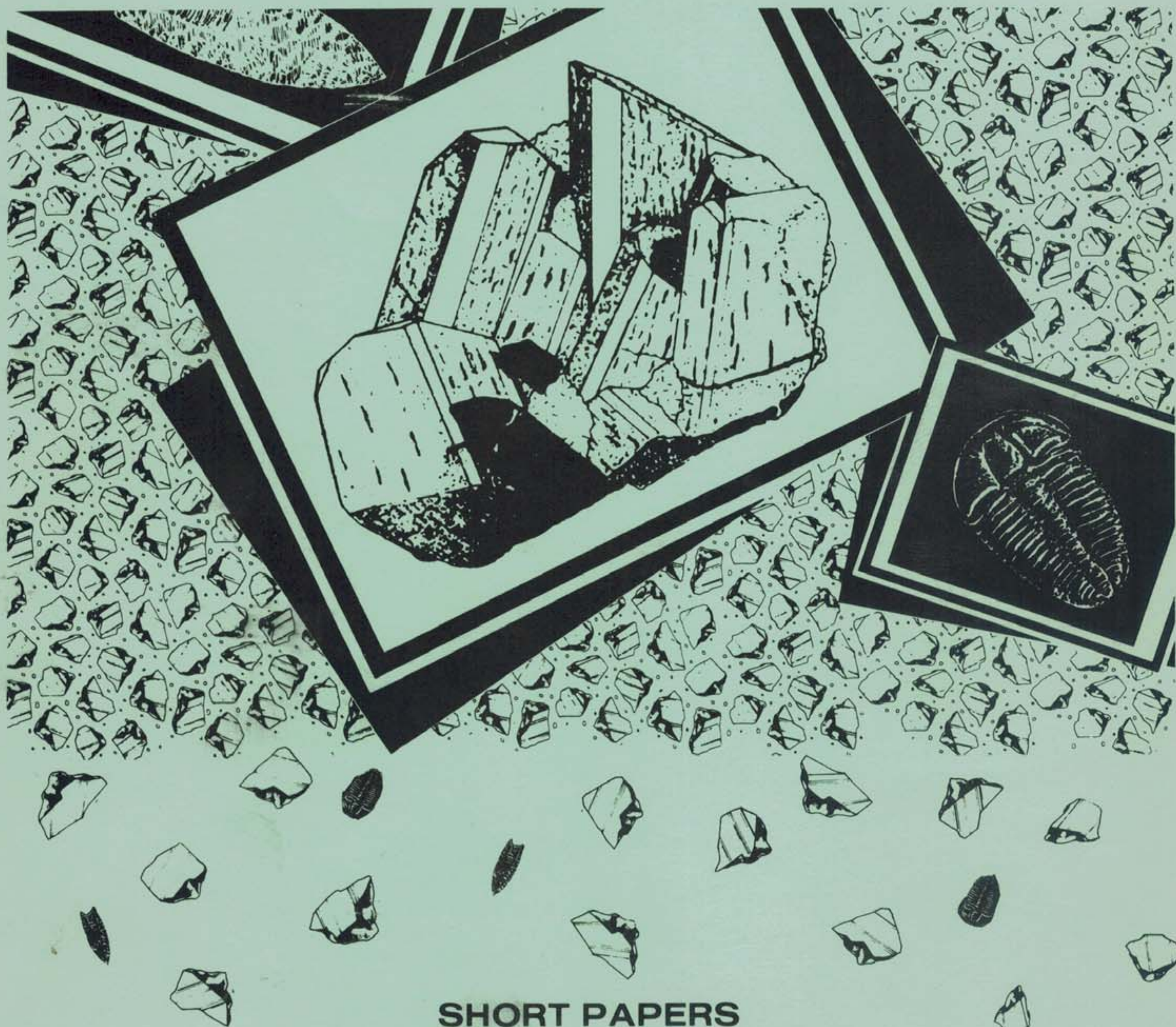
PHOTOGRAPHY OF MINERALOGICAL PALEONTOLOGICAL AND ARCHAEOLOGICAL SPECIMENS

A Symposium On Equipment And Techniques For Professionals and Amateurs



SHORT PAPERS

Presented at the 7th Friends of Mineralogy
Colorado Chapter Symposium

Sponsored by
Colorado Chapter, Friends of Mineralogy and
Department of Earth Sciences, Denver Museum of Natural History
October 28, 1989

PHOTOGRAPHY OF MINERALOGICAL, PALEONTOLOGICAL AND ARCHAEOLOGICAL SPECIMENS

SYMPOSIUM SHORT PAPERS

Presented at
The Friends of Mineralogy, Colorado Chapter 7th Symposium,
"Successful Photography of Gems, Minerals, Fossils and Artifacts."

Ricketson Auditorium
Denver Museum of Natural History
City Park, Denver Colorado

October 28, 1989

Sponsored by:

Friends of Mineralogy, Colorado Chapter
and the
Department of Earth Sciences, Denver Museum of Natural History

1989 Symposium Committee: Raymond R. Berry, James F. Hurlbut, Jack A. Murphy, Jack D. Thompson, Chauncey L. Walden

Publication Editors: Jack A. Murphy and James F. Hurlbut

With special thanks to: Jim Englehorn, Brenda Hawley, Joan Klipping, Peter and Regina Modreski, Cath Murphy, Irene Osborn and Lynn Swain.

PROGRAM OF SPEAKERS AND SCHEDULE

8:00 A.M. Registration.

9:00 Opening remarks - Jim Hurlbut and Ray Berry

9:15 Photography of earth science and archaeological materials (keynote address) - Jeffrey A. Scovil

10:00 - 10:15 Coffee break

10:15 An introduction to stereoscopic photography - Chauncey L. Walden

10:40 I got the photograph - now what do I do with it? - Liz Clancy

11:00 Black and white photography of fossils and artifacts - Gary D. Hall

11:20 Photographic essentials, "necessary and nice" (includes an equipment demonstration) - Jack D. Thompson

12:00 - 1:00 Lunch break

1:00 Photography of fluorescent minerals - Peter J. Modreski

1:30 Techniques for photographing geologic materials to be used in slide presentations - Ed Raines

2:00 Field techniques and close-up photography - Bob Rozinski

2:30 - 2:45 Coffee Break

2:45 Documenting archaeological and paleontological materials - Kevin Black

3:10 Aesthetic gem and mineral photography - Barbara Muntyan

3:45 Mineral photography through the microscope (includes an equipment demonstration) - Arnold Hampson

4:15 - 5:30 Demonstrations:

Techniques of photographing through the microscope..........Arnold Hampson
Photographic equipment and supplies......................Jack D. Thompson
Documenting field discoveries with video.................Peter J. Modreski
Cataloging photographs with a computer database............Jack A. Murphy

TABLE OF CONTENTS

INTRODUCTION

Goals of the 7th FMCC Symposium.

It is our pleasure to co-sponsor the 7th Symposium of the Friends of Mineralogy - Colorado Chapter and the publication of short papers. This organization has produced a substantial publication based on their public symposium series since 1982. This is the first year that the subject has not been strictly involved with mineralogy and regional mining history. The 1989 topic is original and welcome.

There are few places where professionals and amateurs can receive training on how to photograph specimens, from in the field into the laboratory or for use in publications and lectures. Most people are largely self-taught when it comes to photography. Overall, the quality I have seen is good, but there is room for improvement. This is one of the lessons learned after 6 years of FMCC symposia- an excellent talk can be ruined by poor quality 35mm slides and graphics.

Our principal goal is to improve our photographic skills by calling upon those within our community that have demonstrated special expertise. Presented here are 13 excellent short papers that give a wide range of useful information about photographic equipment, techniques and helpful hints on specialized subjects gleaned from experience.

It is my pleasure to know most of the authors represented in this edition. I have worked with many on one project or another, from filming delicate cave formations underground to digging crystals on the alpine slopes of Mount Antero. They are all professionals and have taken considerable time to prepare these papers on a volunteer basis. Therefore, on behalf of the membership of the Colorado Chapter of Friends of Mineralogy, the administration of the Denver Museum of Natural History, and the audience, I extend a sincere thank you to all the authors.

Jack A. Murphy
Curator of Geology
Department of Earth Sciences
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BRIEF BIOGRAPHIES of SPEAKERS

Laura Anderson is a native of Denver, now living in Colorado Springs, where she works for Stewart's Photography. Her experience includes photography of fine art, landscape photography and close-up imagery of nature studies. She is equally comfortable with large format as well as 35 mm.

Kevin Black is the Assistant State Archaeologist at the Office of Archaeology and Historic Preservation of the Colorado Historical Society. His work includes photographic documentation of archaeological features and artifacts in both the field and laboratory.

Liz Clancy has worked at the Denver Museum of Natural History for the past 15 years and has the distinction of becoming the Museum's first Photo Archivist, responsible for centralization, organization, care and storage of all Museum photographic material from the past 90 years.

Gary D. Hall has been Staff Photographer at the Denver Museum of Natural History for the last eight years. He became known for his photographs documenting "Silent Splendor" cave at Manitou Springs, Colorado. Prior to his Museum work he taught at the Colorado Institute of Art.

Arnold G. Hampson, Past President of Colorado Federation of Mineralogical Societies, Ute Mountain Gem and Mineral Society and Past Treasurer of Friends of Mineralogy (National). Has lived in Cortez for 33 years. His primary mineralogical interest is micromounts.

Peter J. Modreski is a geochemist and mineralogist with the U.S. Geological Survey in Denver. A member of numerous gem and mineral societies, he is a long-time mineral collector and past officer of numerous mineral clubs and professional organizations. He is also a Research Associate at the Denver Museum of Natural History.

Barbara L. Muntyan is a charter member of Friends of Mineralogy, is widely published and has presented slide programs at numerous mineral groups. A full-time resident of Ouray, she works for Columbine Minerals in Ouray.

Jack A. Murphy has held the position of Curator of Geology at the Denver Museum of Natural History since 1969. His particular interests are in the minerals and ore deposits of Colorado and the Rocky Mountains.

Ed Raines is a geologist and well-known mineral historian who has written numerous papers and presented lectures on the mineralogy of the Colorado Mineral Belt. He works at Analytica Inc., Golden, Colorado and is teaching a course on the Geology of the Front Range through the Boulder Valley School District.

Bob Rozinski is a full-time wildlife and nature photographer. He has taught photography workshops for over 15 years, covering subjects ranging from macro- to landscape photography as well as wildlife.

Jeffrey Scovil was laboratory photographer for six seasons at Salmon Ruin archaeological dig near Farmington, New Mexico. His work has also included lab photography for the Anthropology Department at Arizona State University, and he organized the Mineral Photography seminar at the Tucson Gem and Mineral Show for five years.

Jack D. Thompson has been a mineral collector for the past 25 years. His photographic experience includes extensive amateur photography and professional laboratory work as a color-lab technician.

Chauncey Walden developed an interest in lapidary work in New Mexico. After moving to Colorado he joined the Littleton Gem and Mineral Club. His first camera was a Graflex Stereo Graphic which was the inspiration for his interest in stereo photography.

PHOTOGRAPHY OF EARTH SCIENCE AND ARCHAEOLOGICAL MATERIALS

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This article is an outline of basic principles of the photography of earth science and related materials. The emphasis is on the "why" and not the "how." It would take a book to cover specific techniques required in each of the sub-disciplines covered briefly in this paper. Such techniques can be gleaned from the available literature, some of which is covered in the bibliography.

Objectives

The primary consideration in specimen photography is the ultimate use of the photographs. What are your objectives in photographing the materials of your particular interest? The answer to this question determines all other considerations such as technique and aesthetics.

There are numerous uses for "specimen" photography including the following: purely aesthetic, displays, teaching, public relations, cataloging, analytical aids, and publication. Specimen photography can also be used to record the progress of conservation/restoration of materials or for sale as items such as postcards, calendars and posters.

The technique used may be dictated by the nature of the subject itself. For example, objects with low relief can only be adequately lighted in a limited number of ways such as co-axial lighting or a low angle grazing light. Objects of a more three-dimensional nature require completely different lighting techniques.

Ultimately, the situation is "Documentation" versus "Art," representing seemingly opposite extremes.

Documentary Photography

Documentary photography lies within the realm of scientific photography which has several basic requirements.

1. First and foremost is accuracy of representation. The form, texture, color and all pertinent features must be clear and identifiable.

2. Proper perspective must be maintained through the use of appropriate lenses. Lenses too short or long in focal length will distort the shape and proportions of the subject.

3. There should be no ambiguity in the photographs. The subject cannot fade into the background becoming indefinite in form due to a lack of contrast and tonal separation. Highlights should not be so large and burned out that surface detail is lost.

4. Several views of the subject should be taken to reveal its shape and all features with a minimum of distortion. This is especially important with objects such as decorated ceramics where the decoration is on a curved surface. In such a case, foreshortening of the design as it comes close to being at right angles to the film plane is unavoidable.

5. Sharpness of the image must be maximized so detail is not lost when enlarged. A compromise must be reached between maximum depth of field and maximum detail. It is an unfortunate fact that as depth of field increases, sharpness (or depth of detail) decreases. For an in-depth discussion of the topic, see Kodak (1969).

6. Backgrounds must be shadowless and non-distracting to eliminate ambiguity, and be pure white or black for publication purposes, with white being preferred.

7. Careful attention needs to be paid to the accurate recording of data on the photographs such as date, exposure, frame and roll number. More important is the recording of data about the subject itself such as catalog number, identification, size, and exact place of origin. A small scale and label with pertinent data should be included in the photograph positioned so that they can be cropped out in printing if necessary. This ensures that the data is never separated from the photograph.

The purpose of scientific photography is to accurately record materials as an aid to analysis. Researchers may not be able to study directly the subjects of their work, and so accurate photographs must be substituted.

Photographs may also make details not normally apparent through direct observation more visible. Some types of study can only be done on accurate photographs of subjects. An example would be flake pattern analysis of stone tools, done by computer analysis of detailed photographs.

Art and scientific photography need not be mutually exclusive. The degree to which the two approaches overlap and compliment one another is governed by the purpose of the photographs. Those made for public presentation can be both highly accurate and aesthetic depending on the lighting and choice of background. The photographer must rely on experience to judge the proper mix. Any photograph, even a scientific format, is a subjective interpretation by the photographer. The laboratory photographer may feel that he is being objective in his work, but it is still based on his perception of the subject as well as the nature of his training, personal tastes and technical capabilities.

What is absolute truth in scientific photography is a difficult question to answer. The process of photography is inherently limited. First, a photograph is a two-dimensional representation of usually a three-dimensional object. Second, a photograph is only one view of an infinite number of angles. This limitation can be reduced by photographing the subject from several standardized angles. However, this approach is obviously still limited. Recognizing these limitations, photographic procedures must be carefully devised to maximize information recording and minimize distortion.

Various techniques such as filtration, light sources, retouching and darkroom manipulation can all be used to improve information content. However, these techniques can be taken to such an extreme that they distort the information. The photographer must design photographic procedures with this in mind.

Two extremes of photographic style in mineral photography are "Mineral" versus "Specimen" photography. The former seems to be primarily a European approach that is more purist and scientific in nature. Mineral photography stresses that the specimen should stand on its own merits without fancy background treatments. Ideally the background is the matrix of the specimen. If this is not possible, the background is plain and shadowless, preferably black.

Specimen photography makes use of creative backgrounds and lighting techniques to enhance a specimen's artistic appeal. There are, of course, many photographers who find a happy medium between these two extremes.

Art Photography

Art photography in its extreme is more concerned with a photographer's interpretation of an object, not an accurate depiction of that object.

Gemstone and lapidary photography present the same technical challenges as documentary photography, but with aesthetics as a major consideration. It is the beauty of gemstones that first and foremost makes them desirable.

The big variable in lapidary photography is backgrounds. The choice of materials and their lighting is nearly infinite. The background must work with the subject to maximize its appeal. Props are an important element which when used in conjunction with backgrounds can relate the subject to its source, use, ownership or manufacture. For instance, pearls or coral can be photographed on a background that gives the illusion of water. An emerald pendant could be placed on a dressing table with evening gloves, opera tickets, etc.

Numerous materials are available for use as backgrounds including textured and patterned plastics, laminates, fabrics, papers and wood veneers.

Be sure that you are illustrating the lapidary material, and do not let the background become overwhelming. The subject is of primary importance and should still be recorded clearly. Faceted stones are particularly difficult to photograph, as are stones that show various phenomenon such as schiller, asterism and opalescence. The photography of lapidary materials presents the greatest potential for creative expression.

Specialized Techniques

Scientific photography, especially if used for analytical work, requires that the photographs be as detailed as possible. One advantage of a photograph is the enlargement of the subject, making more detail visible. Another advantage is that the subject can be illuminated from several angles, defining features in a way not usually obtainable with the limited lighting often used in direct examination.

Besides these advantages attainable through relatively standard techniques, there are other specialized techniques which have been borrowed and adapted from industrial and forensics photography. Their application to the diverse materials of the earth sciences and archaeology are only limited by the photographer's imagination.

Ultraviolet fluorescence photography of mineral specimens is well known, and can certainly be applied to gemstones, artifacts and fossils. Fluorescence is often a diagnostic characteristic in identification. Its use may also be able to separate materials on a subject which appear by visible light to be indistinguishable.

Ultraviolet reflectance photography can have similar uses. In this technique, it is the ultraviolet radiation reflected by the subject that is recorded. This photography requires the use of special filters that eliminate all visible light, as well as special lenses to transmit ultraviolet radiation.

Infrared reflectance photography has proven its worth especially in vegetation studies. It can be useful in penetrating organic stains on ceramics to reveal obscured painted designs.

Co-axial lighting is a technique where light is transmitted to the subject along the axis of the lens, from the direction of the camera (Figure 1). This is accomplished by placing an optical flat or beam-splitter at a forty-five degree angle between the camera and the subject. A light is directed at the beam-splitter which reflects it downward along the lens axis where it reflects off the subject and back up through the beam-splitter to the lens.

