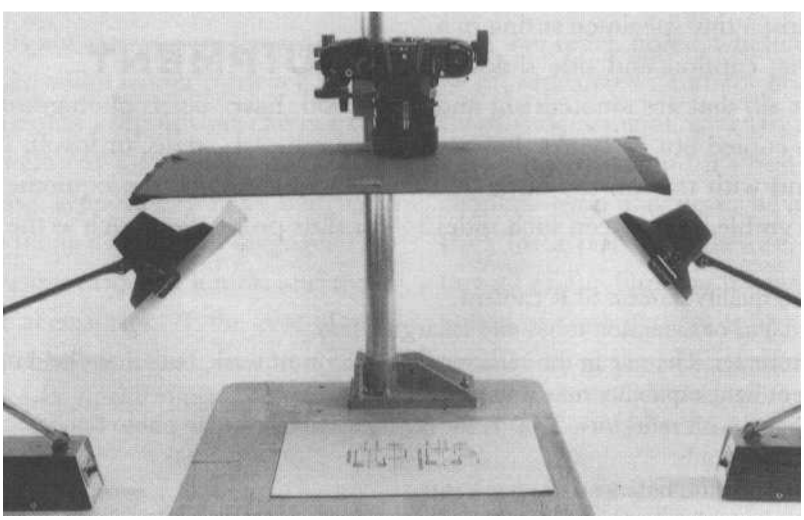


Fig. 19-1 Camera on copy stand with flat art work. Black flocked paper covered cardboard around the lens prevents reflection from the glass used to hold the copy flat.

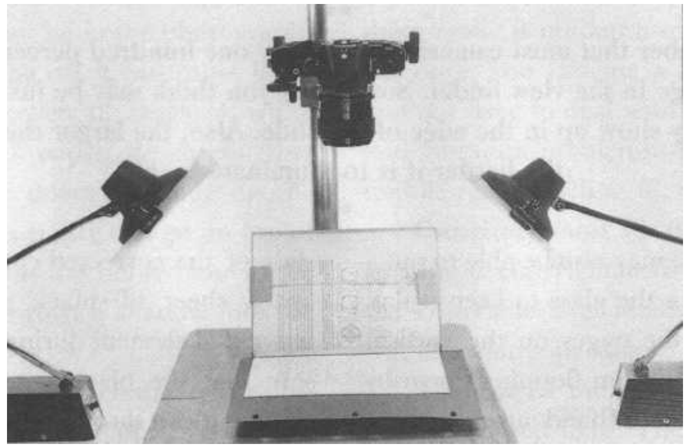


Figure 19-2 Copy arrangement showing rubber bands holding back pages, and cardboard scraps protecting the book from the rubber bands. Black paper beneath the page being copied prevents print on the other side of page from showing.

The camera must be parallel with the base and artwork. To be sure of this positioning, rest a small level on the artwork, and then on the camera back. Adjust the camera until the two are parallel. The most useful level is one that reads off degrees instead of just having a bubble. Such levels can be bought in good hardware and camera stores.

The lens used should be a macro or enlarger lens. Standard lenses are not designed for flat-field photography and so lose sharpness near the edges when used for copying. Macro lenses, and especially enlarger lenses, are designed for such work and will give superior results.

The lights should be placed at about 45° on either side of the artwork. Be sure that they are not so close to the artwork as to reflect into the lens or cause glare. Place a sheet of black construction paper under the artwork to be copied to prevent the color or wood grain of the copy-stand base from showing through. More important, if the artwork has printing on its other side, the black paper will keep it from showing through.

Unless the artwork lies perfectly flat, you'll have to lay the sheet of glass on top of it. If you're copying from a book, the glass may project well beyond the edges of the book and not lay flat. In such instances, use the shims to keep the glass level. The shims can be anything that is handy-cardboard scraps, film canisters, other books, and so on. If you're copying from a book, it's very hard to get the book to lie flat if the whole book is laying flat as if for reading. It's best to prop up the half of the book that you are not copying so that it's vertical. This technique will cause the side of the book with the illustration you are after to lie fairly horizontal. The weight of the glass will usually help flatten it further.

If the illustration doesn't take up the

Remember that most cameras don't show one hundred percent of the image in the view finder. Something you thick may be just out of view may show up in the edge of the slide. Also, the larger the artwork is, the harder it is to illuminate evenlv.

whole page, you may also be able to put a heavy weight on the glass to keep it flat. You can keep the pages on the vertical half of the book from flopping down by stretching a rubber band around them and the cover. AIways be careful that you don't damage the book, especially if it's old and valuable. Protect the pages and cover from the rubber band by placing a scrap of thin cardboard between the two (Fig. 19-2).

Be sure that the artwork fills the frame adequately. lf you are copying a title for instance, it should be large enough to be easily read, not lost in a vast white expanse. The artwork may be an illustration on a page with printed matter or other things you do not want. Frame as tightly as possible to keep these other elements out of the picture. Remember that most cameras don't show one hundred percent of the image in the view finder. Something you think may be just out of view may show up in the edge of the slide.

Since the proportions of the illustration seldom match those of a 35-mm slide, you must have a method to black out unwanted elements. If possible, you can first photocopy the pape, then, using typewriter correction fluid, paint out unwanted elements. You then make the slide of the corrected copy. You can also lay a sheet of black paper over the unwanted element during the copying. Be sure that the black paper is under the glass or it can throw a distracting shadow. The paper should also go all the way from one side of the frame to the other and be parallel to the frame edges. The use of white paper is not advised because, unless it is thick enough, you may be able to see through it to the unwanted copy, and the faint line where it ends over the page is objectionable. lf the edge of the book and the copy-stand base is visible, just make sure that the black paper behind the pape extends far enough to fill that void.

In my opinion, the best way to deal with the problem is the use of photographic slide masking tape. lt is a self adhesive, metallic silver tape available in several widths. Once the slides have been processed, apply the tape to the back side of the slide so that it covers the unwanted areas. Be sure to put the tape on parallel with the frame edges. I usually use a rule to make two marks on the frame edge to guide the placement of the tape. When projected, the tape is invisible, unfke the black paper used for masking the copy itself. No matter how black the paper is, it still shows up in the finished slide.

If there is a large expanse of white paper that will not be in the photograph, the light reflecting off it can cause flare. To avoid this, cover all arcas of white paper with black paper. Be careful that the black paper doesn't intrude on the image arca. This paper can go on top of the glass as long as it is not so Glose to the artwork that it throws a shadow into the image arca.

Use a lens shade to eliminate the possibility of flare. If the copy is dark, the glass will act as a mirror and reflect an image of the camera into the lens. A sheet of black cardboard with a hole cut in it will solve this problem. The lens shade should still be used to eliminate flare from the lights, and if you cut the hole in the cardboard too large, the shade will act like a large nut holding the cardboard in place.

It's best to use a gray card for taking your light reading. This technique is especially important if you're copying line drawings or paint. In such a situation, your meter will read mostly the white background and produce a severely underexposed slide. The gray card will give you the proper exposure, and, as long as your meter is accurate, you probably won't even have to bracket.

The larger the artwork is, the harder it is to illuminate evenly. For such large pieces, you may have to use four lights. These instances are where the handheld meter comes in handy. Use it in incident mode to read all four corners as well as the center to ensure even illumination. If it is not, adjust the lights until it is.

Since you are copying flat artwork, there really is no depth-of-field problem. For once, you can use a larger aperture and not have to deal with long exposures and vibration problems. An f-stop in the middle range, such as f 8, will do nicely.

Caution: most of the work you're copying is copyrighted. Be sure to check the copyright laws relative to how you will use your copy slides.

There is far more to copy work than I have covered here. These include special considerations for black and white photography and for reproduction. The build up of high contrast is a problem and must be controlled. Stains and discolorations on old photography can be removed with proper filtration. Reflections from specular surfaces such as oil paintings can be controlled through the use of polarized light. Most of there considerations have little application in the production of slides for presentations, but nevertheless are very useful to know about. There has been much written on copy techniques such as Kodak 1971. More can be found in the bibliography, your local library or camera store.

ARTWORK

LINE DRAWINGS

If you are a good artist, you're lucky and can produce your own artwork. Most of us are not so blessed and must either hire a professional to do the work, or copy drawings out of a magazine or book. As useful as they may be, black-and-white

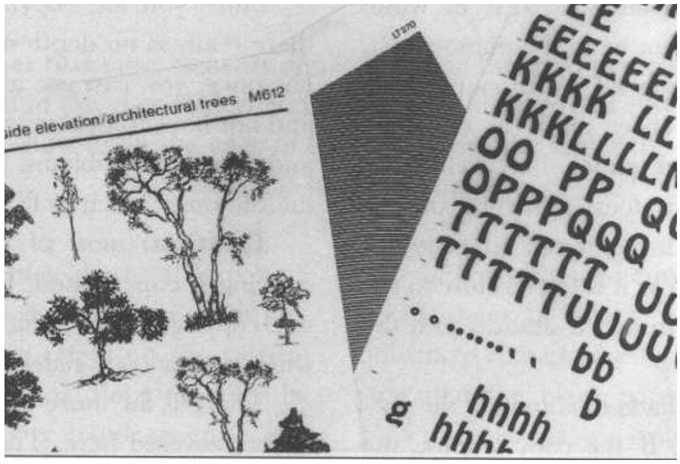


Figure 19-3 Different types of rub-on lettering and graphics.

line drawings can be rather boring as a slide. You can spice them up, though, with a little color. This isn't just window dressing-color can be used to make the illustration easier to understand. Take, for instance, a geological cross section. The rock types may be designated by the typical crosshatching, stipples, or "blocks," but if each were a different color the map would be much more easily interpreted by an audience. Hatchings and such may be easy to see in a book, but in a crowded auditorium at some distance from the screen they are not.

Coloring may be done with the wide variety of colored markers available at art supply stores or with colored acetate overlays. Coloring with markers can leave a streaky effect that doesn't look professional. Acetate overlays come in sheets in a variety of colors. Lay the desired color over the arca to be colored, then cut it out with a X-acto type blade (be sure not to cut through to the artwork). The acetate is self adhesive and will stay where you place it with a little careful burnishing.

It's usually not wise to be coloring your (or other people's) precious books or magazines. The solution is to make a photocopy of the illustration first. This technique also allows you to make modifications to the illustration, such as eliminating unneeded portions with correction fluid, or adding text of your own. If the original is small, you may wish to enlarge it in copying to make it easier to color or to do additional artwork.

Even if you aren't the world's greatest artist, you can produce some great artwork. Any art supply store will have a selection of rub-on, or dry-transfer artwork available. Several companies, such as Chart Pak and Letraset, make sheets of rub-on lettering and designs of all sorts such as trees, people, cars, signs, and so on (Fig. 19-3). You just place the transfer sheet over a piece of paper, then use a ballpoint pen or small burnishing tool to rub the design you are after. The pressure will transfer it to the paper. It's a good idea to tape down your paper with masking tape to be sure it doesn't shift during the transfer. If you plan on doing a lot of this kind of work, it would be a good idea to get a catalog of dry transfer products from at least one manufacturer for referente.

There are also available a large number of self-adhesive tapes. They come in a variety of colors and widths, and you can also get such things as dashes, dots, squares, and other shapes.

TITLE SLIDES

Tide slides (or any other slides for that matter) need not be just plain boring text. To hold the viewers interest, they have to have some life. Try lettering on colored paper instead of plain white. Try overlapping several different colors to create patterns for the shot. Torn edges of the paper can be included, especially if you use the Colorama paper that you use for photographic backgrounds. It has a white base that is exposed when ripped and makes an interesting contrast.

You can also use a photographic print to do your lettering on for a tide slide. Make sure it's germane to the sub ject of the lecture, and is not so busy that it will be distracting or make the text hard to read. If possible, place the text in a uniform background arca for legibility.

Sandwiching is another useful technique in creating tide sides. First, create your tide in black on a white background. Next, find an extra mineral slide, preferably one that is slightly underexposed. Remove both slides from their mounts and place them together in another mount. You can buy empty slide mounts in a variety of styles at most good camera stores. If you have been careful, your tide will be superimposed on the mineral slide and make a very effective title slide. To give myself as many options as possible, I copy the title in several positions so it can fit with either a number of mineral sides, or the only suitable one I may be able to find.

COMPUTER-GENERATED SLIDES

This is not something that I am going to get into in any detail here, but you need to know of this source. The graphics capabilities are astounding and can produce amazing tide slides of a very professional quality. A good color printer to go with your computer and the proper software will provide you with the artwork you need to create stunning illustration and tide slides. Some computers can actually produce the finished slide for you. The Polaroid Corporation makes the Polaroid Palette Computer which consists of a 35-mm motorized camera with macro lens attached to the palette box. The box contains a miniaturized, high-resolution video monitor which displays images from your computer. The unit is compatible with most computers and most graphics software.

MISCELLANEOUS TIPS

Don't make your sudes too busy or they won't be legible. Keep them simple, and have them fill the frame as much as possible.

Choose appropriate illustrations that cover the topic adequately. Don't find yourself in the position where you have to apologize to the audience because you have no slide to illustrate an important concept. Use enough slides to cover the subject, but don't overdo it. Too many slides can be overkill for both the subject and the audience. Lastly, use a good-quality professional lab to process your film. You don't want to go to a lot of work, only to have it ruined by shoddy processing.

Try to get a good variety of shots to illustrate your presentation, not just line drawings and title slides. If you're talking about localities, find historie shots of the arca. Who are the people associated with the mine? Are there any photographs of them that you can copy? How about old stock certificates or photos of mining memorabilia?

And always remember, when all else

APPENDIX

A

Gadgets and Gizmos

EXTENDABLE ARMS

t's often necessary to hold a fill card at some distance above the surface on which the subject and the rest of the fill cards are resting. Extendable jointed arms are available from photography equipment manufacturers in a wide variety of styles and prices. With a little ingenuity, however, you can build extendable arms yourself.

One of the simplest is just a piece of heavy-gauge copper wire. Short lengths can be attached to a heavy base by insertion into a hole in the base. An alligator or spring-loaded paper clip can be attached to the other end to hold the reflector (see *Fig. A-1). If* the base is a magnet, its usefulness can be enhanced because *of* its ability to stick to ferrous metals. Copper wires are very flexible and so are easily positioned. Such holders are not very strong and will only hold lightweight reflectors. *If* heavier gauge wire is used to bear greater weight, it would be wise to use a clamp as a base for greater security

1 made some of my favorite extendable arms from the legs of an old pocket tripod. After removing the telescoping legs from the tripod head, I drilled a hole into the hard rubber tip. 1 then inserted a sheet-metal screw into the hole with a short length of 12-gauge wire wrapped around it. A spring-loaded paper clip is attached to the other end of the wire with a nut and bolt *(Fig. A-1).* The other end of the leg had a small flange with a hole through it. I cut a slot in a short length *of* dowel into which the flange fits. A matching hole is drilled through the dowel, and a nut and bolt inserted to hold the two together *(Fig. A-2).* The nut should be tightened enough to allow movement, but not easily. I used a 3/8-inch aluminum dowel on one leg that fits into the clamp for an old desk lamp. A hole can be drilled into the clamp to accept a set screw and hold the assembly in position. The flat jaws *of* the clamp make it good only for attachment to flat surfaces. With the addition of a V block to one side of the clamp face, it will work well on tubu-