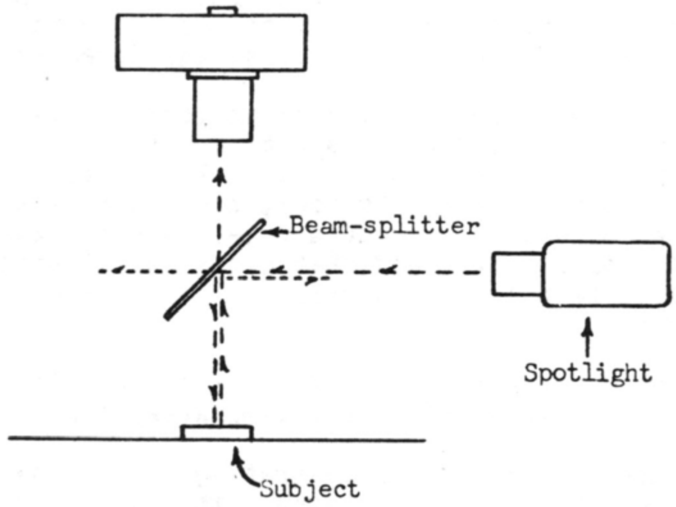

Figure 1.

Best results are achieved with this technique when the subject is relatively flat and reflective such as a polished pendant. Co-axial lighting will reveal in minute detail the microphotography of the subject's surface, otherwise difficult to record due to its very low relief. This can be a great aid in the analysis of the manufacture and use of artifacts, surface detail of low relief fossils and growth features on crystal faces. The technique is also useful in illuminating objects in deep cavities.

Figure 2 illustrates how co-axial 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. See Blaker (1977) and Hine (1971) for a more detailed discussion.

Stereophotography can add immensely to the aesthetic appreciation of all photographic subjects and is the most accurate means of recording three-dimensional objects. Stereophotography can be an important aid in the analysis of artifacts, as it improves definition and appreciation of form and surface features (Semenov, 1964).

Ammonium chloride has long been used as an aid in photographing highly reflective materials such as obsidian (Kraft, 1971), (Weide & Webster, 1967). The process of "smoking" creates a thin opaque coating on the subject that eliminates reflections and keeps form defining shadows from being absorbed. The drawback to this technique is that the true tonality of the subject is not recorded. This is not much of a problem with black and white film. With color film the true colors, plus any internal features (if the subject is translucent or transparent) are obscured.

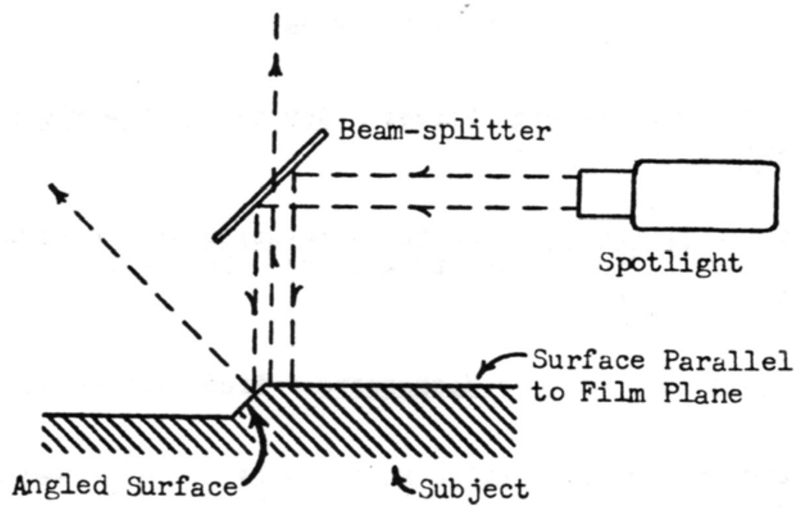

Figure 2.

These specialized techniques are just a few that can be applied to earth science and archaeological materials. There are many others that are specific to certain materials and are beyond the scope of this paper.

Conclusion

Whatever you are photographing, the foremost consideration in your mind would be the ultimate use of the photographs. If the purpose is scientific illustration, the procedure is relatively straight forward and dictated to some degree by the subject. If the purpose of the photographs will be primarily aesthetic, the choice of techniques and styles are much wider in scope. The photographer can exercise a great deal of artistic freedom in lapidary photography.

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AN INTRODUCTION TO STEREOSCOPIC PHOTOGRAPHY

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Stereoscopic photography allows the brain to reconstruct the missing third dimension of depth from a pair of two dimensional images. This technique provides a more complete and more natural documentation of a specimen or situation. Although stereoscopic cameras and projectors are available, no special equipment, other than a simple viewer, is required.

Stereoscopic, or 3-D, photography was developed almost 150 years ago, and has since been through several cycles of popularity. A high point around the turn of the century made the sterescope a familiar household item. Another in the 1950's took advantage of Land's polaroid process to permit 3-D projection and viewing of color transparencies and movies. A low was apparently reached about two years ago when Kodak stopped mounting stereo slides in the most popular Stereo Realist format which was developed by a Colorado resident, Seton Rochwite. This bombshell from Kodak came at about the same time as the stereo issue of The Mineralogical Record. 3-D photography is currently receiving a boost from commercial sources such as advertising and video, and the hard-core stereographers are still out there clicking away.

The stereo process depends on what is called "normal depth perception". That is, the slightly different images of nearby objects produced by the physical separation of the left and right eyes are processed by the brain to populate a three dimensional spatial relationship. This is the brain's game, and it makes the simple rule that the eyes must be basically looking at the same thing. The photographic images must follow this same rule. There is some tolerance for horizontal separation of the center of view, very little for vertical separation, and almost none for rotation of the images.

Stereoscopic cameras allow for this by careful alignment of their lenses. Unfortunately, most of these cameras were produced in the 1950's using the technology then current. Only one camera model, the Nimslo, and its simplified successor, the Nishika, has been mass produced in the last decade. The Nimslo featured automatic exposure and flash coupling, but was doomed commercially because it was designed to produce a 3-D print using a lenticular coating, the image quality of which left something to be desired. They can still be bought new for $50 to $80, a fraction of their original cost. Serious stereographers have discovered that the Nimslo's 4 lenses, separated by about 18mm between each, make fine transparencies, and while the two outer lenses have the separation necessary for normal stereo photos, the two inner lenses, covered with a +2 or +3 closeup lens, permit closeups at 12" to 18". The format is half frame and either Stereo Realist (1 5/8" x 4") or standard (2" x 2") format mounts are available to permit projection or viewing.

Closeups are not possible with a normal stereo camera because the separation of the lenses is fixed at about 2 1/2" and the lenses are aligned for a minimum camera to subject distance of about 4 to 6 feet. This brings us to the modern single lens reflex (SLR). Computer designed optics with programmable electronically controlled exposure and through-the-lens (TTL) controlled electronic flash provide excellent images under a multitude of conditions. Now all we need for stereo is a second image with a proper physical separation from the first; just move the camera horizontally and take another picture. It sounds pretty simple and it is, and you can control the physical separation of the two images to suit your purpose.

The basic field technique for SLR's is called the "Kodak Two-step" in honor of the company which stands to gain the most from increased sales of film and processing. Put simply, you put your weight on your left foot and take the left photo, then shift your weight to your right foot and take the right photo. Some point in the distance should be maintained in a fixed spot in each shot. Your center split image is a good reference point for this. Form a habit of taking the left photo first, then the right. The numbers on your slides can then be a guide to proper orientation. I say can be, because your friends at the processing labs have a neat trick of sometimes switching numbers! Again, be very careful not to tip the camera left or right between shots. Pairs taken with this defect will be found highly objectionable by any viewer. Vertical separation should also be avoided, but can be dealt with by carefully trimming the top or bottom of one of the mounts. (To be used in a viewer, trim the bottom of the high slide - in a projector, trim the top of the low slide.) A motor drive helps to eliminate unwanted shifts in alignment.

When viewing stereo pairs the sense of realism is such that the eyes tend to wander around the scene looking at different objects and making focusing corrections appropriate for the distance at which they think they are working. They become somewhat perplexed if they are unable to bring something into focus. For this reason, try to use the smallest possible aperture consistent with conditions to keep the depth of field to a maximum. Using hyperfocal distance (putting the distance to the most distant object in your picture opposite the far aperture mark on your focusing ring instead of opposite the reference mark) will also increase your working depth of field. If you have to make a choice between having the foreground or the background in focus, choose the foreground.

When shooting at less than about six feet, horizontal separation between shots should be approximately 1mm per inch of distance to the subject. You won't be far off using this rule of thumb. Of course for special effects this may be increased somewhat. When shooting long distance stereo almost any separation can be used (5 to 100 feet, for example), but anything identifiable in the immediate foreground can be very distracting. This hyperstereo (wide-base) effect gives the appearance of looking at a model which could be useful to emphasize topography. One familiar use of this is aerial mapping for which the stereo effect of overlapping photos in a linear series can be used to determine relief. At the other extreme, hypostereo (narrow-base) pairs made using a scanning electron microscope have a separation that is measured in microns, but still produce the full 3-D effect.

Needless to say, movement of the subject between shots is to be strictly avoided. This can be especially trying with people; they hear the click of the first shot and they move. Things moving around in the background, such as people, cars, clouds, water, or even wind-blown bushes are noticeable but somewhat acceptable. There are three ways to get around this problem of subjects in motion: one is to find a used stereo camera (a good Stereo Realist or Kodak will only set you back $100 to $150); the second is to mount two cameras together and trigger their shutters simultaneously; and the third is to obtain a beam splitter attachment. This mounts to the front of your lens, and using mirrors, places two separate images on one frame of film split vertically. At least three different models of these are available: one by Stitz; a second by Pentax at $154.95 (most readily obtained and comes with a viewer); and a third, which permits mirror adjustments for closeups, the Franka, at only $49.95. Optically, some distortion will result from this method, but it is more of a technical consideration than a practical one.

Changes in lighting conditions between shots should also be avoided. Be careful of cloud shadows and partially charged electronic flash units. Ideally, mount your flash on a separate tripod so that the subject receives the same illumination in both shots.

For ultra close-ups under studio conditions try fixing the location of the camera and lighting and rotating the subject 4 to 8 degrees between shots. To do this, center the subject for best appearance, rotate it half the total degrees to your right (left view of subject) and make an exposure, then rotate it the total number of degrees to your left (right view of subject) and make the second exposure. A turntable made from something like a rotating desk caddy with an affixed 6" circular protractor and a carrier for your drape will make this very simple. Your flash should be attached to the rotating table to maintain consistent lighting. A high intensity lamp may be easily moved around to help you decide on the best placement for the flash. Use a medium focal length (80 to 100mm) lens to minimize distortion and use minimum aperture (f22 or f32) to maximize depth of field. Automatic extension tubes or a bellows will permit the desired reproduction ratio to be attained. A powerful TTL controlled flash will provide plenty of light, even at these small apertures, and will ensure good exposures.

Presentation of the processed stereo pairs can be accomplished in several ways. Print pairs will require a viewer for most people. The art of free viewing (using no viewer) prints or slides can be acquired with practice, however, some people never get the knack of it. Inexpensive print viewers for 3 1/2" x 5" prints (as from a beam splitter) are available as are more expensive viewers for the old stereoscope format of 3 1/2" x 7". For the latter you would have to cut and match and mount your prints. Inexpensive plastic prism viewers allow viewing of separate prints of almost any size either horizontally or vertically separated. For slide pair viewing, inexpensive available light viewers are made for either the Realist format or standard mounts. When using an SLR you are not limited to always holding the camera horizontally, so be careful of trying to view the images in a different orientation from which they were taken as sometimes it will almost work, but trying to figure out what is wrong can be quite exasperating. For the ultimate in 3-D viewing, or for larger groups, projection is the answer.

Stereo projection works by having the two projected images pass through polarizing filters set at 90 degrees to each other (at plus 45 degrees and minus 45 degrees), and thence onto a metallized projection screen which maintains the polarization, and finally through the viewer's glasses which have polarized lenses matching those of the projection system. In this way the left eye only sees the left image and the right eye only the right. If the viewer tilts his head sufficiently to the left or right, he will see both images with both eyes. This is not something he will want to do often. Stereo projectors from the 1950's are somewhat difficult to locate and are basically limited to the Realist format mounts. There is a modern magazine fed projector being made in England, however the cost is prohibitive (over $1500). But have no fear, it's Kodak Carousels, or for that matter two of almost any projector with matching lenses, to the rescue. With the addition of 3" x 3" polarizing filters two projectors become a stereo projection system. They will work side by side, but there is less distortion if one is mounted above the other. Two slides taken of the same test pattern type subject without moving the camera are useful in aligning the projectors. It doesn't matter whether the left slide is in the left projector or the right one or the top one or the bottom one, as long as the filter on that projector matches the filter in the left lens of the glasses. The "silver" lenticular screens are very common and the glasses are inexpensive and readily available.

The best all around reference for stereo photography, including history, theory, equipment, and technique, is "The World of 3-D" by Jacobus G. Ferwerda. For the more technically inclined, "Stereo Photography" by Fritz G. Wrack is a good choice. The source for these books and all other 3-D accessories except cameras and projectors is Reel 3-D Enterprises, P.O. Box 2368, Culver City, CA 90231. They will be happy to send you their informative catalog. Cameras, projectors, and some accessories are available from Stereo Photography Unlimited, 1005 Barkwood Court, Safety Harbor, FL 34695, or from various classified advertisers in the "Shutterbug", P.O. Box F, Titusville, FL 32780.

Add another dimension to your photography and double your fun, take stereo pairs instead of one!

I GOT THE PHOTOGRAPH -- NOW WHAT DO I DO WITH IT?

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What good is a photograph if you can't find it when you want it?

What good is a photograph if you <u>can</u> find it, only to discover that the color has faded or shifted? Or the image is scratched, or chipped, or fingerprinted, or blemished, or marred or otherwise less than perfect? What good is it?

I think most of us can agree that it's not much good at all.

The proper organization and storage of photographs requires some careful thought and a moderate amount of expense and time <u>up front</u>, but the rewards at the back end can be enormous and well worth your time, effort and money, if you consider the "frustration factor" alone. Very little in life is more satisfying than actually being able to find what you're looking for in the place it ought to be and finding it in pristine condition, ready for a multitude of uses.

Initial organization actually begins as soon as your photographs come back from the processing lab. This is the perfect time to immediately <u>weed out and DISCARD</u> any images that are out of focus, of lesser quality, of inappropriate subject matter or duplicate images. You may have valid uses for multiple or similar images of the same thing, and that's fine, but remember it's also very easy to have a duplicate print or slide made when you need it, and my experience has been that one specific view is usually the one you use over and over, so keeping a lesser view is most frequently a waste of valuable time spent dealing with it and in taking up even more valuable storage space. I therefore strongly urge you to be relatively ruthless in deciding what to discard! The quality of that image is never going to get any better so get rid of it now and save yourself the aggravation of having to deal with it further.

Next, you should immediately <u>date and identify</u> your images, preferably directly on the slide mount or very lightly in pencil on the back of the print itself. This information will never be more available or more precise than it is when you deal with the image for the first time and the more time that goes by, the more vague your identifications are bound to become. And -- trust me on this one -- years from now some poor family member, historian and/or photo archivist will bless you for it and ever after speak your name with reverence and admiration!

Having decided <u>which</u> images to keep and having identified them properly, you must next make some decisions on <u>how</u> you wish to finally organize them into a functional system.

Whether you are using a manual or automated system, the organization of photographic images requires careful thought to determine what will be the most efficient and logical retrieval system for YOU.

Generally, I favor organizing positive images by <u>subject matter</u> into several broad <u>categories</u> which can then be subdivided again and again as necessary. Because my collections deal with so many different subjects, starting with the very broad subject heading of "Geology," for example, serves to keep all my geology related photos together and not get them inter-filed with anthropology or zoology photos. I can then subdivide within the area of Geology into other areas such as "field trips," "exhibits," "minerals," "mines," etc., and continue to narrow the scope within all of those subdivisions until I have easily manageable groups of findable images.

Photographs can, of course, be organized by date or even by an arbitrary accession number, but these are at the very top of the list for the <u>least</u> desirable methods because if you can't remember the date or number of the photo you want, you're stuck looking through an awful lot of photos that have no relationship to what you want. The "frustration factor" rears its ugly head again!

It's important to remember that there are lots of options when it comes to categorizing your images and you need to give careful consideration to the method that will suit your purposes most effectively. Say you have a 1982 photograph of Jack Murphy removing a spectacular quartz crystal specimen from a site in Colorado. If you ignore the possibility of just lumping this photo in with all your other 1982 photos, you could decide to file it under "Jack Murphy," or "Quartz Crystals," or "Colorado Sites," or even "Specimen Removal Techniques." Any of those categories are valid; what you have to do is decide which one will best suit your needs. What were you trying to illustrate when you took the photo in the first place, and which aspect of the image is likely to be most important to you in the future? At this point there are really no "wrong" decisions; just decisions that may be easier to live with than others, particularly as your collection grows. If you only have a hundred photographs it's no problem. It's when your collection starts to number into the thousands that major obstacles may need to be overcome. On the other hand, nothing about this system is carved in granite or set in concrete. Categories can be changed, modified, broadened, narrowed, or even eliminated if the need arises.

Cross-referencing your collections can be an important tool in future retrieval. If you are computerized, you probably have search capabilities and can find the images you need through key words or fields no matter what the physical storage location might be. But if you have to search manually through a large collection, that's an entirely different ball game and there are two different approaches you might take. One would be to have photocopies, duplicate prints or slides made and simply file them under all the likely categories. This method is expensive and takes up a lot of storage space, but it works. A second, and somewhat more reasonable method, is to simply write a note, or several notes, stating what and where the image is and put them in with secondary category images. Then, when you are looking through the "Quartz Crystal" photos you will also be directed to look at a photo in the "Jack Murphy" file and/or any other categories which you might have cross-referenced to the "Quartz Crystals."

Another common organizational problem is not being able to find the correct negative when you need it. Prints and negatives should NOT be stored together. In order to insure saving at least a portion of your collection in the event of fire or flood, negatives should be stored separately, completely away from your positive images, in another room or, even better, in another building if at all possible. About the easiest way to find a negative is to give it a unique number. That number is then written on the negative's border in permanent ink. The same number is written lightly in pencil on the back of the matching print, and you may then file your negatives away in numerical order.

The numbering system you select is not of great importance but it is imperative that each number be unique, and I always favor keeping it as simple as possible. One very easy numbering system is simply to start at "1" and keep going. I don't particularly care for this system simply because the numbers don't tell you anything and eventually your numbers can get very large and unwieldy, but it does work. For prints and negatives, I find it more preferable to work the date into the number. For example a number like "89.001" tells you that this is the first image numbered in 1989. This has the clear advantage of <u>dating</u> your work automatically and also keeps the number groups to a more manageable size since you will start over again each year; the changing year component making the number unique.

For numbering slides I have found that assigning a number which is also its exact storage location is very simple but effective. I categorize my slides in the same broad subject headings, although I do not generally subdivide them as narrowly as I do prints. I store the slides on Mylar pages which accommodate 20 slides per page and fit nicely into 3-ring binders. I then assign a 3 or 4 letter code to represent the category and complete the unique number by assigning a page number followed by a specific slot number. In other words the first slide on the first page in the "Geology" category would be numbered "GEO 1-1" and the last slide on the first page would be "GEO 1-20." The slide's number is permanently recorded on the slide mount and returning it to its proper location is always easy no matter how many times it is removed or for how long.

When I remove a print from its file I always note the <u>file name</u> on the back of the print to make its return to the correct file a simple operation.

Negatives, of course, are simply filed numerically, so returning them to their proper location is easy.

The next important step in maintaining control is to establish a checkout system so that you know what has become of any image removed from its file or slot. And the one thing I have learned about checkout systems is that if it's not quick and easy, it's not going to get done because nobody will bother, including yourself.

For my system, I have designed several checkout forms in standard sizes of 2x2, 2¼x2¼, 4x5, and 35mm. Minimum information requested is the image number or title, date, name, and reason for removal. The completed checkout form then replaces the image in the file and remains there until the image is returned. I don't require detailed information on the form, just enough so that months later if I need to track the image down I will know its number, who took it, how long they've had it and what they planned to use it for. The "what they planned to use it for" part is really very helpful in jogging memories, especially when the same person has checked out several photographs over time for several different purposes. I personally check out images constantly for a variety of purposes and I cannot always remember why. I have learned, however, that when I do remember why, I can more easily figure out where to look for it.

I have also learned that it simplifies my life to use the checkout form as an out-card in the place the image belongs. Then, when I am going through the file, I have an instant explanation for why the image is missing. I have found that trying to keep track of a lot of little slips or keeping a master list is a lot more trouble than it's worth and it seems to become just one more thing to account for. If I need to insure a return deadline, I simply jot a note on my calendar for the date it is due and I can follow up from there if necessary.

Now that you have brought order out of the chaos, you need to give your attention over to the matter of insuring the longest possible life for your photographic images through proper care and storage.

First of all, you should be aware that while many external factors can damage or destroy photographs, there are also problems inherent with photographic materials and chemicals themselves which can hasten their own destruction and also present opportunities for contamination of other photographs in which they come in contact.

At present, only B&W, archival processed photographs on fiber-based paper are considered permanent photographs. Most contemporary gelatin prints are processed on resin-coated paper [more commonly known as "RC"]. The resin coating limits absorption of processing chemicals and thereby speeds up washing and drying times which explains their growing popularity. However, a number of problems have been observed with these papers, including crazing of the emulsion surface and, at this point, they cannot be considered permanent.

Newly developed, stabilization processed prints are fed into a quick processing machine where 2 solutions activate a developer in the emulsion and stabilize the developed image. A damp-dry print is produced in about 10 seconds, which you can see makes them very appealing indeed. Unfortunately, these prints are loaded with extra strong hypo and are not only unstable in themselves, but may contaminate any photograph placed in contact with them. Since chemicals can migrate through paper, there is real danger of contamination during storage even though prints are in separate envelopes.

Color prints are always produced on RC papers. And, just to make matters worse, they face additional problems from the dyes which produce color.

Contemporary color dyes are unstable and fading is unavoidable in today's technology. This is true not only for color prints but for transparencies on film as well. It is important to know and remember that fading continues even in the dark, a phenomena which is known as "dark fading."

Reversal color developed films like Kodachrome have color forming agents in the processing chemicals and have a proven dark storage life longer than that of other color developed films. Cibachrome is a darkroom-speed reversal material for display type transparencies or prints and has a much higher resistance to image fading from exposure to light than conventional color developed images.

Therefore, you would do well to select your camera film for the longest dark storage life you can get and make duplicate films for work purposes choosing film which has the greatest resistance to fading when exposed to light. It also makes good sense to select your film processing lab for known reliability or, if you do your own processing, to keep these considerations in mind and act accordingly.

Temperature and humidity control is the most important step that can be taken in protecting a photo collection. Ideal conditions would keep the temperature no higher than 70° F. and the relative humidity between 40 and 45%. The <u>lower</u> the temperature the better but relative humidity above 60% or below 25% can bring on other harmful effects. You may want to consider installation of an air-conditioner and dehumidifier to help stabilize environmental conditions in your storage area. And, of course, storage in damp basements or hot attics should be avoided completely.

Light, or more specifically the UV spectrum in light, will potentially cause damage to your photographs. The 2 worst offenders are direct sunlight and fluorescent light. I recommend the use of UV shields over all fluorescent fixtures in your storage and work areas and UV shielding plexiglass sheets directly over matted photographs on display. Damage also depends on the intensity and length of exposure to light so it is prudent to display photographs in subdued light and, very important, <u>use only **duplicate** slides for projection in lectures</u>. Keep your original slides in safe, cool storage and use them only for duplicating another slide when the lecture slide begins to deteriorate.

Some other damaging substances of which you should be aware include gaseous or solid particles found in air pollution and fumes from nearby materials such as cleaners, solvents and insecticides. An air filtration system can be installed for a fairly moderate sum. It should have specially designed filters for both gasses and particles and should also have a fan to pull incoming air through the filters.

Dirt and oils from fingerprints, dust, insects, fungus, and even water are normal everyday problems which must be continually combated.

Work and storage areas should be kept as clean as possible to keep dust and dirt out of the area. Food and beverages should be consumed elsewhere in order to prevent accidental spills and discourage insects, many of whom will eat anything organic including photographic paper and emulsion.

Most properly, you should wear clean, white cotton gloves when handling photographic materials because the dirt and oils from your fingers and hands can permanently damage emulsions. Cotton gloves, however, can also make it difficult to manipulate prints and negatives, so if you find you cannot work with them, do be certain to wash your hands frequently and be extremely careful to handle photographic images only by corners and edges and never to touch the emulsion surface.

I would also like to warn you about some rather commonly used items which are also harmful to photographic materials and, interestingly enough, some of these items have been made specifically for photographic use! They include: paper and glassine envelopes and sleeves, photo albums, mounting boards, cardboard, adhesives, rubber bands, rubber cement, printing and writing inks, raw wood, unprotected steel, newspapers, and some plastics.

The days of stuffing photographs into old cigar and shoe boxes should be gone for good, thank heavens, so the problem is what are better ways to store photographic images?

There are a couple of terms that should be your constant guide when selecting storage materials. They are: **INERT, and ACID-FREE.**

INERT plastic is mylar, triacetate or polyester. These plastics do not give off gasses harmful to photo emulsions. But please be aware that they do not breath either, and therefore, they should not be used in high humidity situations and, because they tend to build up a static charge, you should never use them with old photographs or negatives which display a flaking emulsion.

I love inert plastic storage because it is clear and permits you to view the image without having to remove it, and thus reduces handling problems. You can buy them in standard notebook size pages which have been compartmentalized in all standard photo sizes from 35mm to 8x10. You can also buy individual inert plastic sleeves in all standard photo sizes and they are of great benefit in handling negatives, transparencies and prints alike.

ACID-FREE means that the acid content of a paper product is neutral in pH. Acids in paper have a tendency to migrate and eat away at anything in close contact. Acids will also eventually destroy the original paper as well. Acid-free paper may also be "buffered" with calcium carbonate which offers considerable long-term protection against the paper drifting to the acid side. I have not been able to find any studies which indicate buffering is bad for photographs although some conservationists have voiced concern. I have elected to continue using them based on known long-term protection versus unknown effects of buffering, but of course, you will have to make your own decision and plain, unbuffered supplies are readily available now.

You can buy acid-free paper negative envelopes, file folders, storage boxes and even photo albums in a variety of sizes and shapes to serve a multitude of purposes.

Other storage considerations include cabinets and/or shelving. Basic storage equipment should be constructed of noncombustible and noncorrosive materials such as anodized aluminum, stainless steel, or steel with a baked-on enamel finish. Wooden cabinets, shelves or drawers are bad because they can leach acids.

And yes, archival storage materials are generally more expensive than the regular kind, but if you want long-term protection you just have to bite the bullet. I can't believe you'll ever regret it, and in the long term, I believe the pleasures derived from ease of access and image life span that comes from the careful organization and storage of your photographs are worth every bit of the time and expense involved. I think you'll find that once your system is in place, it really doesn't take much to keep it going.

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BLACK AND WHITE PHOTOGRAPHY OF FOSSILS AND ARTIFACTS

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Today the use of black and white photography is more specific than in the days when it was less expensive and more readily available than color film. Black and white photos are most commonly used in the area of publications. including journals, magazines and newspapers; this will probably continue for some time. The black and white process is also used for archival records, as the long term storage and display of black and white photographs still greatly exceed that of color. Some artists also prefer black and white because the ability to control and manipulate the film and papers allow alterations in contrast and value relationships, and provide interpretative freedoms not always available in color.

There are an infinite number of solutions or choices in the photographic situation. Since each subject may be uniquely different, the approach to photographing it will have its own form of presentation. As our purpose is specific to minerals, fossils and artifacts, we can concentrate on what will probably be a table top situation.

Our first choice in photography is whether we are inclined to use the artistic and creative approach or are we being guided by technical parameters. Artistically, we are not bound to the confines of reality and may choose any means to achieve the desired results. Faults in a subject can be minimized and the important features brought out by the choice of angles, use of depth of field and the lighting. On the other hand, the technical photograph must be a true representation of the object and conform to the expectations of the viewer. Placement of the black and white values must accurately portray the specimen to reflect the equivalent color values. Scales for true size relationship are important to the viewer as well as the necessary details contained in the object. You are trying to show in two dimensions and tones of grey what the eye sees in color and in three dimensions; sometimes a difficult endeavor.

Lighting options may be based on expense, availability or purely preference, and will be influenced by the choice between documentation and artistic expression made above. Use the main light source to define the shape and to emphasize the notable features of the object. Hiding defects with shadows may be desirable unless they compromise the integrity of the object in the photograph. Well placed shadows will help define the subject and add dimension. For example, a round object evenly illuminated will appear to be a disk rather than three dimensional. Additional light should be used to fill the shadows with enough light to record some detail, and also provide some definition of shape. Use a weaker light or reflectors for this purpose. The best use of lights will yield the best photographs.

Available Light: Available light near windows or outdoors yields pleasant results. Controlling this light is difficult, but with the use of reflectors shadows can be filled and highlights added for definition.

Electronic Flash: The advantage, for me, is the portability of hand-held flash units. In the studio or on location, a tripod may not be usable so the speed of flash is desirable. Also, a great advantage of strobe lighting is in cases where the subject moves. (Not usually a problem with minerals, fossils and artifacts.)

Tungsten Light: In the studio, tungsten lights are my preference due to ease of focusing and control of depth of field. Color balance doesn't matter in black and white, however, compensation must be made for the speed of film being lowered in response to artificial light relative to daylight. Intense heat from the lights may also be a problem with artifacts, particularly those of organic nature. The amount of light to which they are subjected must be kept to the minimum consistent with film speed. This is where a compromise with a faster film may become important.

Choice of film may be partially based on the photographer's preference. Using a familiar film has the advantage of predictability, but may not be suitable for a particular situation. Choices vary with manufacturer but the greatest variables will be found in film speed. As a general rule, as the film speed increases so does the appearance of grain and the extension of latitude. The inherent contrast is lowered and there is a loss of resolving power and sharpness. In most cases the desired film is the slowest film (ISO) that can still do the intended task, determined by the object itself or the lighting required by the subject.

Camera and lens choices are also dependant on the situation; for many a 35mm camera with a good macro lens is best. Todays films provide great magnification while maintaining the desired detail. The macro lens is designed for close-up work and doesn't require the exposure calculations of working with bellows extensions. Medium format cameras are more expensive but provide a larger film surface. Some also have polaroid capabilities for added control over lighting, focus and exposure. For these purposes I prefer the 4 x 5 inch large format camera. The addition of swings and tilts gives control over perspective and plain of focus. All of these controls plus the capability of a large film image provide great results, but the large size of the camera can be excessive when dealing with small objects.

Prints for publication should be the best representation of the object you can achieve because the quality of the printed piece is usually downgraded in the printing process. Prints should be on a glossy or other non-textured surface. Important highlight and shadow detail should be recorded completely as well as defining the full range of middle tones. Prints should be protected against scratching and finger prints by a non-abrasive cover sheet. For long term storage or display prints should be on a fiberbase paper. Some recommend resin-coated paper for this use, but they must be properly processed. The print should be completely fixed and washed. Prints from the local lab will usually not meet the requirement of longevity, unless archival printing is requested. The use of gold or selenium toner should be used as additional protection to the life of the print. Toning can also heighten the blacks for crisper appearance. Air drying of fiber-base prints adds life to the print over heat dried techniques.

PHOTOGRAPHIC ESSENTIALS

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All that is really necessary for photography is a lightproof box with a lens that will focus an image on film. Why do cameras cost $500.00 or more? Because we want them and there is a big difference between necessary and nice.

The Camera:

Todays nice basics consist of a single lens reflex for direct focusing through the lens. There is a wide selection of interchangeable lenses, from a 12mm fisheye to a 1200mm telephoto. Light is measured through the lens. There is a choice to use the light meter on manual or automatic, and through the lens flash metering. The programmable to automatic shutter-aperature priority makes photography easier than it used to be. Shutter speeds range from several seconds to 1/2000th of a second. And there are other advances, such as motor drive and rewind, DX film coding, data record keeping, lockup mirror for vibration free micro photographs and view finders with digital read-out of exposure.

Camera formats are grouped in 3 sizes. The 35mm is the handiest to carry and use. They have many accessories and overall are inexpensive to purchase and use. Medium format cameras are 2 1/4 x 2 1/4 inch to 2 1/4 x 3 1/4 inch. Because their film areas are much larger they are suitable for making large prints. Film and processing is more expensive, and generally there are fewer accessories than for the 35mm. Larger format (field and view) cameras are usually 4 x 5 inch in size and use film holders. The field camera folds up and is more compact for use on location photography. It has some swing and tilt of the lens and film holder, while the view camera, which is for studio use, has almost unlimited movement capabilities. These features allow for all types of flatness of field correction and depth of field coverage over a large specimen. The higher costs of these cameras (and film and processing) limit their use mainly to professionals.

Lenses:

For specimen photography the lens used most will probably be a macro of 50mm to 55mm focal length. Macro lenses with a focal length of 75mm to 100mm provide more working space for lights; however, the longer focal length will cut down on depth of field and a large specimen may be difficult to cover and keep sharp.

Many zoom lenses have a macro focus position and some will give as high as 2 to 1 magnification. The newer macro focusing 2x tele-extenders will give a 1 to 1 magnification with a normal 50mm lens. A simple +3 portrait lens over your normal 50mm lens works well for many in-the-field closeups.

Extension tubes or bellows with a normal or a wide angle lens will go beyond 1 to 1 magnification and can be used to photograph micro-minerals. Going beyond 1 to 1 magnification will require a lens reversing ring as the lens to film distance will be longer than lens to subject distance. At this magnification, camera, bellows and lens must be moved as a unit to focus on the subject.

Lights:

Black and white film can be exposed with any or all of the following light sources (see Fig. 1); however, when using color you must gauge the color of the light. You will have to gain some experience by using different films with varying light conditions.

The electronic strobe is a very portable and manageable light source. It is daylight color balanced with no need for special film or filters. Strobe lights are suitable for outdoor flash "fill" in shadowed areas or for shaded subjects. In the studio, for large specimens, I use 2 strobes, one with a diffusing screen to break up shadows, the other without which creates brilliance and sparkle. Bouncing a strobe light off a photo-umbrella will also break up unwanted shadow.

For small specimens I use a light box made of translucent plastic in a semicircle with space for specimens inside and a track around the outside to position multiple strobes, modeling lights or a ring light. The ring light goes around the lens and gives a very flat even type of lighting. It can be used in combination with strobe lights. A ring light attached to the microscope also works well. Modeling lights can be a flashlight or any small spot light that is used to create or diminish reflections and shadows.

Reflectors are useful outdoors to balance lighting and fill shadows, or, to aim light down into an excavation pit. They can be as simple as white paper or a sheet of newspaper. In the studio, colored reflectors may be used to change or enhance the color on a subject, or the shadows of the subject. A sheet of aluminum foil is easy to carry and works well as a reflector.

A word of warning: photo floods, spotlights and quartz lights work well in specimen photography but watch out for excessive heat which can damage specimens as well as cameras and film.

Light meter:

The reflected light meter built into most 35mm cameras will give good exposures in daylight or with photo floods. This meter will not give good exposures if the subject is all, or almost all, white or black. The answer to this problem is the 18% gray card. Take the meter reading from the card with the in-camera meter (or hand held meter) to give you the best balanced exposure. The flash meter is another necessity. It reads and calculates the flash from one or more strobes (combined with room light) to give the correct exposure. Since flash meters read the light falling on the subject, their accuracy is very good, even on extreme light and dark contrast subjects.

Tripod:

I use a vertical center post tripod with an extension arm mounted at right angles where the camera is mounted. This setup allows me to place the camera over a table, in my light box, or down in an excavation. Along with the tripod, a cable release is necessary to prevent camera movement during exposure.

Filters:

In black and white specimen photography filters are used to increase contrast. Read the color sensitivity charts for black and white film for recommended filters to match subject. Color film filters will primarily be used for balancing light to film color temperature. Don't be afraid to experiment as some clear minerals take on special effects with colored filters.

Equipment:

There is a variety of soft carrying cases, gadget bags, photographer's vests or metal suitcases for carrying your photography gear. With experience, you find what is practical for you. Don't forget other bits and pieces like lens hood, angle view finder, c-clamp tripod, lens cleaner, plastic rain bag, lead foil bag for airline x-ray machines, extension cords, slave tripper for strobe lights, plus other equipment that is either necessary or nice.

Video:

"Camcorders" (combination video cameras and tape recorders) are now made by all major camera and electronic manufacturers. There is a large variety of portable self-contained units to choose from, depending upon your goals. The main differences between these video cameras is size, weight, level of light sensitivity and power of the zoom lens. The size of the magnetic video tape and the type of machine go hand in hand, in other words, if you want to use 8mm tape you have to buy a 8mm video camera. The standard formats for home videos are 8mm and VHS (1/2 inch wide). Standard T.V. station broadcast and professional production size video tapes are 3/4 inch wide.