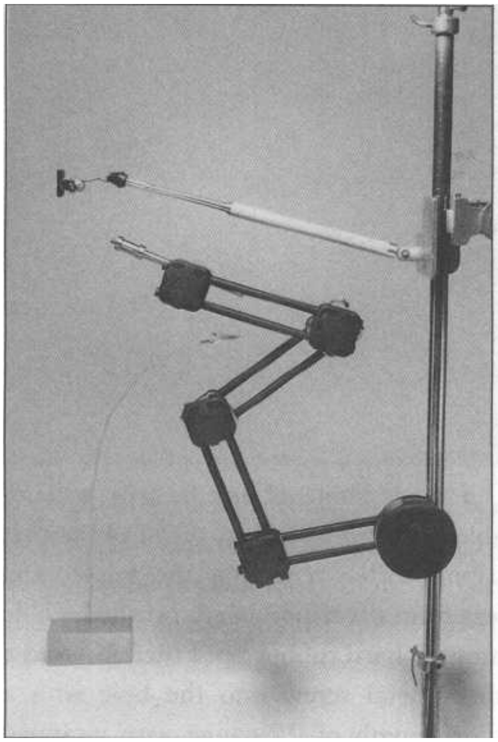


Figure A-1 Homemade adjustable arms to hold reflectors. Top to bottom: Old pocket tripod leg with clip attached to end by a piece of wire. An elaborate arm of aluminum rods with wooden joints, each joint made of two pairs of wood with matching grooves to hold rods, held together by carriage bolts and large knobs. A simple arm of 12-gauge wire with alligator clip, inserted into wood block.

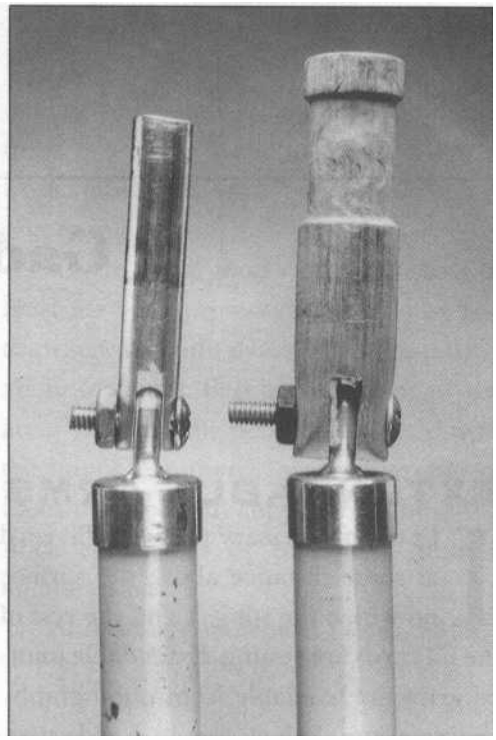


Figure A-2 Close-up of adapters attached to the ends of tripod leg extendable arms. On left is 3/8-inch aluminum rod, and on right a 5/8-inch wood dowel with groove turned (or filed) into it. If the set screw holding the unit into a clamp should loosen, the groove keeps the unit from falling out.

lar light stands. One of my tripod-leg reflector holders has a 5/8-inch dowel that matches the holes on most commercial photo clamps. A straight dowel will do the job, but one shaped with a "spool" profile is safer in case the set screw loosens a little (see Fig. A-2). 1 turned mine on a wood lathe from a length of maple dowel.

A good extendable arm can be made from an old jointed desk lamp with the head removed. Extendable arms can be made from many pirated items, all you need is a little imagination.

GIANT EXTENSION TuBES

If you own a set of extension tubes or a bellows, you may find that you can't get enough magnification with them. You can make yourself a much longer extension tube that will do the job. I have seen adjustable tubes made from two lenghs of black (ABS) pipe that fit snugly, one

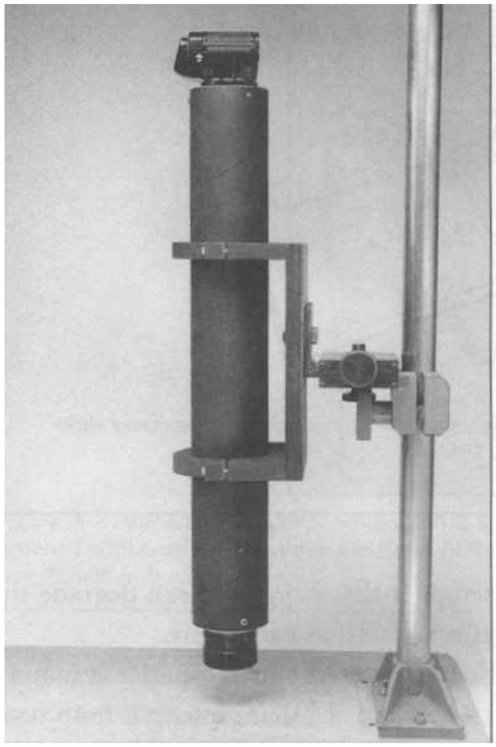


Figure A-3 Extra-large homemade extension tube made from cardboard carpet tube lined with black flocked paper. Doughnut-like wooden plugs at either end hold the adapters made from an old camera front and rear thread of an old lens.

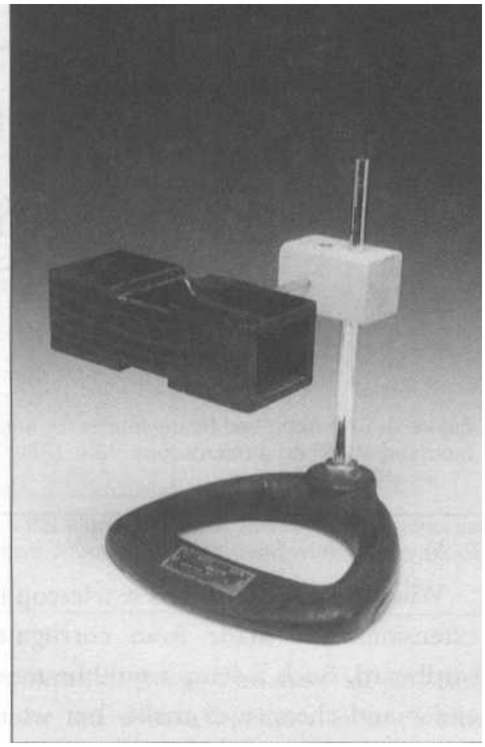


Figure A-4 Beam-splitter made of 1/4-inch plywood and lined with black flocked paper as per Figure 7-7. The unit is mounted to an old microscope light base via an adapter (Figure A-7). A 1/4-inch carriage bolt passes through the adapter and is threaded into a threaded insert in a block glued on the far side of the beamsplitter box

inside the other. This nesting arrangement allows you to vary the magnification. Adapters were added to either end to attach the lens and camera body, and the whole assembly mounted on a copy stand.

1 made mine from a length of heavy cardboard tube on which carpet had been rolled. After cutting the ends square, 1 inserted plugs of wood that had a large hole drilled in the center of each. In the junk bin of a local camera store, 1 found the front of an old Pentax camera and the rear of a Pentax thread lens. These components were mounted on the ends of my tube after the interior was lined with black flocked paper to eliminate stray light from bouncing around in the tube. All components were painted a matte black to eliminate glare, and a yoke was attached so that the assembly could be mounted on my copy stand (Fig. A-3). If you can't find used components for your camera, you may be able to use those of another camera, and use adapters to attach your camera.