I use the 8mm format which is the smallest unit and tape size, but with one of the highest quality images. It can be edited and transferred to VHS tape for the convenience of showing it to anyone with a VCR video recorder.

Prices of amateur video cameras have been decreasing and now are in the range $800.00 to $2,000.00. Accessories such as dubbing or editing units, quartz lights, a slide transfer unit, auxiliary wide angle, telephoto, or close-up lenses, plus the VCR playback recorder, and the T.V. monitor are all considerations that cost extra.

With video equipment that is now available you can document your field trips and finds, plus add images from 35mm slides or old photographs, all while narrating (with background music) your own script. You can also easily document your collection of minerals, fossils or artifacts with video images and accompanying narrations.

SUMMARY OF 35mm COLOR FILM

With experience you can select the film that best suits your needs. The following comments apply to all film types and manufactures.

KODACHROME

KM135	25 ASA	Fine grain for sharp slides and large prints.
KR135	64 ASA	Medium-fine grain; faster film speeds works well in hand held cameras, gives acceptable sharpness
KL135	200 ASA	Not as fine grain; high speed allows for use of long telephoto lens, and/or low light.

EKTACHROME

EC135	100 ASA	Similar to characteristics noted above.
ED135	200 ASA	" " " " "
EL135	400 ASA	" " " " "
EES135	400 ASA	Made to be pushed processed to 1600 ASA.
ET135	160 ASA	Use with Tungsten 3200 K. lights.
EPY135	50 ASA	Use with Tungsten 3200 K. lights.
EHC135	100 ASA	High color saturation.

FUJICHROME

RF135	50 ASA	Fujichrome slide film will normally produce more pastel colors and a little better green.
RD135	100 ASA	
RH135	400 ASA	

SUMMARY OF COLOR TEMPERATURES
(Temperatures in degrees Kelvin)

Clear blue sky (north)	12000 K.	No film available
Clear blue sky(sunlight)	6500 K.	Color balance of daylight film
Strobe light	6500 K.	Color balance of daylight film
Sunlight (noon)	5400 K.	Add some blue to daylight film with a filter
Photoflood lamp	3400 K.	Use tungsten film w/ filter
Tungsten lamp	3200 K.	Use tungsten film
Household lamp	2500 K.	Use tungsten film w/filter
Candle flame	1900 K.	Not recommended

The mixing of light sources with different color temperatures is not recommended with color films except for special effects.

PHOTOGRAPHY OF FLUORESCENT MINERALS

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Introduction

Fluorescent minerals are those which emit visible light when exposed to invisible ultraviolet radiation. The effect can range from bright and spectacular, to faint and elusive. Fluorescence provides a valuable tool for mineralogists to learn about the composition, growth history, and crystal structure of minerals. For the mineral collector, it can present a fascinating new dimension to the variability and beauty of minerals. About 15 percent of the known minerals can be visibly fluorescent. In most of these, fluorescence is due to trace-metal impurities--"activators"--though in some, there is intrinsic fluorescence caused by ions or molecules which are an essential part of the mineral (White, 1975).

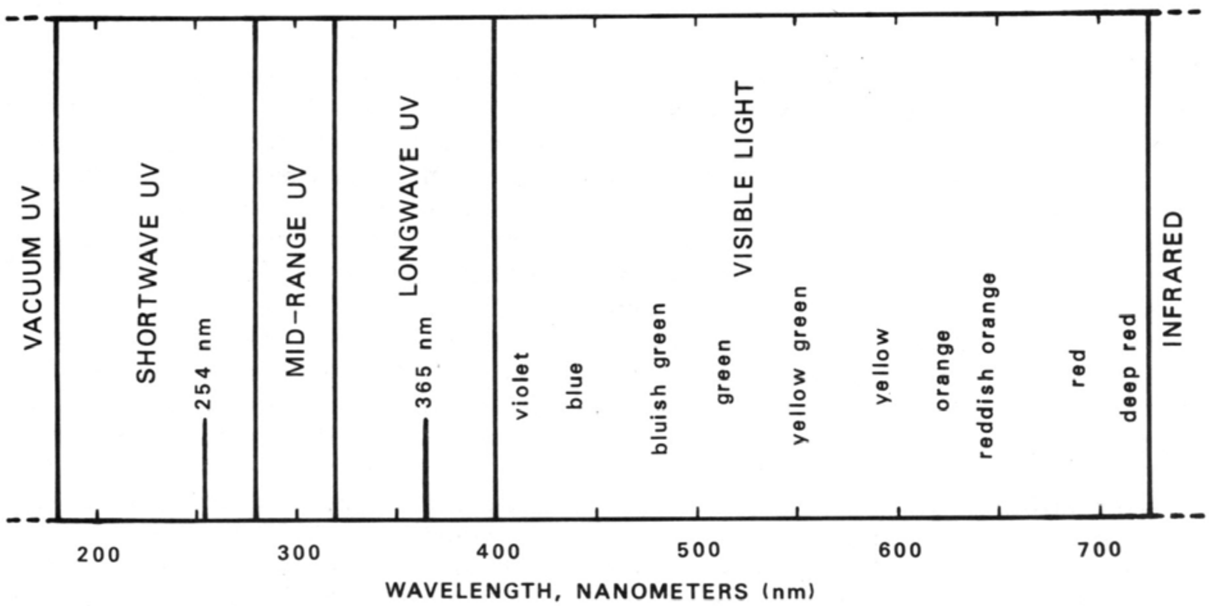
The visible portion of the electromagnetic spectrum (figure 1) extends from wavelengths of about 400 nanometers (nm)--violet light--to about 700 nm (red) (400 nm = 4000 Angstroms). The sensitivity range of the human eye may extend slightly beyond these limits. The ultraviolet (UV) region extends to shorter wavelengths than the 400 nm limit of visible violet light. In mineralogy, two parts of the UV spectrum are commonly used for the excitation of fluorescence; (1) the shortwave UV region (from about 180 to 280 nm, and exemplified by the wavelength of 254 nm that is strongly emitted by a mercury vapor lamp) and (2), closer to the visible spectrum, the longwave UV region (from about 320 to 400 nm, and particularly the mercury line at 365 nm). The region from 280 to 320 nm is known as the mid-range or middle UV (it is this part of the solar spectrum that is responsible for tanning and sunburn), and the high-energy UV region from 180 nm down to the boundary with soft X-rays at 10 nm is known as the vacuum ultraviolet because it not transmitted through air. I will use the term "fluorescence" to mean the emission of visible light produced by ultraviolet-light excitation; "luminescence", a more general term, can refer to light produced by a variety of excitation mechanisms, a few of which will be briefly mentioned.

Because the subject and the photographic conditions are so varied and different from those normally encountered in photography, taking pictures of fluorescent minerals can be quite an art. Some published articles which may provide useful advice on fluorescence photography include those by Gregory (1965), Standfast (1980), DeMenna (1983), Modreski (1987), Snow and Brown (1987), Curasi (1989), plus short descriptions of photographic techniques (accompanied by 35-mm color slides) which have appeared over the past 16 years in the Journal of the Fluorescent Mineral Society (Chittenden, 1975; Turnbull, 1977; Modreski, 1975, 1983; and Fluorescent Mineral Society 1974, 1976, and 1987). Other valuable information on photographic techniques is found in Eastman Kodak* publications M-3 (1963), M-27 (1972), E-73 (1978), and P-2 (1980).

Minerals, of course, are the subject we wish to photograph, not to exclude gemstones, fossils (Rolfe, 1965), archaeological materials, and innumerable other objects for which fluorescence photography can prove very illuminating! Useful books and articles about the fluorescence of minerals

*Use of trade names is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

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



include those by Gleason (1972), Robbins (1983), Newsome and Modreski (1981), and Newsome (1982, 1985). The world-famous fluorescent minerals of Franklin and Sterling Hill, New Jersey, which have been responsible for much of the interest generated in fluorescent minerals, are described by Jones (1970) and by Bostwick (1977, 1982). A comprehensive summary of all the minerals reported to date to be fluorescent (566!) is the Henkel Glossary of Fluorescent Minerals, recently published by the Fluorescent Mineral Society, P.O. Box 2694, Sepulveda, CA 91343 (Verbeek and Modreski, 1989).

__UV light sources__

An ultraviolet light consists of the UV-generating bulb itself, plus a suitable "exciter" filter which screens out visible light from the bulb. The two common types of UV sources produce shortwave (SW) and longwave (LW) ultraviolet. A shortwave UV lamp produces ultraviolet light from a mercury vapor emission line at a wavelength of 254 nm; other mercury lines in the visible part of the spectrum, including those at 405, 436, 546, and 579 nm, are screened out by the filter. A longwave lamp produces light with a maximum near 365 nm; this emission is generally from a mercury vapor bulb coated on the inside with a synthetic phosphor; again, an appropriate filter screens out unwanted visible light emitted by the phosphor and the mercury discharge. An ultraviolet source as strong as possible is desirable for photography, to increase the brightness of the fluorescence and reduce the required exposure times. I have often used lamps such as the UVG-54 (shortwave) and UVL-56 (longwave) 6-watt lamps made by UVP, Inc. If available, it would be an advantage to use even more powerful display-type lamps, such as UVP's 15- or 30-watt shortwave lamps (UVG-D15 or UVG-D215), especially when photographing large displays, or minerals with weak fluorescence. Shortwave UV lamps manufactured before about 1981 contained filters which degraded ("solarized") with use, resulting in decreased transmission of ultraviolet light--to as little as 20% of the original transmission after a few tens of hours of use. A lamp with such filters would produce weaker fluorescence, both visually and for photography. Subsequently, a new formulation of filter glass has been used that shows minimal solarization (Warren, 1983; Newsome, 1988). Attempts at photography with a lamp which has a solarized filter of the old type are likely to be less successful.

Film

Nearly all of my photography of fluorescent minerals has used color slide film (color prints can be more easily and cheaply made from color slides than vice versa). Because fluorescent minerals present a considerably different type of subject than photography in ordinary light, the usual distinctions of proper film type do not necessarily apply. I have mostly used daylight-type films, generally either Kodachrome or Ektachrome, but in some case indoor-type (tungsten) film may give equally good or better results. You may want to take ultraviolet and ordinary-light photographs of each specimen at the same position and orientation; if so, you might prefer to use either tungsten or daylight type film, depending on whether you wish to do your standard-light photography with incandescent light or with a flash. Faster films are an advantage, to obtain greater depth of field and avoid inconveniently long exposure times. I mostly use Kodachrome 64, and Ektachrome 64, 200, and 400. For particularly dim fluorescent minerals, faster films with speeds of 1000 or more are available, and most films can be "pushed" to still faster speeds with custom developing. For carefully controlled work (especially when you have already determined the approximate correct exposure), "professional" films, which should be kept refrigerated and used without too much delay, can help insure greater uniformity of color rendition. Black-and-white photography of fluorescence is seldom used, but it does offer the potential of higher speed (3200 or more) and higher resolution of zoning or patterns of fluorescence.

Cameras

Most any SLR (single-lens reflex) camera capable of manual exposure settings is suitable for fluorescent photography. Most photographs will be long (more than a second), with manually timed exposures. For most of my photographs, I have used a Canon SLR (either an Ftb or an AE-1) with a standard 55-mm focal length, f/1.4 lens. I have occasionally used a telephoto (70-210 mm) zoom lens for photographs of large exhibits or for the convenience of zooming in on a specimen, much as one would use such a lens for portait photography. For macrophotography of small specimens, I have used the same zoom lens in its macro focusing mode, with or without extension tubes to further increase magnification. I've also had excellent results with a Nikon SLR with an f/3.5 Micro-Nikkor 55-mm macro lens. Since small apertures (typically f/8 or f/11) will be desired to give good depth of field for most exposures, a wide aperture (such as f/1.4) is generally not an important requirement, unless photographing very dim fluorescent minerals.

Barrier filters

For best results, an additional "barrier filter" should be placed over the camera lens to prevent ultraviolet light from entering the lens and registering on the photograph as unwanted blue light, or causing fluorescence (usually strong blue under shortwave UV) of the lens elements to further fog the film. Requirements for a barrier filter are that it absorb shortwave or longwave ultraviolet light (or both), that it not itself be fluorescent, and that it not absorb too much light in the visible part of the spectrum. A standard "UV/haze" lens filter will work, especially for longwave UV, but it is likely to fluoresce strongly under shortwave UV. Wratten barrier filters, available from Kodak as 75 x 75 mm (about 3" x 3") gelatin squares, are normally used. A metal frame can be purchased to hold the delicate filters, and for somewhat greater cost, one can get a threaded or spring-clamp holder to attach the frame to the lens (I just tape it on). Three useful Kodak Wratten filters are, in order of decreasing transmission of violet and blue visible light, numbers 2B, 2A, and 2E (see Kodak Publication M-27, 1972). Since the filters are not capable of perfectly blocking only the ultraviolet (wavelengths less than 400 nm) light, these three filters all appear pale yellow, and become slightly deeper yellow in the order listed. I have used either a Wratten 2A or 2E barrier filter for fluorescence photographs, and both have given good results. Even the Wratten filters may fluoresce somewhat, especially under longwave UV, and this may interfere slightly with very long exposure photographs. DeMenna (1983) has also suggested using a Wratten type O (UV) or K2 (yellow) filter. The best procedure is to minimize fluorescence by keeping direct UV light off the filter and camera.

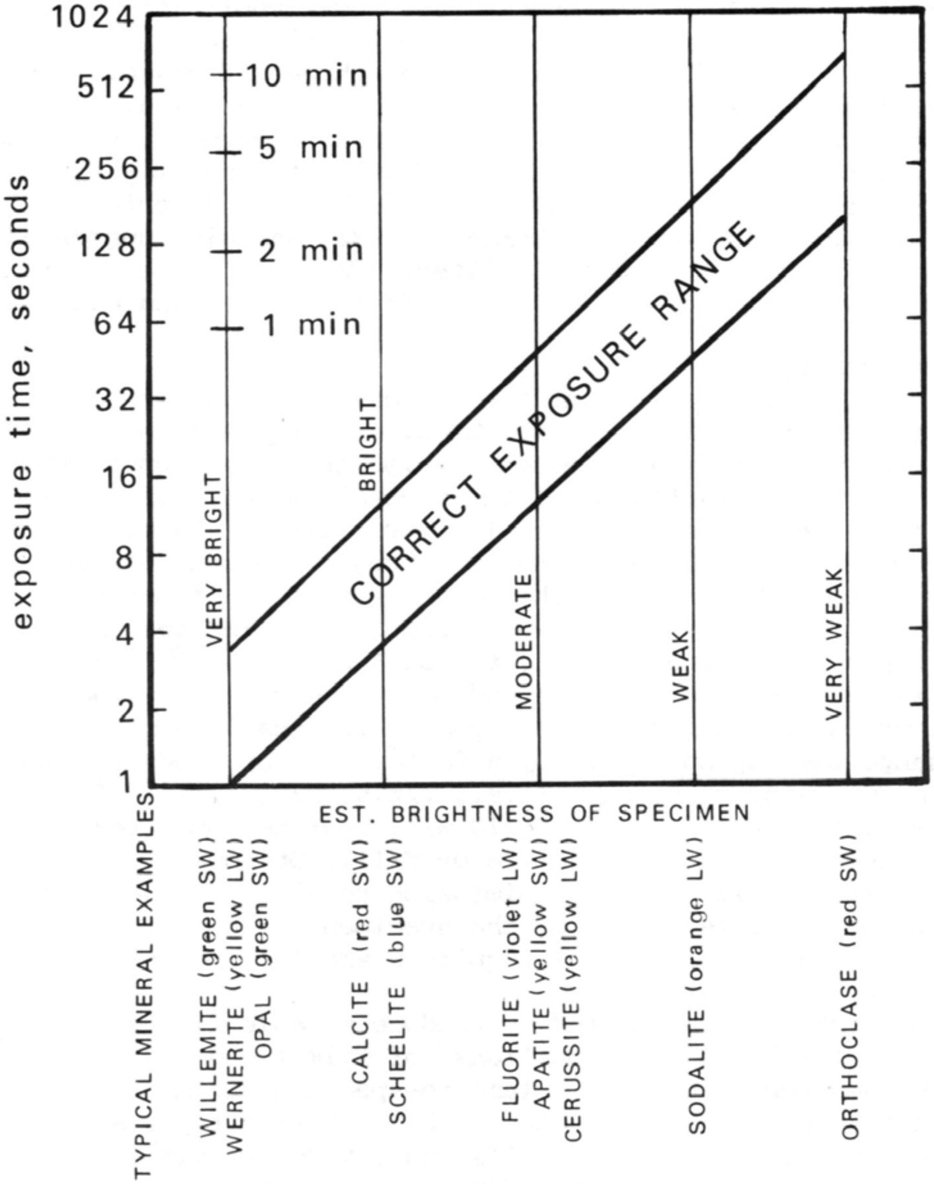
<u>Exposure conditions</u>

Trial and error to determine the approximate exposure conditions for a given setup, plus bracketing of exposures, are the basic ways to obtain the optimum exposure. The optimum exposure time is a function of the UV source intensity, intrinsic brightness of the mineral subject, lamp-to-subject distance, film speed, lens aperture (f-stop), type of barrier filter, and (for close-up, macro-focusing conditions) the subject-to-lens distance. If your camera has a sensitive enough light meter (some do), it may be possible to make correct or near-correct exposures simply by using the camera on its automatic exposure setting. Still, the best results will probably be obtained by bracketing exposures both above and below the metered value. Bracketing by making fairly large changes in the exposure is usually most efficient; I usually change the exposure time by a factor of 2 or 3 per increment, or the f-stop by a full stop up or down (i.e., f/5.6, f/8, f/11, f/16). Unless the specimen is quite flat, depth-of-field will best be conserved if a small aperture is used; I typically use f/8 or f/11. Obviously, a specimen oriented as much as possible with its flat dimension parallel to the film plane will put the largest possible amount of the specimen in sharp focus, and a specimen with high up-and-down relief will require a smaller aperture to produce a uniformly sharp focus.

DeMenna (1983) has attempted to produce a table giving approximate exposure times for "standard conditions" of film speed (64 to 400), shortwave or longwave lamp power (6 watts), lamp-to-specimen distance (16"), specimen-to-camera distance (16"-20"), f-stop (f/5.6), filter type, and color and intensity of the fluorescent mineral(s) as divided by him into 26 "color groups". Given these variables, DeMenna's recommended exposure times range from 1/30 to 150 seconds.

Figure 2 is a diagram showing the approximate range of successful exposure times I have used for minerals of different fluorescence brightness. Standard conditions for this figure are a film speed of 64, a UVG-54 6-watt shortwave or UVL-56 6-watt longwave lamp (I find the exposures to be comparable for both), aperture f/5.6 on a 55-mm focal length lens, lamp-to-subject distance of about 8 inches, and subject-to-lens distance of about 12 inches. The brightness of fluorescence of the minerals is an arbitrary, qualitative estimate. Newsome (1987) gives numerical measurements of the fluorescent brightness of various minerals. One could attempt to use such values to predict exposure times, though it must be remembered that relative brightness as measured instrumentally (on an instrument calibrated to correspond to the color sensitivity of the human eye) may not closely correspond to the color sensitivity of photographic films. The chart is an approximation but is offered as a useful guide to reduce the trial-and-error. Correct exposure time will be inversely proportional to film speed and lens opening (f/8 requires twice as long an exposure as f/5.6), and doubling the

Fig. 2 APPROX. EXPOSURE TIMES SW OR LW ULTRAVIOLET



standard exposure conditions: UVG-54 6-watt shortwave lamp or UVL-56 longwave lamp; Wratten 2E barrier filter; 55 mm lens; lamp-specimen distance 8 inches; specimen-lens distance 12 inches; film speed 64 ISO (ASA); lens aperture f/5.6

lamp-to-subject distance should require an exposure four times as long. For the focusing range (about 12" to infinity) of normal (low magnification) camera lenses, changes in the subject-to-lens distance do not significantly affect the exposure time. For close-focusing situations using a macro lens or extension tubes, increased magnification of the subject will require longer exposures. This becomes important when the image:subject magnification ratio is larger than about 1:5 (i.e., if the size of the image on the film is larger than 1/5 the actual size of the subject). The factor by which the exposure should be increased is given by $(R+1)^2$ where R is the magnification ratio, or alternatively by $(v/f)^2$ where v is the distance from the film plane of the camera to the mid-point of the lens (usually near the iris diaphragm) and f is the focal length of the lens (Koch and Marchesi, 1983, p. 115; Neblette, 1942, p. 89).

Background

A dark, non-fluorescent and non-reflecting background (and a dark room!) is a must for fluorescent photography. I prefer a completely black background for most photographs; flat black paint, black paper or cardboard, and cloth all work. Cloth is handy, but it can be a real problem to get all lint fibers off the cloth--they fluoresce brilliantly, and thanks to the high sensitivity of most films to blue light, fibers barely visible when focusing may stand out spectacularly in the final photograph, especially in closeups. An alternate technique is to use a dark-colored but slightly fluorescent cardboard to provide a blue or violet background to help outline the specimen. I find this to be helpful when the specimen consists of brightly fluorescent mineral grains set in a totally non-fluorescent matrix; with no background color, the photograph will show bright, unconnected fluorescent patches floating in a sea of black, with no definition of the shape of the specimen. Another useful variation is to briefly illuminate the specimen with white light after making the fluorescence exposure; then the brightly fluorescent patches will appear superimposed on the more dimly lit matrix of the specimen.

Technique

Because most photographs will require long exposures, you will need a means of manually starting, timing, and stopping the exposure. The system must be kept free of vibration during the process. A cable shutter release which can be locked to keep the shutter open for a time exposure is best. You can also use the auto timer on a camera to start the exposure without touching the camera. Another good technique is to cover the lens (without jarring the camera) with a suitable mask (lens cap, black cloth or card) when you start the exposure, to prevent any movement or vibration when tripping the shutter from affecting the photograph. A sturdy tripod to hold the camera is very important. Similarly, a laboratory jack stand to hold the specimen and adjust its position will be a great convenience. A watch or timer visible (or audible) in the dark is desired for timing the exposure. You'll probably want to use a white light when focusing on the specimen(s), especially if the fluorescence is not bright.

The ultraviolet light source should be positioned as close as possible to the specimen for maximum intensity, without blocking the field of view. The UV light should not shine directly on the camera lens because the lens elements may fluoresce. If the specimen being photographed is large or irregularly shaped, one may need to move the light farther from it to produce even illumination. A firmly mounted light source is usually most convenient, but there is no reason it has to be fixed; I have sometimes found it useful to move the light by hand during a long exposure--to more evenly illuminate all parts of the specimen, or even to intentionally highlight certain areas.

Other Types of Luminescence

Luminescence in minerals can be produced by types of excitation other than ultraviolet light, and I will just touch on these in this paper. Cathodoluminescence (CL) is luminescence excited by bombardment of the surface of a polished sample by a high-voltage electron beam. The beam is produced in a special vacuum chamber attached to a microscope. CL is a standard technique that provides much novel information about mineral zoning, growth, and origin, and it is commonly documented with photographs (Barker and Wood, 1986;

Marshall, 1988; McLemore and Barker, 1987). It has also been used in the study of gemstones (Ponahlo and Koroschetz, 1986). CL is usually bright enough to use a camera's standard light meter to determine exposure. An alternative technique to examining and photographing small areas for CL under a high-power microscope is to use a defocused electron beam to irradiate a 1-2 cm or larger area on a specimen and photograph it with a standard camera and macro lens (Mariano, 1983). Thermoluminescence is the glow produced when some minerals are heated, allowing electrons "trapped" in certain lattice sites to recombine with other ions. Commonly observed in minerals such as fluorite, calcite, and quartz, thermoluminescence is normally recorded with sensitive light detection instruments rather than photography, but it can be photographed; Weiner (1977) shows a photograph of green thermoluminescence of fluorite, as well as one of blue-violet phosphorescence from the same specimen. Phosphorescence is the continued afterglow of light emitted by a material after the source of excitation is removed; it is common in some fluorescent minerals but rare or absent in others. Because it is by nature always weaker than fluorescence, and is of continually decreasing intensity (though it may persist for very long times, up to thousands or even tens of thousands of hours (Millson and Millson, 1950)), phosphorescence is correspondingly more difficult to photograph. The color of phosphorescence may be the same, or be significantly different, than the fluorescence of the same specimen. Triboluminescence is light produced by scratching, crushing, or grinding a mineral; it may be seen in minerals including sphalerite, quartz, and calcite. Generally weak and short-lived, there have been few attempts to photograph it. Radioluminescence is a general term for visible luminescence produced by various types of high-energy radiation--X-rays, gamma-rays, protons, neutrons, etc. Although it has been known for many years (Kunz and Baskerville, 1903), photographs of this type of luminescence are rarely seen. Dooley and others (1985) produced color photos showing orange to pink luminescence of spodumene after neutron irradiation. Many minerals are also known to luminesce in the infrared part of the spectrum, upon exposure to ultraviolet or even visible light (Barnes, 1958); photography of such minerals could be attempted with infrared-sensitive film and special filter combinations to block visible light (Kodak Publications M-3, 1963, and M-28, 1970).

Photography in the field

There are many times when it will be desirable to take fluorescence photographs in the field--at a mine, quarry, cave, or rock outcrop. This isn't easy, and I've seldom attempted it. For one thing, battery-powered portable ultraviolet lights are usually not as powerful as the 120V lights; and, one is less likely to have all the other desired equipment--tripod, barrier filter, timer, cable release, etc.--handy in the field. Also, the time for the required long exposures, and the peace and quiet to take your time, and think about and record what you are doing, are not always available. I have taken some good fluorescence photographs of beaded helictites and other speleothems in "Silent Splendor" at Cave of the Winds, Manitou Springs, Colorado, but conveniently a 120V electrical cord was available in the cave then.

Special Problems:

Reciprocity failure in film is a problem wherein the film exhibits a fall-off in sensitivity for long exposures at very low light levels. Furthermore, the decrease in sensitivity may vary for the several emulsion layers which record the different colors on the film, resulting in a change in the color balance of the image. Experimentation is necessary to see if this causes a significant problem; if it does, color filters may be used to correct it (Kodak Publication M-27, 1972).

Another effect that will be noticed in fluorescence photography is that colors appear to change as the brightness of the recorded image increases, particularly as the more brightly-fluorescing part of a specimen becomes overexposed. Thus, green fluorescence of willemite tends to appear yellow and then white with increasing overexposure. This effect is a problem mainly when photographing a specimen that contains several different fluorescing minerals, some of which are significantly more brilliant than the others. There is no universal solution, but a slightly underexposed photograph may give the best results in this case.

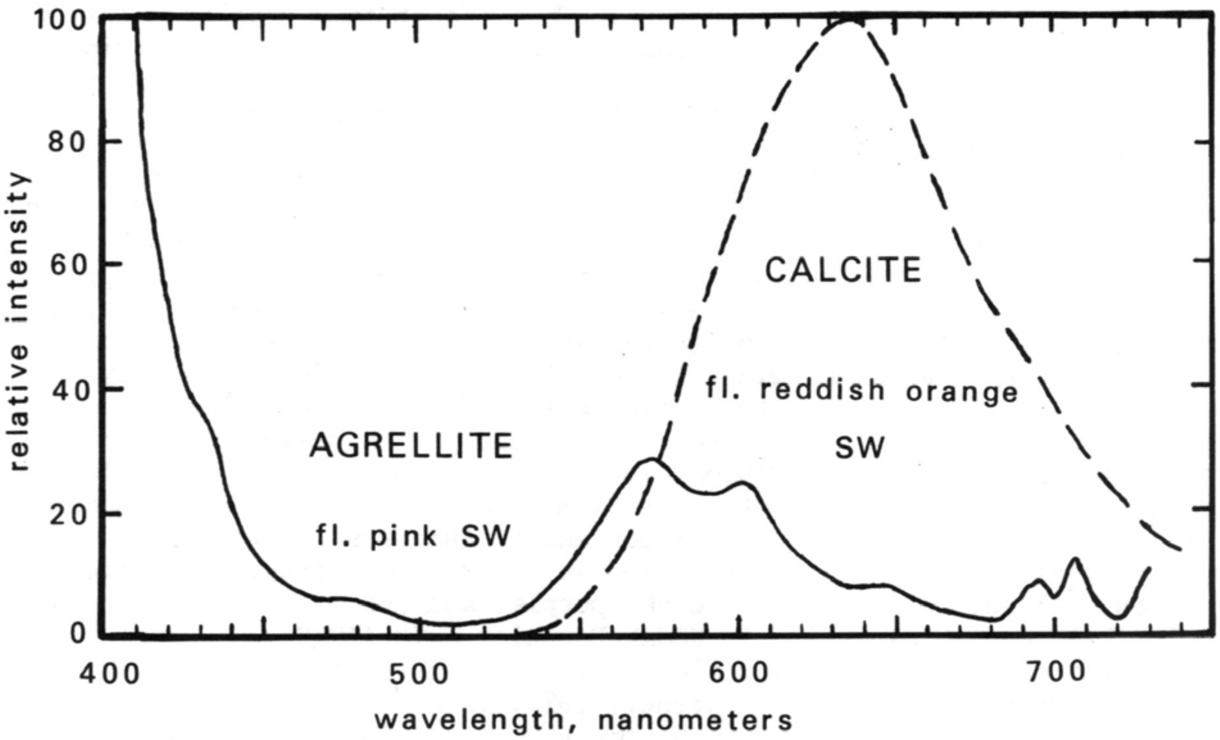
Another problem is that it may be almost impossible to obtain an accurate reproduction of some fluorescent colors. This is particularly true for pastel shades and for pink, orange, and brown colors. Part of the problem is perceptual; for some combinations of color, small differences in the spectral hue seen by the eye may be perceived as a significantly different color, and thus, the color balance in a photograph may not be perceived the same as that seen when viewing the actual mineral. A color that is a "pure", nearly monochromatic (saturated) spectral color will present fewer problems than one which is composed of a wide spectral distribution, with peaks in different parts of the spectrum. The problem is also in the ability of color films to match all colors perfectly; most color films are balanced to achieve accurate color rendition of those hues most important to the usual photographic subjects--flesh tones, green grass, blue sky, and black, gray, and white--and do not do well for colors such as pink, purple, and orange. Problems related to color balance are discussed in Kodak Pamphlet E-73 (1978).

Agrellite, a sodium calcium fluorosilicate mineral that fluoresces a striking shade of violet-pink (Modreski, 1979) is one that I found particularly difficult to photograph properly; the color on slides tends to look blue or violet. Figure 3 compares the relatively simple fluorescence spectrum of red-orange fluorescent, manganese-activated calcite (Newsome and Modreski, 1981) with the more complex spectrum of agrellite (Newsome, 1985), in which several rare-earth elements are probably the activators. In some cases, it may be necessary to use color filters over the camera lens to artificially change the color reaching the film to obtain a reasonable result in the photograph. This may seem to be "cheating", but the color of the final result is probably the only valid criterion. I found it necessary to use yellow filters to obtain a good reproduction of the yellow-fluorescent, molybdenum-bearing centers and blue-fluorescent rims of scheelite crystals found a few years ago at the East Camp Bird mine. In a similar situation not connected with luminescence, I found it necessary to use green filters to capture the visually perceived red-green color change observed in chrome-rich pyrope garnet from the Sloan kimberlite under different illumination conditions (Collins and Modreski, 1987). Obviously, the use of colored filters would probably not work if minerals fluorescing in a number of different colors were being photographed in one field of view.

I have photographed large exhibits containing a variety of different-color fluorescent minerals under 15- or 30-watt UV lamps. This has worked fine, and the results have sometimes been spectacular. The best exposures have been the equivalent of about 15-60 seconds at f/5.6 with ISO/ASA 64 film. One could selectively mask the brighter specimens during part of such an exposure, to obtain a photograph in which all the minerals were ideally exposed.

Photography of the fluorescence of small specimens or microcrystals can be attempted through a microscope, or with bellows, extension tubes, and other standard methods used for photomicrography (Kodak Publication P-2, 1980;

Fig. 3 Fluorescence spectrum of a mineral with a simple peak shape (calcite) and one with a complex spectrum (agrellite)



Wilson, 1974). My own attempts at fluorescence photography at high magnification have met with mixed results; the usual difficulties of photomicrography are compounded by the relatively low intensity of the fluorescence one is trying to capture. Photography of mineral grains in polished rock sections through a high-power microscope equipped with a longwave ultraviolet light source is valuable especially in the study of sedimentary and petroleum-containing rocks (Dravis and Yurewicz, 1985).

Microscopists who produce photographs showing cathodoluminescence of minerals have noted that it is often helpful, when having color prints made, to supply the custom printing laboratory with a previously prepared sample photograph that best illustrates the true color of the luminescent mineral (Barker and Wood, 1986). This allows the color analyzer used in printing to be adjusted to give exactly the desired results; the same precaution could profitably be used in printing of color photographs of ultraviolet-excited fluorescence.

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TECHNIQUES FOR PHOTOGRAPHING GEOLOGIC MATERIALS

TO BE USED IN SLIDE PRESENTATIONS

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<u>INTRODUCTORY NOTE:</u> The equipment and techniques discussed in this extended abstract refer to photographic methods appropriate for slide presentations. While some information may be applicable to the graphic techniques used for publication, most is not. The ideas discussed here are designed to ease the task of putting together the slide illustrations necessary to make a good presentation before an audience. The techniques are simple, but it is relatively hard to find this information in print. Hopefully, many mineralogists, amateur and professional alike, will find enough useful information to encourage them to give more presentations. The rest of us will benefit greatly from such an increase.

I. "REGULAR" EQUIPMENT

A. **Single Lens Reflex Camera capable of accepting different lenses.

B. **Macro Lens (any lens that can be used for photographing mineral specimens).

C. **Light metering system (either self-contained in the camera, or a separate meter).

D. **Lights (two lights will be enough for all "normal" situations).

E. **Stands for lights (chemistry labware stands work very well).

F. **Color Slide Film (the film will need to match the lighting in some situations, but will not matter in others).

G. Copy Stand (an inexpensive one will do, and a tripod can be used in some situations--see fig. 2). If you already have a set of lights and stands, you won't need to buy a stand with lights attached. In fact, the author finds much added versatility in using separate lights and stands.

H. Plate of Glass (11" X 14" X 1/4" works well in most situations, but the additional weight of 3/8" or even 1/2" plate can be quite useful when copying from books).

I. Lens Adapter Ring.

J. Black Poster Board (measuring approximately 8 1/2" X 11", with a hole cut in the center the same size as the front of your lens).

K. Black "Construction" Paper.

L. Gray Card (Kodak "Neutral Test Card"--gray side has 18% reflectance).

M. Paper Weights and Shims.

N. Colored Pencils, White-Out, Ruler, Pen & Ink (many of the "flo-tip" varieties work well), Lettering Guide or Stencil, Scissors, Razor Knife, and other miscellaneous drafting equipment.

O. Copy Machine that both reduces and enlarges.

II. "STANDARD" TECHNIQUES

A. Fill your camera's viewfinder frame with your subject matter. Use both the vertical and horizontal format for your photos, choosing whichever will best fill the frame. Since your camera is attached to the copy stand, you will not be able to turn it to use a vertical format; instead, you will have to turn your subject matter. Remember that approximately one-half of all subjects are viewed better from the vertical format. If you doubt this, notice the number of canvases that are painted in the vertical format when you next visit an art gallery.

B. Remove all filters from your camera lens.

C. Always compose your photo by looking through the viewfinder, not by just looking at the subject with your naked eye.

D. You will need to use your macro lens (or the macro adjustments on a standard lens that has macro capability) for all your photos.

E. Set up your copy stand (you don't need an expensive one) as shown in figure 1. You can use a tripod with the vertical adjustment rod reversed (as shown in figure 2), but this technique is probably best left as an emergency trick to pull out of your hat when you need to copy something and don't have a copy stand available.

1. Set up your lights on each side of your subject matter. Position them so that they are aligned with the center of the subject matter and shining at approximately 45° with respect to the horizontal plane of your subject matter.

2. Use your glass plate to flatten the subject matter so that it does not have folds, wrinkles, etc.

3. Make sure that the plane of your film and the plane of your subject matter subject matter are parallel. Use cardboard shims, paperweights, etc. to help align thick books.

4. Be sure that your lights are far enough away from the subject matter to prevent them from reflecting in the plate glass. If you see a reflection or bright spot in your viewfinder frame, it will turn up on the slide.

5. Use a lens adapter ring to attach a piece of black poster board to your lens in order to keep your camera from reflecting in the plate glass. (See fig. 3.)