COVER GLASS

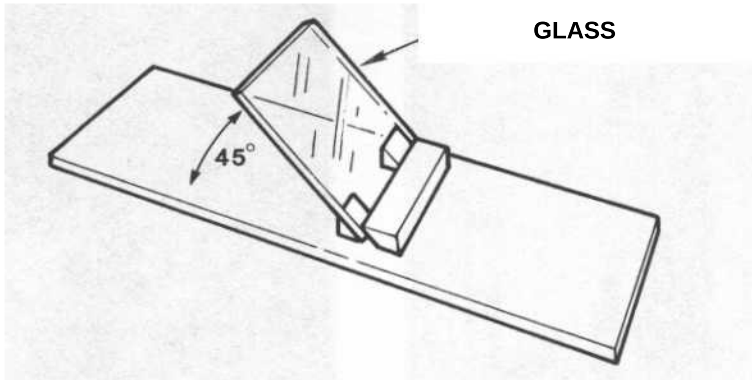


Figure A-5 An improved beam-splitter for micro subjects, made from a microscope cover slide mounted at *45°* on a microscope slide. (After Blaker, *1989)*

Wilson (1974) illustrates a telescoping extension tube made from corrugated cardboard. Such a setup would be much easier and chcaper to make, but would have problems with proper alignment of the camera and lens.

An old enlarger can often be converted for photomacrography. A means will have to be found for mounting the camera in place of the light head on top of the bellows. As discussed already, the enlarger lenses are excellent for photomacrography, and the enlarger comes with its own built-in copy stand.

AXIAL LIGHTING

The main requirement to achieve axial lighting is a means of holding your beam-splitter in position. The apparatus can be as simple as using a laboratory stand and arm to hold it. You can certainly rig some sort of upright with a rod at right angles to do the job, made from whatever is on hand. The problem with these simple setups is that stray light can degrade the effect as well as cause flare.

lt's best if the beam-splitter is mounted in a housing that protects it from stray light. A simple rectangular box can be built of quarter-inch plywood, as in *Figure* A-4. One end of the box is open to admit the beam of light. In the center of the box are openings top and bottom, aligned with the enclosed beam-splitter. 1 used a sheet of cover glass from a 35-mm slide mount for my beam-splitter. Grooves were cut in the vertical sides of the box at 45 ° to hold the glass. The interior is lined with black, flocked paper to reduce reflections. To one side I mounted a small block of wood with a 1/4 x 20 threaded insert so that 1 could mount the apparatus.

For larger subjects I've made a larger box using the glass from a 4 x 5 glass photographic plate. The emulsion was removed using a solution of bleach. Boxes for microscopic subjects are hard to make.

Figure A-6 Homemade gel/filter holder of 1/8 x 1/2 inch flat aluminum stock painted black. Joints are fastened with nuts, lock washers and bolts, or thumbscrews. Mounted to light stand with adapter block. (see Figure A-7)

A microscope slide can be used to hold both the subject and the beam-splitter at a 45° angle as seen in *Figure A-5.* The beam-splitter is made from a microscope cover slide.

DIFFUSER AND FILTER HOLDERS

You'll probably find that you need some way of supporting diffusing materials, large filters (such as polarizing materials), and colored gels in front of your lights. With the small, high-intensity lights this is not much of a problem because such materials can be taped directly onto the shades. Most other light sources are much too hot to tape directly to the shades. What's needed is a framework that can hold the material a short distance in front of the light source.

1 built the diffuser/gel holder shown in *Figure A-6* using 1/8- x 1/2-inch aluminum flat stock. The material can easily be cut with a hacksaw or a carbide blade on a table saw. The ends of the pieces have holes drilled in them so they can be joined with machine bolts fitted with lock washers and wing nuts. Notice the twist in the part of the arm just below the frame assembly that allows it to remain at right angles to the arm. The whole assembly folds compactly for easy storage. Diffusion materials and gels are held in place by spring-loaded clips.

The unit can be attached to the light stand by means of a homemade adapter such as is seen in *Figure A-7.* A block of wood has a 3/8-inch hole drilled through it, and at right angles to that at the other end of the block is a 1/4 x 20 threaded insert. There is also a threaded insert with a hole that intersects the 3/8-inch hole. These holes are for a set screw to hold the unit in place on a light stand.

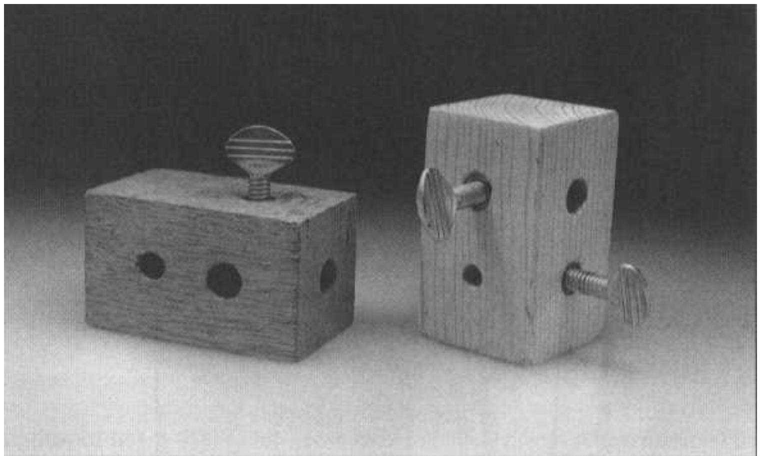


Figure A-7 Wooden adapter blocks with 3/8 and 1/4 inch holes. The 1/4x 20 thumbscrews are threaded finto 1/4 x 20 inserts.

Both inserts are used with a thumb screw for case of use.

The last section of the diffuser/gel holder has a 1 /4-inch hole, through which the thumb screw on the adapter is inserted to hold the two together.

Some light heads have 3/8-inch holes in their light stand adapters designed to hold the shaft of a photographic umbrella. There are also separate adapters that fit on the end of a light stand that have such holes *(Fig. A-8).* If you have such lights or adapters, the last segment of the diffuser/gel holder can be a 3/8-inch dowel instead, for insertion into these umbrella holes.

FOCUSING STAGES

When photographing small subjects, it's usually easier to focus by moving the subject rather than the camera assembly. This movement is done with a focusing stage. Such stages are available commercially, as are lab jacks that work like a car's scissors jack. Both are very accurate, but expensive. There are, however, several homemade devices that can do the job very well.

Kodak (1969, p. 13) details a suitable focusing stage with a ball-and-socket head, but it's a project for someone who is very handy with a metal lathe. Wilson (1974) illustrates a much simpler stage that can be built from quarter-inch plywood, nuts, and bolts *(Fig. A-9).* Surplus equipment stores can be treasure houses of usable gadgets including focusing stages. Any smoothly geared drive can be adapted for such use. If you're lucky, you might find the focusing mechanism for an old microscope.

1 accomplished several things simultaneously with my multifunctional focusing stage made from an old enlarger head. The head is mounted upside down in a homemade bracket *(Fig. A-10)* and the

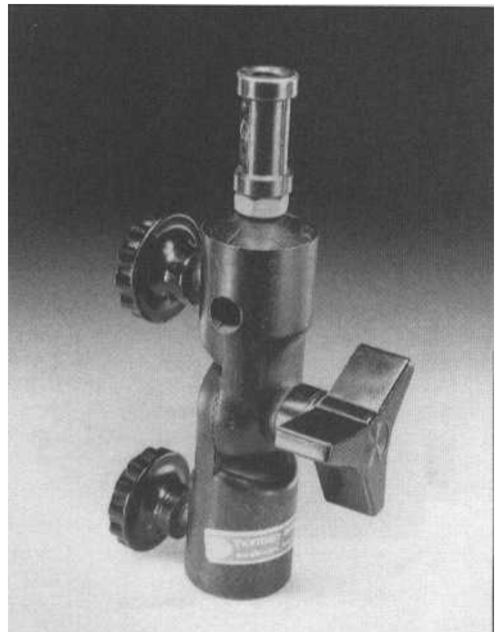


Figure A-8 A commercial adapter for mounting lights, umbrellas, and gel/filter holders on a light stand.