6. It is best to use a cable release to take your photos.

7. Place a sheet of black construction paper behind any illustration that has printing on both sides. Use a white sheet of paper behind any illustration that has print only on the side that you are photographing.

8. Use black construction paper to block non-relevant matter from your photo. By and large, what you see through your viewfinder is what you will get in your photo. But remember, the scene in the viewfinder of some cameras is not EXACTLY the scene transferred to the film--you will have to learn the idiosyncrasies of your camera.

9. If you are photographing an illustration that extends all the way to the edge of the page in a book, put a sheet of black construction paper behind the page, leaving a black margin extending around the edge of the page. This will prevent the edge or corner of the book from intruding itself into your photograph. Make sure that the construction paper completely covers the back of the illustration that you are copying, so that your slide will show even color tones. Use several sheets of black paper if necessary.

10. Use a "gray card" (Kodak calls it a neutral test card) to meter on. This is the only way to reliably obtain correct exposures when photographing printed material! Remember to remove the card before shooting your photo. Almost every photographer will eventually take at least one nice, evenly lit, gray slide. This is, of course, just one more reason to take your photos far enough in advance of your presentation, so that there will be time enough to correct mistakes.

11. Again, get used to composing your photograph through your viewfinder frame. It's what you see there (or sometimes see and don't notice) that will turn up on your slide.

F. Use your regular mineral photo lights and a color slide film that is balanced for those lights. (The author uses Kodak Tungsten 160 film and 3200 K lights.) If you are copying only black and white subject matter, you can often use film that is out of date as an economy measure. So watch for bargain film on the counter of camera stores. After purchasing out of date film (or any film, for that matter) store it in your refrigerator to prevent further deterioration.

G. When copying line drawing illustrations from a book or journal, it is often times better to xerox the illustration, and then photograph the xerox.

1. A line drawing may often be greatly improved by coloring all, or part, with colored pencils. Sometimes simply highlighting a line with color will bring out an important feature in such a way that your audience will more easily see your point. Keep this trick in mind when dealing with maps that have one geological (or topographic) feature superimposed on top of another.

2. Coloring a small drawing can be extremely tedious, so it sometimes helps to enlarge the copy while you are copying it. Occasionally the reverse is true, thus one needs to obtain access to copy a machine that will both enlarge and reduce copies.

3. If the illustration contains material not relevant to your subject, you can "white-out" those parts from your first copy, and then re-make a final copy from which you will photograph.

4. The greenish tint imparted to illustrations taken through thick glass will not be noticeable in photos of hand colored line drawings. Thus you can use a thick piece of plate glass if extra weight helps

flatten your illustration.

5. Meter on the gray card. Hand colored line drawings will turn out perfectly exposed with this system.

H. When copying color photographs, you will need to remember that more often than not, your copy will not be as good as the original.

1. Use only 1/4" thick plate glass to hold down the original, as thicker glass will cause the illustration to take on a green tint.

2. Again, meter on the gray card, but be prepared to go back and bracket one stop to each side of the gray card exposure if the exposures don't turn out well. In fact, you may want to go ahead and bracket these exposures during your first shooting session.

3. Don't expect too much from copies of color photographs. Even with the hassles and poorer quality copies, it is often better to have a particular illustration, than none at all.

I. Don't try to put too much in your photograph. A slide that can't be seen is very annoying to your audience. This is especially true for labels on maps, cross sections, and diagrams. More often than not either the scale is wrong, or the illustration simply too large. There is always a way to work around a busy drawing, or too large a scale--it just takes time and a commitment to show only first class slides to your audience. The solution may be as simple as dividing the illustration into several different illustrations by zeroing in on the various parts of the original. Or it may call for typing larger labels, or perhaps re-drawing the illustration. Even re-drawing can be a fairly simple task if you make maximum use of a copy machine and lots of white-out.

J. Use lots of illustrations. A picture, truly, is worth a thousand words.

K. When you are in the field, take lots of photographs. Approach your subject from different angles, and always fill the frame. Walk the extra 100 yards to fill the frame, or use a zoom lens to do it for you. Nothing will make you look more amateurish than to point at a small indistinguishable dot on the scene and say,

> "that's the Little Pittsburg Mine. Sorry that the photograph didn't turn out very well, but I was a long way off."

When you say that, much of your audience will be thinking, "well, if it was important enough to illustrate, it certainly was important enough to show a good picture. Is that guy just lazy, ignorant, or what?"

Good field photography is a separate subject. There are many good books and articles on the subject. Study them.

L. Try to find line drawings ("cartoon geology") that compliment your field photos, and vice-versa.

M. Don't be afraid to take your whole photographic setup to the library. (Ask the librarian first--they may give you a room to work in!) If that's where the illustrations are, and they can't be checked out, then that's where you need to go.

N. Again, zero your camera in on what's of interest to you and your talk. This principle applies to copying photographs as well as line drawings. Just because someone else used more information for their subject than you need for your presentation, doesn't mean that you have to use it too. Only photograph what is of interest to you.

O. Use a reputable lab to process your film. Avoid places that specialize in fast developing of your teen-age daughter's slumber party photographs. These places are not even in the same league with the pro's, and their work shows it.

III. SPECIAL TECHNIQUES

A. Use a yellow filter and Ektachrome 100 to get the blue and white line drawing reproductions that are becoming so popular. You must specify "c-41" processing when you have them developed.

Polaroid also makes a special film (called Pola-Blue) that will turn out these slides. Your camera store will process them for you.

B. Don't hesitate to draw your own graphs whenever you need to. Just remember to use a scale that will show your data in an accurate manner without distortion.

C. You can use clear overlays to make additional points about an illustration. You may be able to use the special acetate sheets made for copy machines to lessen your work. A xerox line drawing overlay on clear acetate can be colored with some transparent inks in order to emphasize whatever it is that you want to show. That copy machine can be a real work-horse.

IV. ONE FINAL THOUGHT--If you have a good slide to illustrate every single point that you want to make, you won't need any written notes when you make your presentation. The slides, themselves, become your notes!

** Items marked with an asterisk are usually found in all mineral photography setups. Only those items without an asterisk will need to be added to your equipment.

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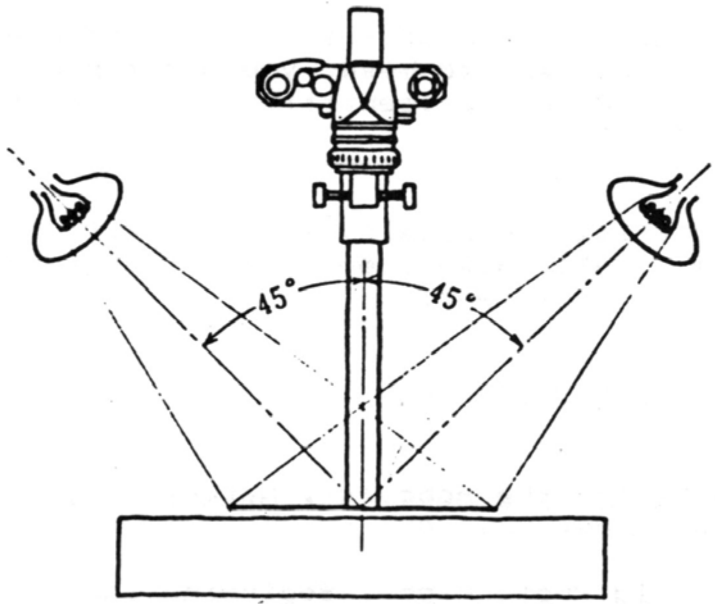

Figure 1.

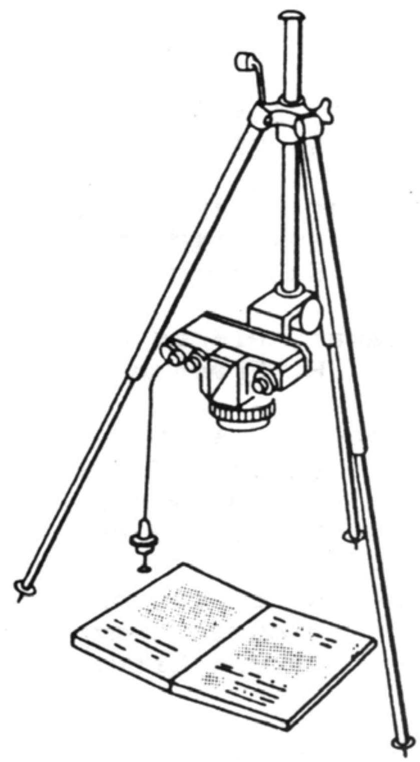

Figure 2.

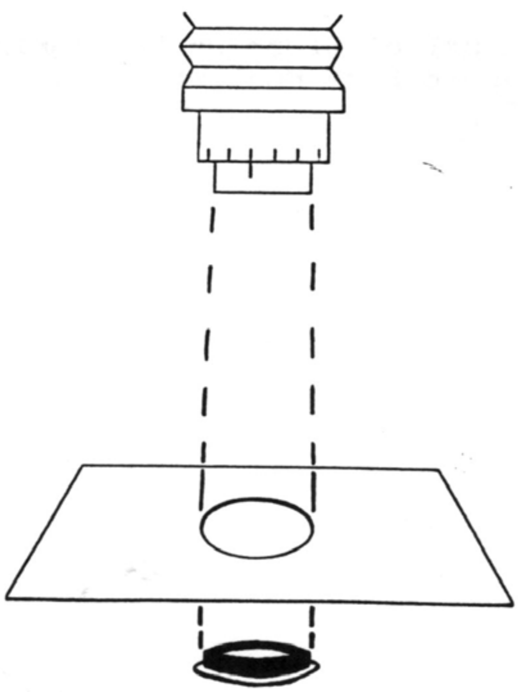

Figure 3.

SOLUTIONS FOR SOLVING PROBLEMS ENCOUNTERED WITH CLOSE UP PHOTOGRAPHY

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Image magnification beyond the capabilities of normal photographic equipment is often needed to aid identification and show the specimen to the best advantage. Since subject magnification is one of the factors governing the amount of depth of field, one is confronted with the problem of solving one problem and creating another. Depth of field is defined as the area of sharpness in front of and behind the point of focus. As magnification approaches 1 to 1, or life-size, the depth of field is approximately equal on both sides. Aperture is the other factor controlling depth of field. Smaller apertures such as f22 or f32 give more depth of field than f2.8 or f4. Each full f-stop increase, ie. f5.6 to f8, will give about 1/3 more total depth of field. Conversely, each decrease in f-stop (enlargement of aperture) will decrease the depth by about 1/3.

Although depth of field increases at smaller apertures, sharpness often suffers due to diffraction limiting. Diffraction limiting is defined as the inability of light rays to make the extreme bends required by small apertures, resulting in unsharp images. Lens extension via bellows or extension tubes compounds this problem as "effective aperture" must be calculated. Lenses usually have their greatest sharpness in the middle of their f-stop range. Compromise must be made between sharpness gained by depth of field and sharpness lost due to diffraction limiting.

Efforts should be made to reduce the amount of depth of field needed. One method is to find the plane of greatest importance in the specimen and then align the camera back parallel with that plane. Dual axis focusing rails ease the difficulties encountered in this alignment. Other tools that can aid the 35mm photographer in solving depth of field problems have their roots with view cameras. Olympus, Nikon, and Canon have perspective control lenses that either shift, tilt, or both. Unfortunately the longest of these is 35mm; usually too short for close-up work.

The other tool is a bellows with movable front or rear standards. Unfortunately, nothing is in current production. The mail order firm Spiratone of New York made the Bellowsmaster SST with full movements front and rear. It used the T mount system so any brand of equipment could be used. The construction was a bit light and the bellows was capable of movements exceeding the covering powers of some lenses. However, if you need what this unit can offer give it a look. Another bellows unit that has shift and tilt capabilities is the Nikon PB4. It can be adapted to use with other camera systems. The PB4 is very robust and capable of professional results.

Ideally, the bellows should be used with a short-mount lens designed for close up work. An often overlooked option is a high quality enlarging lens. These are highly corrected, designed to work in this range and with the longer focal length such as 100 to 150 mm they offer apertures to f45. Use of focal lengths of at least 100 mm is recommended to obtain proper perspective and working distance.

A strange sounding but workable tool for magnification in the 3x to 5x range is a 200mm lens used in combination with a 50mm or 100mm lens attached to the front in a reverse position. The reverse lens acts as a high quality diopter. The advantages of this combination are a bright viewfinder image, good working distance, approximately 3 inches, and sharpness because diffraction limiting does not occur.

If you have a limited amount of equipment, there is another, not well known option. Nikon makes a high quality 2-element close up diopter for use on lenses of 100mm or longer. The Nikon designation is 3T, 4T, 5T and 6T. The 3T and 4T have a filter diameter of 52mm and are approximately 1-1/2 and 3 power diopters. The 5T and 6T have a filter diameter of 62mm and the same powers as the 3T and 4T. These units are much superior to normal diopters and can be used with any lens 62mm or smaller filter diameter with step up rings. With the 6T on a 300mm lens the magnification is in the range of 1-3/4 times life size. A big advantage when working in the field is they can also be used on zoom lenses in the 80 to 300mm range. The quality is not equal to true macro or bellows lenses but is totally adequate for reproduction in major magazines. They offer low cost, small size and weight, and good versatility.

Taking close-ups in the field is an extremely challenging endeavor and I suggest you become completely familiar with your equipment at home. The other key to success is to be adaptable and be willing to try any combination of equipment which might help solve your special photographic problems.

DOCUMENTING ARCHAEOLOGICAL AND PALEONTOLOGICAL MATERIALS

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Photography has been a basic form of documentation for archaeological and paleontological sites and materials since the late 19th century (e.g. Nordenskiold 1979). Such recording is done at three different levels: upon discovery, during excavation and removal of specimens, and in laboratory settings. In all these cases it is critical to maintain accurate and complete records of all photographs taken, both color and black-and-white. Having the proper equipment both available and well-maintained is another obvious requirement, but one that is easy to take for granted. Wide-angle lenses are especially valuable in the field under most normal circumstances, particularly those with macro focusing capabilities, but you'll find that individual cases cumulatively will require a wide range of photographic hardware. Many excellent books are available that summarize the subject (see Matthews 1968; Simmons 1969; Joukowsky 1980; Banta and Hinsley 1986), and the magazine Archaeology has a regular column devoted to photographic topics (e.g. Levin 1986; Szegedy-Maszak 1989).

The time of discovery of archaeological and paleontological materials is quite important to record in photographs, in order to provide the earliest documentation of the item(s)' context and precise location, should the authenticity of the find come into question. A good overall photograph of the local environment will help both in relocating the site and in establishing general context; increasingly closer shots serve to pinpoint the find within the site. As an aside, aerial photography has become a valuable discovery tool for large-scale archaeological sites and features (Riley 1987) but, of course, this has only indirect relevance to the close-up photography described here.

Often, archaeological and paleontological materials are not excavated but, instead, are left *in situ* because the location is not threatened by development or destruction, funding and/or labor are not immediately available, the undisturbed location is desirable for educational purposes, preservation is preferred as a long-term strategy until better excavation techniques are developed, etc. In these cases, the same kinds of overall and close-up pictures mentioned above for the time of discovery would be appropriate. It might also be possible under these circumstances to return to the site at various times of the day to photograph the site, artifacts, or fossils during the most advantageous lighting conditions.

When materials are excavated, however, many more diverse situations arise which require photodocumentation. On a general level, merely taking overall site and excavation pit photos on a daily basis provides a valuable log of progress that can often clear up ambiguities in the field recording process. Such in-progress photos taken in morning, mid-day and late afternoon light also yields benefits in high-quality exposures. Stratigraphic records are important as well, and occasionally introduce a problem of scale that bears close attention. Particularly in trenches or small test pits--more common to archaeology than to paleontology--the overhead oblique perspective of soil profiles that is easiest to accomplish is also one that distorts the scale of individual soil horizons, both alone and in relation to each other. When documenting the context of artifacts, features or fossils in stratigraphic columns, this problem of distorted scale becomes even more critical. The best solution, albeit one not always available, is to take such photographs with the plane of the film as parallel to the plane of the excavation wall as possible. This necessitates crawling into the trench or pit, and using a wide-angle lens (e.g. a 24mm lens, not a distorting fish eye lens); another option is to use a "tilt-and-shift" (T&S) lens to correct the oblique perspective, although these specialized lenses are more useful in photographing above-ground vertical objects such as columns or tall buildings (Metz 1983).

Normally, in-progress excavation photographs of artifacts, features or fossils are taken under less limiting conditions. Still, there are a number of valuable principles to follow. As noted before, context is absolutely critical, as the precise location of the item(s) is as important as the item itself in determining age, function, relationships to other artifacts/features/fossils, etc. Thus, even if your main objective is to take that pretty close-up view with your macro or telephoto lens, step back a bit and take at least one more photo with a normal or wide angle lens to show the position of the object in its surroundings. Again, be careful of scale distortions; direct overhead or vertical views are preferable to oblique ones in most (but not all) cases. Extremely high contrast situations, such as an artifact or fossil on the edge of bright sunlight and deep shadows, are to be avoided and are easily handled by simply shading the entire area with a tarp, poncho, space blanket, or even a row of people standing shoulder-to-shoulder. Similarly, overly dark situations can be brightened by using a reflector such as the shiny side of a space blanket. Oblique light as provided in mornings and late afternoons can enhance the texture and visibility of artifacts, fossils, or incised features like rock art that otherwise might blend in with the background under direct light or shaded conditions.

In some situations, the color of the artifact, fossil or soil/rock matrix is important to document. Thus, having at least two cameras on hand for black-and-white and color photos is advisable beyond the simple desire to take slides for audience presentations. Finally, whatever the situation, two important pieces of information should be added to each and every photograph you take, i.e. the exact scale and direction of the view. The scale can consist of almost anything--a tape measure, meter stick, stadia rod, ruler, pen, trowel, etc.--but at least three sizes should be available: small, e.g. 5-15cm, for close-up views and small objects; medium, ca. 50cm-2m, for context photos and larger artifacts or fossils; and long, up to 4-5m, for deep trenches/pits and larger features. A directional arrow, usually pointed north, should also be placed in view. One efficient method commonly used is to make a cardboard or wooden arrow onto which a 1-5cm scale has been painted.

Always be sure to orient the plane of the film in your camera parallel to the plane of the scale to avoid distortion. One last optional addition is a small chalk board or menu board listing the site name/number, feature or artifact, locational information, date, etc. Place the board, scale and directional arrow toward the edge of the view so they can be cropped out if desired.