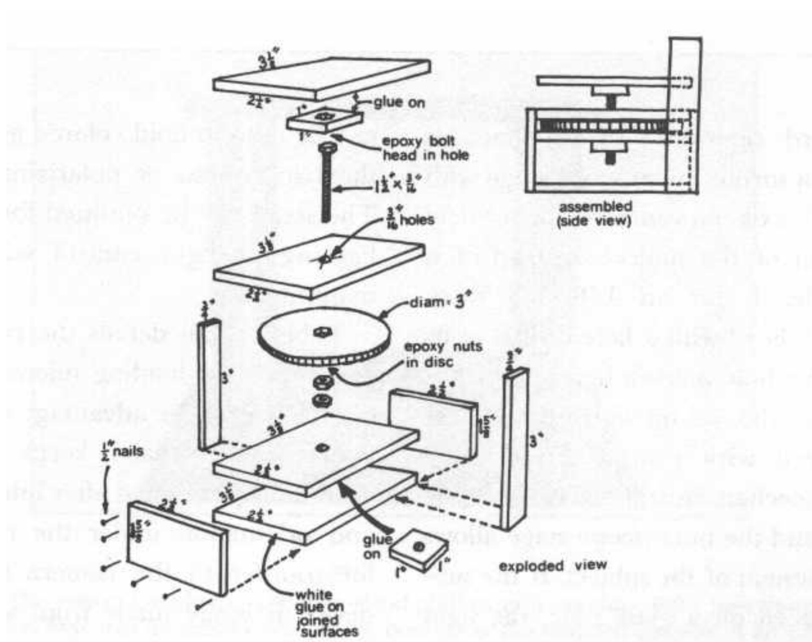


Figure A-9 A homemade focusing stage for photographing micromounts. (Wilson, 1974)

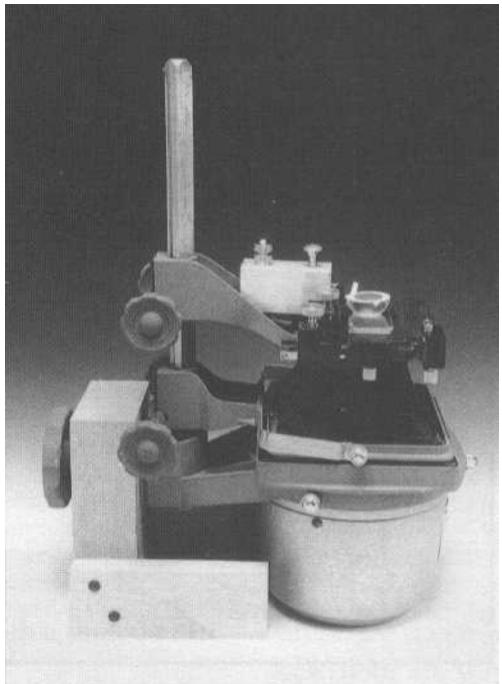


Figure A-10 A focusing stage made from an inverted enlarger head. The lens board has been replaced with a microscope stage for fine adjustment on the X and Y axes. A ball table made from a halved acrylic sphere is mounted on the stage.

lens board removed. In its place is mounted a surplus microscope stage with X and Y axis movements for critical adjustment of the subject. Instead of a glass slide, 1 use an 1 /8-inch thick Plexiglas "slide" with a hole drilled in its center. The hole holds a hemisphere cut from an acrylic ball on which the subject is mounted with putty. The original focusing mechanism still serves the same purpose and the microscope stage allows fine adjustment of the subject. If the subject is placed on a glass slide, the light source in the head can be used for transillumination. The opening for negatives can be used to hold colored gels to color the background or polarizing material. The setup can be outfitted for dark-field lighting or light control with an iris diaphragm.

Leber (1989) details the construction of a stage for holding micromounts for photography. The advantage of this particular stage is that it keeps the subject accurately positioned after initial viewing and orientation under the microscope, for transfer to the camera setup. The device is easily made from a Spiratone Quick-Way tripod mount.

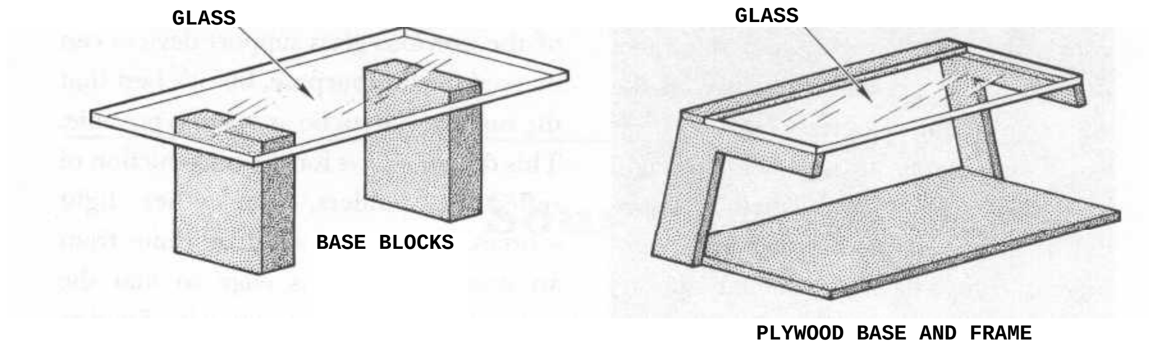


Figure A-11 Supports for shooting on glass with a copy-stand arrangement. The simplest is two blocks holding the glass. A slightly more sophisticated setup involves attaching two inverted L-shaped supports to a wood platform. The base is larger than the glass to allow for the increased field-of-view further from the camera. (After Blaker, 1989)

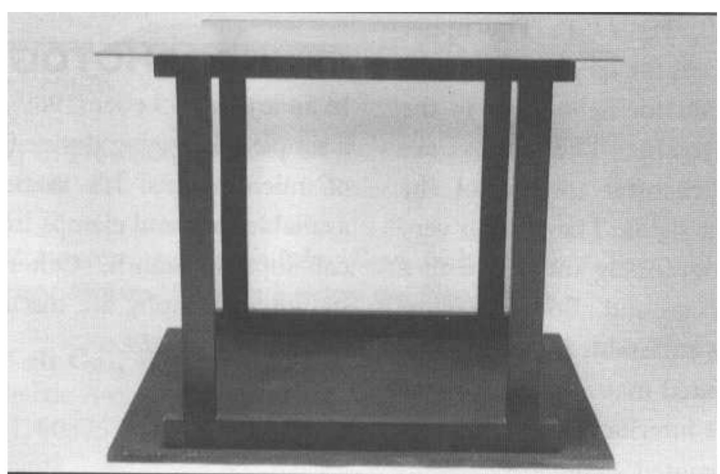


Figure A-12 The system I made for non-copy-stand photography on glass. Bolts pass through holes in the plywood base into threaded inserts in the bottoms of the wooden uprights. A lip along the outer edge of top of uprights keeps the glass from sliding off.

GLASS BACKGROUNDS

For Shooting down on the specimen in a copy-stand arrangement, your setup can be as simple as resting the glass on the ends of a couple of upright books. This is not a very stable arrangement, though, and you should devise something more permanent. A simple but strong arrangement is to cut a pair of L-shaped supports from at least 1 /2-inch plywood. The supports are inverted and attached to a base (*Fig.* A-11). The base can be a sheet of plywood with blocks of wood attached at opposite ends, parallel with each other, to which are attached the uprights. Another arrangement would be to have the base constructed as a shallow, inverted box for greater rigidity. The uprights can be attached with bolts and wing nuts, or with bolts and T-nuts so that they can be removable for easier packing or transport.

A much more elaborate setup is shown in Kodak (1962; *Fig. 11-4).* The upper sheet of glass holds the specimen, and the lower is a diffuser for lights held in the lower compartment. The bulbs are attached to a rheostat to control the brightness of the lights. The setup is very useful for photographing subjects with a solid white background. Both the glass and diffuser are adjustable in height. The assembly is painted matte black with the exception of the interior of the lower section, which is painted white.