Upon completion of the excavation of archaeological or paleontological materials, final documentary photographs are taken. Proper preparation for such photos includes clipping obtrusive roots, removing all equipment out of the view (other than the scale and directional arrow!), gently sweeping out footprints and loose piles of dirt/rock, etc. (Figure 1). Since this is the last chance to document your findings, bracket your exposure, take photos from several angles and, if possible, do both at different times of the day. There is no chance of taking too many pictures, and there is a big chance that you'll regret not having taken that one last angle or exposure.

Laboratory photography is certainly less pressured or frustrating, or at least it should be. You control the conditions, not Mother Nature, and you usually have the opportunity to retake the photos if something goes wrong. First, choose an appropriate background material--one that is non-reflective and contrasting with the artifacts or fossils. Felt is an excellent choice of material albeit lint needs to be removed frequently; use black, maroon, or any other dark shade for light-colored items and light gray or any other pale shade (but not pure white) for dark-colored objects. With such a natural color contrast in materials, proper light exposure can be tricky, as it's easy to expose either for the background or the object(s); proper exposure balance is easy to achieve using a neutral-colored "gray card." Correct focusing can be a problem when together photographing items of different height, since depth-of-field is usually reduced in laboratory light. Props for low/thin items, e.g. blocks of wood or modeling clay, are easy to use but should be small enough to not detract from the artifacts or fossils. Clay props are also suitable for stabilizing tools of stone and other materials to take close-up shots of edge wear scars.

Correct lighting conditions in the lab are not always straightforward, especially for those archaeological materials such as stone tools for which manufacturing techniques and patterns are desirable to highlight. Side lighting in these cases is critical, and both good texture and sufficiently strong light can be provided by using two light stands--one somewhat brighter than the other--set up on opposite sides of the viewing table. These stands should not be placed directly opposite each other but, rather, at slightly oblique angles to highlight the artifact/fossil contours. A labeled scale is a requisite addition to each laboratory photograph, and should be propped up to the level of the upper surface of the artifact(s) or fossil(s) for proper focusing (Figure 2).

An additional way of highlighting item contours, especially of translucent and/or reflective materials like obsidian, is to use a removable metallic coating such as aluminum powder (Callahan 1987), or a chemical smoke such as ammonium chloride (Weide and Webster 1967).

Satisfactory results also have been achieved simply by using a polarizing filter (Rovner 1974). One final word about context: when photographing multiple items, be sure the combination does not convey misleading information. As an example, presenting items of different age in a single picture may not be appropriate, unless they are of similar function or a direct comparison of morphology is desired. In a nutshell, the foregoing discussion has been directed toward one overriding goal. Photography of archaeological and paleontological materials is meant to precisely document information about past peoples, plants and animals, not to fill art magazines. But feel free to take additional pictures for your art collection!

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Figure 1. How not to take a close-up of an artifact or fossil: the menu board and scale dominate the photo rather than the artifact, there is no directional arrow, and footprints are overly prominent.

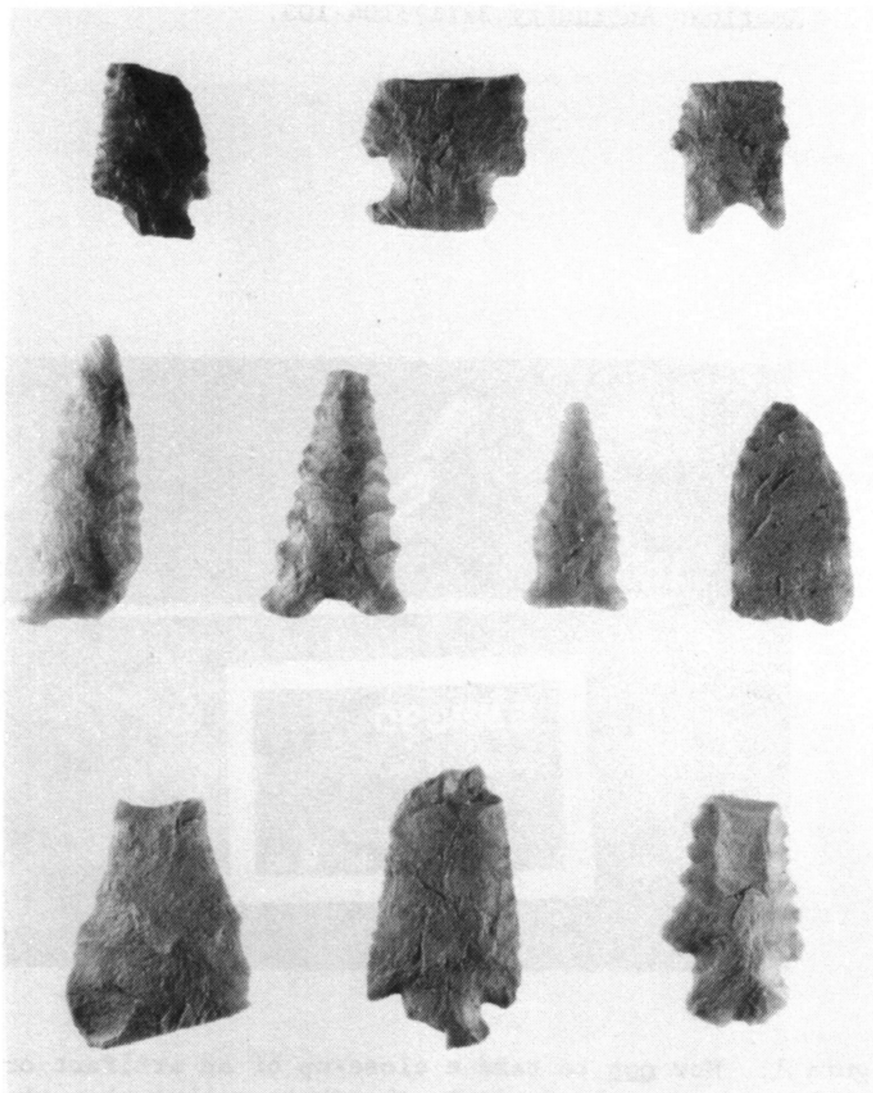

Figure 2. Projectile points from a site in southwestern Colorado. Background contrast with the artifact materials is good, but not great, and the centimeter scale could be a bit more focused. The importance of appropriate lab lighting is highlighted by the flaking patterns visible on these artifacts.

AESTHETIC GEM AND MINERAL PHOTOGRAPHY

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Aesthetically pleasing photography of mineral and gem material is similar to portrait photography of people; the objective is to make the subject look better than actual, not to take an accurate recording of the material. (Aesthetic photography is not the same as documentary photography!). This can be accomplished if one selects appropriate equipment and film, flattering lighting, complimentary background color, and interesting photo-angle and framing. Of course, as in portrait photography, the camera can enhance the subject only so far; an ugly dowager will remain unattractive no matter how good the photograph, and a poor quality specimen will never look like a world-class mineral, no matter how hard you try.

EQUIPMENT AND FILM.

There are numerous types of cameras on today's market, ranging from large format view cameras with bellows, to medium format 2-1/4 inch cameras such as those manufactured by Hasselblad and Rollei, to 35mm single lens reflex cameras. Professionals generally use large or medium format equipment because of the larger negative size, which allows for greater sharpness of image in blow ups for magazine or poster requirements.

For most photographers, however, large format equipment is both prohibitively expensive ($3,000-$10,000 for a full outfit) and too difficult to master, since nothing is "automatic." Instead, the majority of amateur photographers select some type of 35mm camera, normally with either a 50mm or 90mm macro close focusing lens.

In selecting a 35mm camera, off-the-film-plane metering capability is very desirable, since it will ensure the greatest percentage of well balanced exposures for your efforts. Such a camera, especially when used in conjunction with a dedicated flash (one made by the camera's own manufacturer specifically for that camera) will provide generally technically correct pictures almost every time. While there are several cameras with this important feature, I use and recommend the Olympus OM-2 with the 50mm macro lens and the Olympus T-20 or T-32 dedicated flash. Fully automatic cameras are not suitable for mineral photography.

Strobe-lit photographs are a must. A picture taken in sunlight will have too high contrast to make a pleasing photo and will be impossible for magazine color separation. Some photographers believe that incandescent light and a color balanced film can be used successfully; they like to use Tensor lamps to light the specimen. In the author's opinion, any lighting temperature other than 6400 Kelvin (daylight and strobe) will produce off tone colors. The only way to insure reliable color reproduction is with electronic strobe and off-the-film-plane metering.

Selection of film is also a matter of concern to the photographer who wishes to produce an aesthetically pleasing image. In the authors' opinion, Kodachrome 64 is the best all around film for its fine grain and color saturation. It is not, however, the best choice for blues and greens; if the mineral specimen is in this color range, Etkachrome 100 is the better choice. Kodachrome 25 is an extremely fine grained film, but it is also quite slow and unless a tripod is being used (the author generally avoids them) the resulting image may not be sharp due to long exposure time. For prints, use Kodacolor 100 (not Kodacolor 200 or higher). Also, use a good professional lab for development; bargain quick print places produce poor mineral prints.

LIGHTING.

Appropriate lighting is most important in producing an aesthetically pleasing photograph of a mineral specimen or gemstone. Try to obtain definition; avoid flat lighting (usually from the front), and try to highlight from above and approximately 45 degree from center (Illustration 1). Also remember to avoid harsh, "burned out" highlights.

Fill-lighting is also important to provide details in recesses and to even out harsh contrast. Fill-lighting is most often accomplished by the use of reflectors or even bits of silver foil used at about 90 degrees from the light source. This lessens the likelihood of unsuitable shadows (Illustration 2).

It should be mentioned here that the photographic requirements for magazine reproduction mandate very low contrast lighting. Color separations for publications like The Mineralogical Record and Rocks and Minerals cannot handle high contrast lighting. However, for slide programs higher contrast lighting (defined highlights and shadows) make much more interesting and therefore aesthetically pleasing photographs

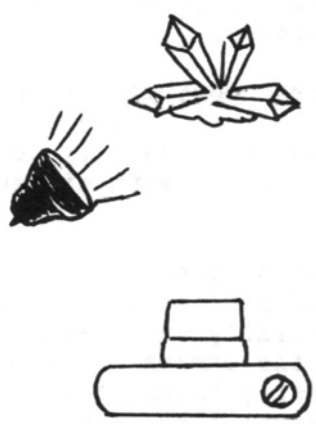

Illustration No. 1

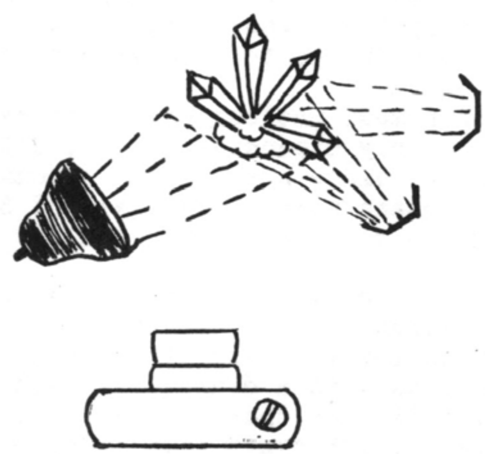

Illustration No. 2

BACKGROUND MATERIALS AND COLORS.

There are two basic requirements for selection of background; it must be texture free and it should be in a color reciprocal of the main color of the mineral specimen. There are many excellent colored papers available which will meet these requirements. They are generally available in good artists' supply stores.

The "color reciprocal" means a hue opposite on the color scale. For instance, blue-green amazonite looks awful on blue, grey, or green backgrounds; it looks wonderful on tangerine, salmon, red, or rusty-brown backgrounds. Trial and error experimentation will soon provide the photographer with a standard selection of suitable color backgrounds for different mineral photographs. Occasionally, a much darker or much lighter shade of the same color makes a good background choice. I frequently use darkest purple as the background color for rhodochrosite specimens, especially those on a white quartz matrix.

PHOTO-ANGLE AND FRAMING.

Successful mineral photographs require that the subject fill the frame. First, this means getting close enough (hence the requirement of a close focusing macro lens which goes down to a 1:1 image on the negative). Second, it means deciding on whether the shape of the mineral specimen dictates a horizontal or a vertical format. Most mineral specimens are not equal in all dimensions, and the image cannot normally be cropped unless the photographic assignment is for magazine or other printed reproduction. Even then, most editors prefer images which do not require major cropping to "clean up". Select the right framing angle (horizontal or vertical, high or low) to start.

PHOTOGRAPHING GEMSTONES.

The photography of cut gems presents certain special problems. The main problems are unexpected reflections from facet surfaces, unplanned color reflections from the background, and a boring look to loose stones.

The first problem, reflections, will always remain tricky to solve unless the photographer invests in expensive strobes with modeling lights. Moving around ever so slightly to obtain different angles with an on-camera flash and taking four or five shots is the photographer's best insurance for obtaining an acceptable photograph.

There is little one can do to prevent undesirable internal color reflections from the facets of a cut gemstone. The best insurance is to use a very neutral background color. Pearl grey offers a good choice. Loose stones photographed alone are not interesting. If you have control, try to select a stone with interesting faceting -- a marquis cut stone is more interesting than a standard brilliant cut. Or try to group several stones across the background, many are better than one most of the time.

SELECTING THE RIGHT SPECIMEN.

Finally, a few words about selecting the right specimen to make aesthetically pleasing pictures. It is not true that one can take a great-looking photograph of an ugly specimen.

The camera always magnifies all defects. Therefore, avoid material which shows damage. Avoid material which is dirty -- it won't look cleaner in the picture! Avoid material with thick matrix or specimens glued onto a display base as these items truly ruin the picture. Avoid specimens which have crystals coming "at" the camera lens: the mind can compensate for the distortion recorded by the eye, but the camera lens cannot and the resulting photograph will have some very misshapen crystals.

Realize that large specimens and tiny ones do not photograph well. The optimum size specimen for 35mm photography is one between 2" x 2" and 4" x 4". Larger or smaller specimens present problems for this camera format size, especially in depth-of-field sharpness for small specimens (even thumbnail size).

Finally, select specimens which have relatively few crystals. Material which has many small crystals will look "busy" and unpleasing in a photograph. That is why very large specimens (while admittedly impressive pieces) often photograph poorly. Select specimens which have two to five main crystals, preferably grouped nicely across the matrix. Remember, some of the best high fashion models do not look great in person, but they look great in front of the camera. In the same way, the prettiest mineral specimen held in the hand does not necessarily make the best photographic subject.

If the reader follows the suggestions outlined in this analysis, more aesthetically pleasing mineral photographs are certain to result from the effort. Nothing, however, can take the place of practice and experience. The more one tries to apply the suggestions contained herein, and the more one trains one's "critical eye", the better able one is to take mineral and gemstone photographs which will be widely recognized as aesthetically pleasing.

MINERAL PHOTOGRAPHY THROUGH THE MICROSCOPE

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My introduction to photography through the microscope, or photomicrography, originated with the need to help viewers of micromounts distinguish and appreciate the microscopic-sized crystals mounted in one inch plastic boxes. In order for the observers to have a better visual image of my specimens in competitive exhibits in mineral shows, I placed 2-1/2 x 3-1/2 inch color prints, made from 35mm slides, directly below the micromount box and label in the display case.

The single lens reflex (SLR) camera body that I use is a Pentax Model ME with a standard bayonet mount 50mm lens. This camera was originally purchased in 1973 for taking outdoor 35mm color slides. There were no plans to photograph through the microscope at that time.

In my photomicrography of crystals, the 50 millimeter lens is easily removed so that a standard microscope adapter can be attached to the bayonet mount of the camera body. This adaptor is a two-piece unit with the front portion designed to hold a microscope eyepiece in place with two finger-tightened set screws. The rear portion, or the part attaching to the camera body, holds the front sleeve of the adaptor containing the eyepiece in place, also with two set screws. The entire unit joins the camera to the microscope (see Figure 1 and 2). Although I use a 10 power eyepiece, other differing power optics are available and easily interchangeable.

My stereoscopic microscope is a Unitron Zoom Model ZSB. With 10x eyepieces it has a zoom range of from 7 to 45 magnification. This microscope is used both for the examination of micro minerals, the preparation of micromounts and photomicrography.

The light source is a fiberoptic illuminator (Fiber Lite Model 190) manufactured by Dolan Jenner Industries, Incorporated. It has a single flexible goose-neck that readily directs the light appropriate for this type of photography. There is an adjustable hood over the light beam that regulates the intensity and area of the light beam.

I have mainly been using two types of 35mm color slide film, Kodak Ektachrome 100 (Fujichrome 100) or Kodak Ektachrome 50 Tungsten DX Professional film. The Ektachrome and Fujichrome 100 are "daylight" type films and when used with a fiberoptic illuminator (or an incandescent light) a filter must be used to balance the color, otherwise the slides show a false yellowish tone. On the recommendation printed inside the Ektachrome 100 film box for use with photo lamps, I use an 80 B filter (a 49mm diameter Tiffen model that threads into the lower part of the microscope body) which provides a good color balance.

With Ektachrome 50 Tungsten film, no filter has been used to achieve a proper color balance. Without the need for a filter there are the additional advantages of shorter exposure time and more light available for focusing on the specimen through the camera-microscope setup. The Ektachrome 50 Tungsten film is somewhat more expensive than Ektachrome or Fujichrome 100 Daylight film and may only be available on special order from most camera shops. It can be ordered in bulk quantities of 50 or 100 feet. With an inexpensive kit one can make up one's own rolls of film. It is important to store this film in a refrigerator at a temperature below 55 degrees Fahrenheit.

A sturdy table or bench free of vibration is an essential work surface when photographing through a microscope. A cable shutter release attached to the camera is also necessary to minimize movement.

It is important to carefully choose the area of the subject to be photographed. A support method I have found successful is to set the micromount (or unmounted specimen) in a bowl of rice grains on the microscope stand where it can be adjusted to the desired position and will stay in place when released. The crystal area should be arranged parallel to the film plane or the specimen will be out of focus. This is due to the very limited depth of field in photographs taken under magnification. Some close-up photographs are better at less magnification, especially acicular crystals where more detail with greater depth of field is needed. The higher the magnification, the more critical it is to have the area of coverage in parallel alignment.

When possible, it is best to locate individual crystals or crystal areas where some color contrast can be achieved. A dark crystal area on a lighter background, or vice versa, is an ideal condition. This will allow the subject to stand out prominently and will give a stronger, aesthetic image. Often this situation can not be achieved and it is necessary to use other techniques such as highlighting selected crystal faces with fiber optic light.