You can also shoot on glass as if in the standard table-top arrangement. Either of the previous glass support devices can be used for this purpose, but it's best that the support system be as open as possible. This design allows for the introduction of reflectors, holders, and other light sources. Shooting should be done from an unsupported glass edge so that the support does not interfere with lighting or show in the photo.

For such a support, 1 built the system shown in *Figure* A-12. Each side consists of a pair of connected uprights, bolted to a 1 /2-inch plywood sheet. The uprights have a relief cut into their facing edges to hold the glass so that it can't move to the sides. The uprights are attached by means of bolts from the bottom so that they can be removed for storage. All components are painted matte black to eliminate reflections.

STEREOPHOTOGRAPHY

In an article by Leber (1989), he illustrates a simple positioning device for stereopairs of micromounts. It's made from easily available rods and clamps used for chemical support stands. Other devices for stereophotography are discussed in some detail in *Chapter 14.*

APPENDIX

B

Sources of Supplies

Aaron Jones, Inc.
Box 5799
Santa Fe, NM 87502
(505) 986-2015
Maker of Hosemaster light painting system.

Art Specialty Co.
3720 N. Milwaukee Ave.
Chicago, IL 60641
(312) 545-6607
Took over manufacture of Tensor's Model 6500 lame. New model number is 5120.

Bogen Photo Corp.
565 E. Crescent Ave.
P.O. Box 506
Ramsey, NJ 07446-0506
(201) 818-9500
(201) 818-9177
Maker of photographic equipment including Bogen Light Modulator System for photomacrography. Also distributes Elinchrome studio flash systems and Fiber Lite Kit.

Brandess/Kalt Co., Inc.
5441 N. Kedzie Ave.
Chicago, IL 60625
(312) 588-8801
(800) 621-5488
(312) 588-8606 FAX
Graduated and special effects backgrounds.

Calumet

890 Supreme Dr.
Bensenville, IL 60106
(800) 225-8638
(708) 860-7105 FAX
Moto supplies (allformats), film, *cameras, chemistry, paper, darkroom supplies, storage, mounting and matting, studio and darkroom equipment, special effects supplies, lighting, backgrounds, books, videos.*

Chartpak

Customer Service Dept.
One River Rd.
Leeds, MA 01053
(800) 628-1910
(413) 584-6781 FAX
Maker of rub-on lettering and graphics.

Chiu Technical Corp.

Marketing Dept.
252 Indian Head Rd.
Kings Park, NY 11754
(516) 544-0606
Maker of adjustable fiber-optic ringlight.

CPM, INC.

1830 Sanden Dr.
Dallas, TX 75238
(214) 349-6886
Maker of Delta I Suspend-It, a very strong tungsten alloy black photo wire, that comes in 20 foot rolls in 1 mil (supports 112 lb), 2 mil (supports 2 lbs), and 3 mil (supports 4 lbs). Each kit includes the wire, plus adhesive, dryer, hot-melt glue sticks, and 12 clear plastic hooks with adhesive backing

Dolan Jenner

Blueberry Hill Industrial Park
Box 1020
Woburn, MA 01801
(617) 935-7444
Fiber optics.

Dyonics, Inc.

160 Dascomb Rd.
Andover, MA 01810
(800) 343-8386/87
(617) 470-2800 (in MA)
Fiber optics.

Edmund Scientific
101 E. Gloucester Pike
Barrington, Nj 08007
(609) 573-6240
Magnifiers, microscopes, tools, fiber optics, lasers, optics, positioning equipment. Ask for Optics, Science and Education catalog

EJ. Westcott Co.
1447 Summit St.
PO. Box 1596
Toledo, OH 43603
(419) 243-7311
Maker of lighting products, including light tents good for shooting jewelry.

Fiberoptics Technology, Inc.
1 Fiber Rd.
Pomfret, GT 06258
(203) 928-0443
Fiber optics.

Flexible Products Co.
14504 60th St. North
Clearwater, FL 34620
(813) 536-3142
Bellows.

Foto-Care Ltd.
170 Fifth Ave.
New York, NY 10010
(212) 741-2990
Maker of adjustable rector and subject positioning device.

Gaylord
Box 4901
Syracuse, NY 13221-4901
(800) 448-6160 orders
(800) 272-3412 orders
(800) 634-6307 customer service
(800) 428-3631 conservator
Archival supplies for storage, mounting, and display, including slide and negative pages, albums, light boxes, porfolios, carrying cases, slide mounts, slide masking tape, etc.

Gemlab

PO. Box 212
Rego Park, NY 11374
(212) 335-5087
Gemological instruments including fiber optics, microscopes, spectroscopes, dichroscopes, polariscopes, immersion liquids, etc.

Graphic Products Corp.

Format
1480 S. Wolf Rd.
Wheeling, IL 60090-6514
(708) 537-9300
Maker of Format brand rub-on lettering and graphic arts.

Herbach and Rademan

18 Canal St.
PO. Box 122
Bristol, PA 19007-0122
(800) 848-8001 sales
(215) 788-9577 FAX
Optical and electronic surplus and miscellany, including carrying cases, mechanical components, and motors. Great stuff for tinkerers.

Irvine Optical Corp.

1903 Empire Ave.
Burbank, CA 91504
(818) 841-5320 phone/FAX
Maker of Dynaphot scanning light photography system.

Jobo Fototechnic, Inc.

PO. Box 3721
Ann Arbor, MI 48106
(313) 995-4192
Maker of antistatic brushes and cleaners.

Letraset

40 Eisenhower Dr.
PO. Box 281
Paramus, NJ 07653-9985
(201) 845-6100
Maker of rub-on lettering and graphics.

Light FX
751 Turquoise St.
San Diego, CA 92109
(619) 539-3912
Maker of Light FX light painting system.

Light Impressions
439 Monro Ave.
P.O. Box 940
Rochester, NY 14603-0940
(800) 828-6216
(800) 828-5539 FAX orders
Archival supplies for storage, mounting, and display, including slide and negative pages, albums, light boxee, portfolios, carrying cases, slide mounts, slide masking tape, etc.

Lumiquest
140 Heimer, Suite 775
San Antonio, TX 78232
(210) 490-1400
Maker of Table Top Reflector System.

Melles Griot
1770 Kettering St.
Irvine, CA 92714
(714) 261-5600
Lenses, mirrors, lasers, prisms, beam-splitters, filters, polarizing componente, optomechanical accessories, optical tablee and rails, component holders, and positioning devices.

Photographers Specialized Services
650 Armour Rd.
P. O. Box 46
Oconomowoc, WI 53066
(414) 567-8043
Maker of low-cost Light Tech light painting system.

Poly-Optical Products, Inc.
1815 E. Carnegie Ave.
Santa Ana, CA 92705
(714) 957-9288
Fiber optics.

Porter's Camera Store, Inc.

Box 628
Cedar Falls, IA 50613
(800) 553-2001
Carnes Trans-Lum Diffusion Material, which has matte surface on both sides and comes in 54-inch x I S foot rolls.

Reel Three-D Enterprises, Inc.

PO. Box 2368
Culver City, CA 90231
(310) 837-2368
Stereophotography supplies.

Rosco

36 Bush Ave., Hollywood, CA 90038
1135 N. Highland Ave.,
Hollywood, CA 90038 *or*
1271 Denison St. #66
Markham, Ontario, Canada MR 4B5 *or*
Blanchard Works, Kangley Bridge Rd.
Sydenham, London SE26 5RQ England *or*
42 Sawyer Lane, Artarmon 2064
New South Wales, Australia
Maker of photographic lighting and color-correction gels.

Savage Universal Corp.

800 W Fairmont Dr.
Tempe, AZ 85282
(602) 967-5882
Motographic backgrounds.

Sinar-Bron

17 Progress St.
Edison, NJ 08820
(908) 754-5800
(800) 456-0203
(908) 754-5507 FAX
Sinar large format supplies and studio equipment, and Broncolor lighting equipment including Broncolor's Fibrolite and Lightbrush.

Turner Bellows
526 Child St.
Rochester, NY 14606
(716) 235-4456
Bellows.

Universal Bellows Co.
25 Hanse Ave.
Freeport, NY 11520
(516) 378-1264
Bellows.

University Products, Inc.
517 Main St.
PO. Box 101
Holyoke, MA 01041-0101
(800) 628-4847
Archival display and storage products.

UV Systems
16605 127th Ave. S.E.
Renton, WA 98058-5549
(206) 228-9988 phone/FAX
Ultraviolet products: filters, goggles, and lights.

Wards Natural Science
PO. Box 5010,
San Luis Obispo, CA 93403
P O. Box 92912, Rochester, NY 14692
(800) 962-2660 (for both locations)
Laboratory and educacional supplies for biological and earth sciences. Ask for geology catalog

Webway Incorporated
2815 Clearwater Road
PO. Box 767
St. Cloud, MN 56302
(800) 328-2344
(612) 251-3822
Archival display and storage products.

Glossary

Ambient light: preexisting light falling on subject from other than photographic lights.

AF (auto focus): a feature of lenses (and cameras) that provides focusing by means of small motors instead of manually; usually an integral part of the lens.

ammonium chloride: a powdery compound that, when heated, vaporizes and sublimates on surfaces as an opaque coating making them easier to photograph if they are of a highly lustrous or transparent nature.

angle finder: a finder that allows the photographer to view the image at right angles to the direction he or she is facing. Especially handy when doing copy work.

angle of view: the widest angle of light rays entering a lens that will loan an acceptably sharp image on the film plane.

aperture: the adjustable opening centered within the lens on its axis that admits fght.

ASA: acronym for the American Standards Association that, when used with a number, is an arithmetically progressive rating of a film's sensitivity to light. For example, ASA 400 film is twice as sensitive as ASA 200 film. Now known as ISO.

axial lighting: see coaxial lighting.

Backlighting: the illumination of a subject from the side opposite the camera. Usually done to show the subject's transparency or translucency, or to reveal internal features.

barn doors: adjustable flaps attached to the front of a photographic lamp to limit the spread of light.

beam-splitter: an optical device for dividing a light beam into two. There are three types: (1) plate, consisting of a plate of optical crown glass with a different coating on each side, one being partially reflective; (2) cube, consisting of a pair of identical right-angle prisms with the hypotenuse faces cemented together with a partially reflective coating on one; and (3) pellicle, a very thin nitrocellulose membrane mounted in a metal frame (it looks like a screw-in filter).

bellows: accordionfke sleeve extending between a lens and camera body. An integral part of some cameras (especially larger format) allowing focusing. In 35-mm and medium-format cameras, an accessory permitting lens extension for photomacrography.

boom: an armlike fght support attached to a metal stand to hold a lamp out over a subject.

bounced light: the reflecting of light off a large surface so as to increase the arca of illumination and soften the light.

bracketing: (exposures): taking extra exposures of longer and shorter duration, or at larger or smaller f-stops, than the meter-recommended setting to ensure a proper exposure.

camera movements: mechanical adjustments of a large-format camera for manipulation of the image and placement of the plane of focus.

Glose-up photography: work done between the shortest distante a normal lens will focus and life size.

coaxial lighting: where illumination of a subject is transmitted along the axis of the camera lens. Also called axial lighting.

color balance: adjustments made to ensure proper match of colors and neutrality of grays in a photographic medium to that of subject.

color cast: the overall color bias of a photograph.

color-compensating (CC) filters: pale colored filters used to fine-tune the match between films and light sources. A typical designation would be CC 10M, where CC stands for color-compensating, 10 for its density, and M for magenta.

color-conversion filters: filters used to match a film with a light source for which it was not designed. For example, a blue 80A is typically used to match daylight-balanced Kodachrome 25 with 3200 K tungsten light.

color temperature: the temperature to which a theoretical inert material would have to be heated to glow a particular color. Measured in kelvins (K).

covering power: the ability of a lens to produce a sharp image all the way to the edges of the photographic plate it was designed to cover when focused with the diaphragm wide open. An important consideration when choosing a large-format lens that will be able to deal with the camera movements.

dark-field lighting: a lighting technique used primarily in gemstone inclusion photography where the subject is illumnnated from all sides by a hollow cope of light and the background remains black.

darkslide: a lightproof sheet used to protect film from exposure before mounting in a medium- or large-format camera.

daylight film: a color film balanced for use with a 5400 K light source such as daylight or electronic flash.

deep field photography: see scanning light photography.

depth-of-field: the total distante in front of and beyond the principal plane of focus in which a subject will appear to be acceptably in focus. The distante increases with the uses of smaller apertures.

depth-of-focus: the total distante through which a film plane can be moved and still produce an acceptably sharp image. The distante increases with the use of smaller apertures.

diaphragm: the adjustable opening that controls the amount of light passing through a lens. Also called an iris diaphragm.

diffuser: any material used to scatter light

and so increase the effective arca of flumination and reduce the specularity of the light.

DIN (Deutsche Industrie Norm): a logarithmically progressive rating of the light sensitivity of a film.

DX code: a pattern of light and dark squares on a film canister, read by sensors in a camera to tell it the ISO of the film.

edge light: a light source placed behind or nearly behind a subject to create a halofke rim of light around the edges of the subject. It emphasizes and separates the subject from the background.

electronic flash: an artificial light source of very short duration produced by passing an electric spark between two electrodes inside an enclosed, gas-filled tube. The color temperature is usually 5400 K.

emulsion: the light sensitive coating on photographic film, papers, and plates consisting primarily of a silver salt(s) suspended in a gelatin medium.

emulsion batch number: a number placed on the packaging of photographic papers and films identifying the batch from which that particular paper or film was made. Often important for color rendition and processing consistency.

exposure: the amount of light reaching a photographic emulsion depending on both duration and intensity.

exposure latitude: the range of exposure that a film will tolerate and still produce detail in both shadows and highlights.

exposure meter: a device used to measure the light reflected from or falling on a photographic subject. The meter converts the light energy into exposure units indicating both lens aperture and shutter speed.

exposure value (EV): an exposure setting notation system linking aperture and shutter speed. A single EV number can represent several shutter speed-aperture combinations as long as they all produce the same exposure, for example, 1/250 second at f8 equals 1/125 second at f16.

extension: an adjustable or fixed tube placed between a lens and the camera body used to increase image magnification.

f-number: a notation for relative aperture that is actually the ratio of focal length to aperture diameter. The speed or maximum fght gathering ability of a lens is designated by its widest aperture (lowest f number). Lens aperture rings are calibrated in a standard series: fl, f1.4, f2, f2, 5.6, 8, f8, f1.4 l, f16, f22, f32, f64.

fiber optic: a flexible bundle of plastic or glass fibers for transmitting light with high effciency. Used for highly controlled photographic illumination.

fill: the illumination of shadow arcas on a subject or scene.

film plane: the plane in the back of a camera in which the film lies and at which focus is determined.

ñlter factor: the number by which an exposure must be multiplied to compensate for light loss due to absorption by a filter.

flag: a matte black sheet positioned between a light and the camera for reducing flair, or placed to keep light off a portion of the image arca.

flare: reflected and scattered light not used to produce an image, which degrades image quality

flash: see electronic flash.

flash synchronization: system in a camera ensuring peak flash output simultaneously with full opening of the shutter.

focal plane shutter: a shutter located at, or actually immediately in front of, the camera's focal (and film) plane.

format: size and shape of the film and the camera system that must be used with that film, for example, 35-mm format, medium format, and large format.

fresnel lens: a nearly flat lens consisting of a series of concentric, stepped, convex rings. When used with the viewing screen on a large-format camera, it substantially brightens the image. Fresnel lenses are also used on certain spotlights.

gelatin filter: filters made from a thin film of dyed gelatin. Relatively inexpensive, but easily damaged.

gobo: usually a black card placed between a lens and a light source to prevent flare.

graininess: the subjective impression of texture of a photographic image due to the clumps of silver halide that make up the image. The more an image is enlarged, the greater the graminess. Generally, slower speed films have finer grain.

highlight: the brightest arcas of a scene and the photographic image of that scene.

hyperfocal distante: the distante from the camera to the nearest subject in focus when the lens is focused at infinity This distante decreases with smaller apertures.

incident reading: meter measurement of the light falling on the subject as opposed to the light reflected from the subject.

ISO (International Standards Organization): the film speed notation replacing the ASA and DIN notation systems. See ASA.

joule: unit of output from an electronic flash, equal to one watt-second.

kelvin: usually abbreviated as K. The standard unit for the measurement of color temperature.

latitude: degree to which a film can be over- or underexposed and still retain detail in the highlights and shadows.

LCD (liquid crystal diode): a solid-state display system used in electronic equipment, camera viewfinders, and control panels.

lighting ratio: the relative intensities of the main light and the fill-in light on the subject.

light painting: illumination of a subject with a moving, handheld light source during a long exposure.

light tent: an enclosure that surrounds a subject and is illuminated from the outside to provide very diffused, even lighting for reflective subjects.

macro: short for photomacrographic, pertaining to the photography of small objects with the camera, bellows, and/or extension tubes and special lenses.

macro lens: a lens designed specifically for close-up and photomacrography. Such a lens can focus closer to an object (and usually attain a life-size image) than a normal lens because the optics are optimized for working with shallow depth-of-field and usually attain smaller apertures (f22 or f32).

microphotography: the production of very small photographs.

modeling lamp: the incandescent lamp liitted along with the flash tube in the head of a studio flash unit. It shows what the light will be like when using the flash.

monorail: the rail that supports most modem studio-view cameras. Sometimes used as an abbreviation for such cameras.

multiple exposure: the combining of more than one image taken successively on a single frame or sheet of film.

multiple flash: the repeated triggering of a flash unit to achieve proper exposure of a stationary subject. Also called serial flash.

neutral-density filter: a filter with no color absorption that is used to reduce the amount of light reaching the film.

objective: the image-forming lens on an optical instrument, for example, the lens of a microscope closest to the subject.

opal glass: a translucent milky glass used for diffusion in some enlargers.

optical axis: an imaginary line between the centers of lenses, also called the principal axis. A light ray entering a lens on this axis will emerge without being bent or refracted.

orthochromatic: photographic materials insenstivie to the color red. Most black-and-white printing papers are orthochromatic so that they can be used with red safelights.

off the film (OTF): usually referring to metering systems or flash units that have light sensors located at the film plane.

pan: moving a camera in the horizontal plane during exposure.

pancromatic: photographic materials sensitive to all colors of the spectrum.

pan head: the device on the top of a tripod that permits camera movement in both the horizontal and vertical planes. Also referring to a head designed for the case of horizontal movement during exposures, especially for movie and video cameras.

parallax error: the error inherent in the use of rangefinder and twin-lens cameras where the viewing and picture-taking lenses are separate. At short distances the two lenses do not see the same thing; that is, there is an apparent displacement of an object seen from two different points not on a straight line with the object.

photoelectric cell: the light-sensitive electronic cell in a light meter used to measure light.

photomacrography: see macro.

photomicrography: photography through a microscope.

photomicroscopy: see photomicrography.

polarization: restriction of the vibration of light to a single plane. In photography, it is accomplished by the use of a polanzing filter usually for the control of reflections.

pulling: developing film for a shorter time than normal to compensate for overexposure or to reduce contrast.

pushing: developing film for a longer time than normal to compensate for underexposure or to increase contrast.

quartz-halogen lamp: see tungsten-halogen lamp.

rangefinder camera: camera with a lens for picture taking and a separate viewfinder for composing and focusing. The rangefinder is sometimes connected with the lens for focusing and limited parallax correction.

reciprocity failure: shifts in color and light sensitivity of film with excessively long or short exposures.

reciprocity law: exposure = intensity x time, which means that the quantity of light reaching the film is the result of the size of the aperture opening and exposure length.

reflector: any surface used to reflect light. The texture and reflectivity of the surface plus color and tone affect the quality of the reflected light.

reproduction ratio: the relative proportions of a subject and its image.

ringlight: a circular flash tube that fits around the end of the lens. It produces an even, flat lighting.

rise and fall: vertical movement of front or rear standards of a view camera.

roll film: film rolled onto a spool along with a black paper backing, usually used in medium-format photography. The most common roll film format used today is 120.

roll film holder or adapter: an accessory permitting the use of roll film in cameras that normally use sheet film or planes.

safelight: a darkroom light that does not affect light-sensitive photography materials.

scanning light photography (SLP): a technique where the subject is photographed while moving through a thin plane of light that is perpendicular to the direction of movement and the lens axis.

scheimpflug principle: a rule in view-camera photography that states that the planes of front and rear standards plus the plane of the subject, must all intersect at the same place for optimum placement of the plane of focus.

scrim: a piece of diffusion material placed in front of a light source to reduce its intensity and diffuse it to a small degree.

shadow detail: detail visible in the darkest arca of a subject or its image.

sheet film: film that comes as individual sheets as opposed to rolls, and usually used in view cameras. Also called cut film.

shift: lateral movement of the front or rear standard of a view camera.

single lens reflex (SLR): camera with one lens that serves for both viewing and picture taking. It has a mirror located in front of the film plane that moves out of the way at the time of exposure.

SLP: see scanning light photography.

SLR: see single lens reflex.

snoot: a tapered cone or cylinder that mounts on the front of a light source to restrict the light.

specularity: pertaining to the degree of highlight reflectivity of a surface.

spotlight: a lamp containing a lens used to concentrate its light.

spot meter: a light meter that reads only a very small amount of light reflected from a subject, usually 1-3 degrees.

strobe: abbreviation for "stroboscopic light," a rapidly repeating flash unit that can be used for multiple exposures of moving objects.

supplementary lens: a simple accessory lens mounted on the front of the normal lens to increase image size of the subject.

swing: movement about a vertical axis of the front or rear standard of a view camera.

through the lens (TTL) meter: light metering done inside the camera on the light coming through the lens.

tilt: rotation around a horizontal axil of the front or rear standards of a view camera.

TLR: see twin lens reflex.

TTL: see through the lens.

tungsten-balanced film: color film designed for use with artificial lights, usually with a color temperature of 3200 K (Type B film), and the less common Type A film balanced for use with 3400 K lights.

tungsten-halogen lamp: an improved lamp that has its tungsten filament in a halogen gas-filled, high quartz content glass housing. Such bulbs do not change color temperature as they age because of the redeposition oí' the vaporized tungsten on the filament. Also called a quartz-halogen lamp.

tungsten lamp: an artificial lamp that produces light by passing electricity through a tungsten filament causing it to glow due to heating resulting from resistance of the filament. Such lamps change color temperature as they age due to the vaporized tungsten being deposited on the inside of the bulb.

twin lens reflex (TLR): a camera with matched, coupled lenses. The lenses are usually one above the other with the upper one used for viewing and composing and coupled with the lower taking lens. The viewfinder is usually located on top of the camera and must be looked down into.

view camera: a large-format camera usually with front and rear standards capable of a range of movements. The image is projected onto a ground-glass viewing screen, which is replaced by film in a film holder for exposure.

vignette: the process of restricting light falling on the film so that the image fades out toward the edges. Done on purpose in portraits, and by mistake by the use of lens shades that are too long or not wide enough for the lens used. Also caused by improper choice of a lens that does not completely cover the film's imaging area with the projected image.

watt-second: a unit of energy equal to one joule.

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