After the subject of the photograph has been satisfactorily posed, one of the eyepieces of the stereoscopic microscope is removed so the camera-adapter unit can be inserted. I use the left eyepiece cylinder but either one should produce similar results. The microscope is next focused by viewing through the focusing screen on the camera. The center of attraction for the slide should be selected as the focus point. Achieving sharp focus through all the optics is an exacting and precise operation performed under less than ideal conditions because magnification causes the matte area of the focusing screen to darken. The subject can only be seen distinctly in the bull's eye split image area in the center of the focusing screen. There are interchangeable focusing screens available for certain camera models. A clear field type of screen allows for focusing over the entire area seen through the view finder.

Once focused, I decide if any adjustment of the automatic shutter speed is needed to balance the exposure. If a light colored specimen is to be photographed I leave the shutter speed dial set at AUTO and the exposure compensation dial set at 1x. With a medium value this dial is moved to 2x, then to 3x for a darker specimen. The use of this technique allows for additional shutter speed time and partially offsets the effect of reciprocity failure of the film emulsion. The camera can also be controlled for a timed exposure by activating the cable release after setting the shutter speed dial at the "B" position.

The photograph is now ready to be taken by simply pressing the cable release button. The automatic mode is the best selector; it activates the shutter to accommodate existing light conditions and any compensation. It has not been necessary for me to bracket exposures with the techniques described. Approximately 75% of my slides are what I consider to be satisfactory or better on the first attempt.

I keep a log of each photograph taken that records the magnification, shutter time, exposure compensation, and whether I had my glasses on when I focused through the camera screen. The log is an invaluable aid to making corrections when it is necessary to rephotograph less than satisfactory original results.

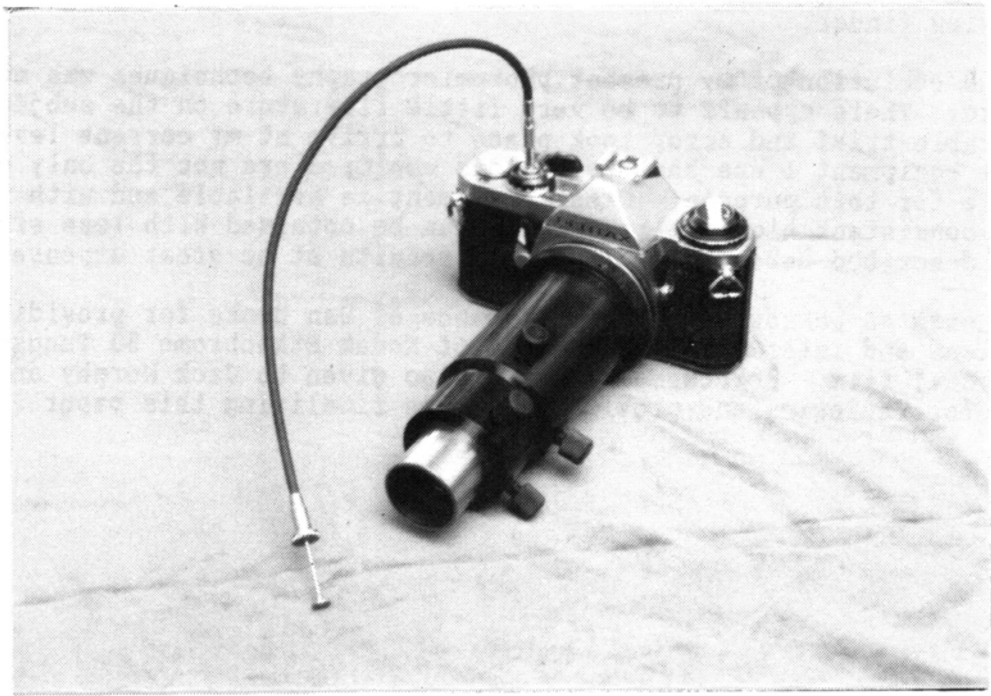

Fig. 1. The camera with the microscope adapter.

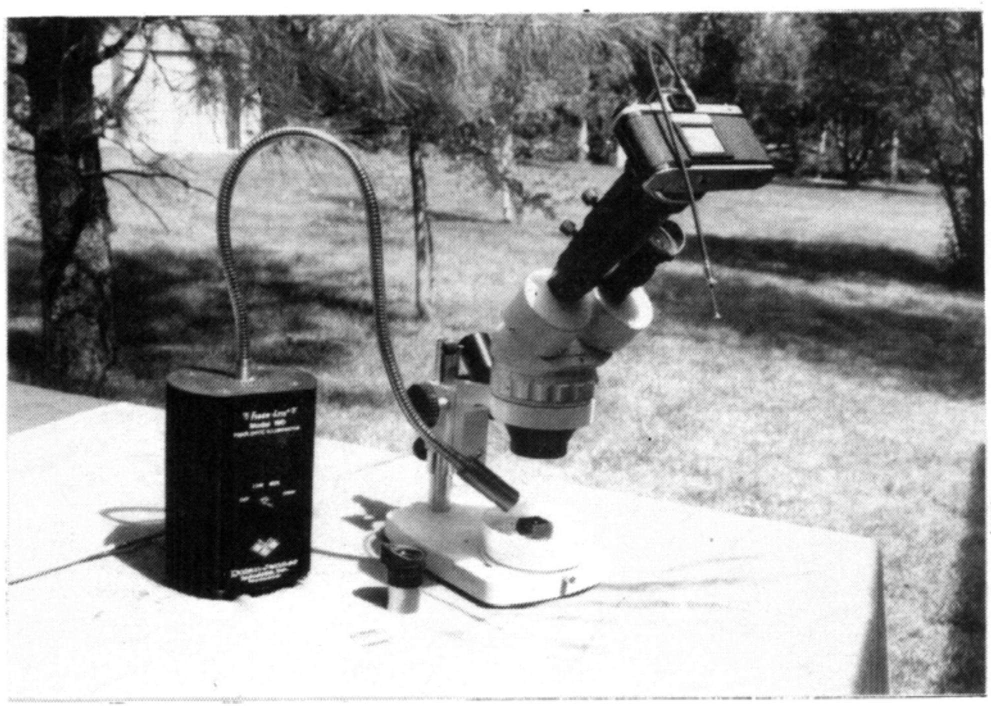

Fig. 2. The complete microscope set up with the camera, adapter and fiber optic light.

It is important to wear your glasses or corrective lenses when focusing through the camera, otherwise out of focus images may result. In place of eye glasses, accessory corrective diopter lenses are available that adapt to the camera view finder.

The evolution of my present photomicrography techniques was not immediate. There appears to be very little literature on the subject and considerable trial and error took place to arrive at my current level. I am sure the equipment I use and the methods employed are not the only ones available for this purpose. Other equipment is available and with its use perhaps consistent high quality slides can be obtained with less effort. The methods described here can achieve good results at no great expense.

I wish to acknowledge the assistance of Dan Benke for providing suggestions and information on the use of Kodak Etkachrome 50 Tungsten Professional film. Acknowledgement is also given to Jack Murphy and Jim Hurlbut for reviewing and providing help in finalizing this paper.

CATALOGING 35mm SLIDES ON A COMPUTER DATABASE

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Collectors of minerals, fossils and artifacts are commonly using computers with database programs to catalog their specimens. Articles about computerizing collections, such as Kampf (1989), provide practical information to begin a collections data-management program. The capability of the computer to rapidly store, organize and retrieve data allows the individual to easily perform a variety of creative curatorial functions. Plus, thorough, accurate records contribute to the value of a collection, not only monetarily, but as a historical and scientific resource.

The same principles and procedures that apply to a computer database for geological or archaeological specimens can also be used to manage a collection of photographs. Cataloging color and black and white prints and 35mm slides is a vital, but time-consuming task; unfortunately it is frequently a responsibility that is neglected. Photographs without information are practically useless to anyone but the photographer. Many potentially historical photographs are of no value to family members or a professional archive if the subjects are not properly identified.

Printing labels for 35mm slides and prints is one of the more efficient applications that can be accomplished with the computer program. Most of the commercial software available for organizing photographs emphasize quick and easy labeling. This helps eliminate the frustration of writing small captions around the narrow perimeter of the slide mounting. One product prints directly on the slide mounting.

There is a big difference between labeling the photographs and cataloguing them. In cataloguing the goal is to develop a systematic or classified system with a unique reference number. This organization allows for orderly arrangement of the collection and the capability to list and cross reference subjects by many categories (called fields in a database program). Imagine having an alphabetical list of all photographs in your collection with columns of related information such as image, location, date the photo was taken and notes about the type of film, the exposure, the film speed, or other subjects that interest you. For those who travel widely and visit museums, shows and conferences and make photographic records of specimens in exhibits, a computer database is for you. Say you want a list of all the photographs you have of Mexican minerals. You can, for example, easily retrieve an alphabetical list with specific localities, including ownership of the specimen, and any other information that you initially enter into the fields on the database record.

There are three main ways to proceed with a computer database program: 1) purchase a commercially designed software program for photographs, 2) design your own photo management system with commercial database software (such as DbaseIII, PFS Professional File), or, 3) write your own program with the disk operating system (DOS) in a computer language like BASIC (Gerig, 1989). If you have programming skills option 3 may interest you, however, the power of commercial database programs is available at reasonable prices for you to begin immediate input.

I developed an easy to use photographic data system with a commercial database software program that cost less than $200.00. This was done out of necessity to organize and label many hundreds of 35mm slides that were accumulating after museum field trips and exhibits projects. There was simply not sufficient time to adequately write all pertinent information on the slide mounting, therefore, a scheme was developed so that one catalog number was placed on the slide (just as you would catalog a specimen or artifact). This number is the first key element to finding and listing all 35mm slides. Since this number is based on the photograph date, it automatically contains the first bit of real data about the photograph and where it is stored.

Most commercial software database programs are analogous to a card index file; that is, you fill in "fields" to complete information about one photograph for each record. Records are stored in the computer memory until recalled, arranged alphabetically by a subject or numerically by the photo catalog number, or by whatever category the photographer may choose. The power of the computer to sort and quickly arrange data greatly facilitates record management of your photographic collection and is limited only by your imagination.

The database that I developed consists of a record with the following fields:

Subject:	Catg:	Photo No:
Title:		
Photo date (yy/mm/dd):	Photographer:	Strg.loc:
Site name:	District:	Town:
County:	State:	Country:
Tech.data:		Dups:
Remarks:		

The computer reads this particular program horizontally, from left to right, and so the fields are arranged across the form with adequate space reserved for input data. This program sorts alphabetically or numerically on the first two fields selected by the user. For example, by selecting "Photo

Date" as column one and "Title" as column two you can produce a list of photographs arranged by date as the primary sort and by title as the secondary sort. These are the kinds of details that are explained in the user manual.

Concise and accurate information has to be entered in the fields. I recommend and use the following terms:

01. Subject - A short identifying term suitable for exact match searches and preparing an alphabetical index.
02. Category - A code designation for searches of like-subjects (see hierarchy below).
03. Photo No.- The key number, prefixed with the year (89-001).
04. Title - Contains all the identifying information about the image. Probably what you would use to caption the photograph if it were published.
05. Photodate - Date picture was taken; always use same format for searching (yy/mm/dd, or dd/mm/yy, depending on how your program sorts dates).
06. Photographer-Use initials; specify copies and source credit.
07. Strg.Loc - Shows the location where the slide is stored.
08. Site name - Most specific location name (Sunnyside Mine).
09. District - Usually a geographic identifyer (San Juan Mountains).
10. Town - Use if applicable.
11. County - Use if applicable (use Province or Territory here).
12. State - Use zip code abbreviations for U.S.A.
13. Country - Use if applicable.
14. Tech.data - A note section for technical data such as camera, film, lens, filter, f/stop, shutter speed, etc.
15. # Dupls - Shows the number of duplicate slides available.
16. Remarks - For additional data or clarification.

After you have cataloged and labeled the slides you need a system for storage. The computer database system can help organize your slide collections by year and category. You use the computer generated index to find the particular subjects or localities you might want, say for a lecture. I set up the following topical hierarchy for this organization and it has worked well. The integrity of one year's worth of photographs is together, stored in archival-quality Mylar plastic sleeves (20 slides per page) in notebooks subdivided by the following categories:

01. TRAVEL SCENES/PLACES
02. FIELD TRIPS
03. RESEARCH LOCATIONS
04. DMNH OFFICE/LABORATORY WORK
05. SPECIMENS/COLLECTIONS
06. PEOPLE
07. EVENTS
08. EXHIBITS
09. MUSEUMS
10. GEOLOGICAL FEATURES
11. NATURE STUDIES
12. ART AND ARCHITECTURE
13. GRAPHICS AND ILLUSTRATIONS
14. PROGRAMS
15. RESEARCH PROJECTS

The following figures give examples of the types of sorting and indexing possible with the database program I have used. For my purposes, it has been important to have lists of subjects and localities in order to find photographs for publications and talks. The single catalog number system has worked well, however, in retrospect, I would prefer to also have a printed label on most slides. For most, unless you have very special applications, I recommend a photographic software product that easily prints and indexes subjects much in the manner I have described.

Selected References

Kampf, Anthony, R., 1989, Computerizing your mineral collection: Rocks and Minerals, vol. 64, no. 2, p. 128-133.

Gerig, Lynn A., 1989, How to label and file slides on your PC: Industrial Photography, vol. 38, no. 4 (April), published, PTN Publishing Co., 210 Crossways Park Dr., Woodbury, New York 11797, p. 24-25, 49.

Gartenberg, Jon, 1987, Cataloging films on a PC: Curator, vol. 30, no. 2, American Museum of Natural History, New York, p. 131-145.


```
Subject: Foord and Simmons                    Catg: 06 Photo No: 84-004
Title: Gene Foord, Skip Simmons and others on pegmatite symposium field trip.
Photo date (yy/mm/dd): 84/06/00 Photographer: JAM        Strg. Loc: 1984
Site name: Serrie pegmatite          Dist: South Platte     Town: Buffalo Creek
County: Jefferson              State: CO                    Country:
Tech.data: OM2:ASA64:60th:auto.                             # Dups: 0
Remarks: The group is looking at a smoky quartz crystal pocket discovered
         by Mark Jacobson and Al Falster.
```

Fig. 1. The computer record form, as it would be seen on the data entry screen, with data entered into fields (printed at 15 cpi).

CATALOG OF 35mm SLIDES FOR 1984
Photos by J. A. Murphy, Geology

Photo No	Subject	Catg	Site name
84-001	Field trip (So. Platte)	02	Serrie pegmatite
84-002	Jacobson & Falster	06	Serrie pegmatite
84-003	Jacobson & Falster	06	Serrie pegmatite
84-004	Foord and Simmons	06	Serrie pegmatite
84-005	Field trip (Seerie peg.)	02	Serrie pegmatite
84-006	Field trip (Serrie peg.)	02	Serrie pegmatite
84-007	Foord and Simmons	06	Serrie pegmatite
84-008	Mineral structure	05	Serrie pegmatite
84-009	Pegmatite (Bobcat)	03	Bobcat pegmatite
84-010	Pegmatite (Bobcat)	03	Bobcat pegmatite
84-011	San Luis Valley, CO	03	Bobcat pegmatite
84-012	Field trip (Bobcat)	02	Bobcat pegmatite
84-013	Field trip (Bobcat)	02	Bobcat pegmatite
84-014	Pegmatite (Bobcat)	03	Bobcat pegmatite
84-015	Modreski, Peter (at the Bobcat)	06	Bobcat pegmatite
84-016	Mineral collector-Bobcat peg.	02	Bobcat pegmatite
84-017	Allanite (Bobcat peg.)	05	Bobcat pegmatite
84-018	Jacobson, Mark (@ Bobcat peg.)	06	Bobcat pegmatite
84-019	Falster, Al (@ Bobcat peg.)	06	Bobcat pegmatite
84-020	Mineral collectors @ Bobcat peg.	02	Bobcat pegmatite
84-021	Field camp, Quartz Creek	02	Brown Derby mine
84-022	Gold deposit, Gunnison Co.	03	Good Hope mine
84-023	Gold deposit, Gunnison CO.	03	Good Hope mine
84-024	Field trip (DREGS)	02	Good Hope mine
84-025	Vulcan Dist. (geol.map)	13	Good Hope mine
84-026	Vulcan Dist. (x-sect)	13	Good Hope mine
84-027	Vulcan Dist. (map)	13	Good Hope mine
84-028	Vulcan Dist.-map	13	Good Hope mine
84-029	Thompson, Tommy-at Good Hope mine	06	Good Hope mine
84-030	Field trip (DREGS)	02	Good Hope mine
84-031	Gold deposit, Gunnison Co.	03	Good Hope mine
84-032	Gateway, Mesa Co., Colo.	01	Gateway;Dolores River
84-033	Uranium deposit, Mesa Co.	01	Abandoned mine
84-034	Uranium deposit, Mesa Co.	01	Abandoned mine
84-035	Uranium deposit, Mesa Co.	01	Abandoned mine
84-036	Uranium deposit, Mesa Co.	01	Abandoned mine
84-037	Field camp, Quartz Creek	02	Brown Derby pegmatite
84-038	Field trip, Quartz Creek	02	Brown Derby pegmatite
84-039	Field trip, Quartz Creek	02	Brown Derby pegmatite
84-040	Simmons, Skip	06	Brown Derby pegmatite
84-041	Jacobson, Mark	06	Brown Derby pegmatite

Fig. 2. A printout of a numerical listing of slides cataloged in 1984; with subject and locality (size reduced).

Alpha List of 1984 35mm slides
Photos by J. A. Murphy, Geology

Subject	Catg	Photo No	Site name
Allanite (Bobcat peg.)	05	84-017	Bobcat pegmatite
Falster, Al (@ Bobcat peg.)	06	84-019	Bobcat pegmatite
Field camp, Quartz Creek	02	84-021	Brown Derby mine
Field camp, Quartz Creek	02	84-037	Brown Derby pegmatite
Field trip (Bobcat)	02	84-012	Bobcat pegmatite
Field trip (Bobcat)	02	84-013	Bobcat pegmatite
Field trip (DREGS)	02	84-024	Good Hope mine
Field trip (DREGS)	02	84-030	Good Hope mine
Field trip (Seerie peg.)	02	84-005	Serrie pegmatite
Field trip (Serrie peg.)	02	84-006	Serrie pegmatite
Field trip (So. Platte)	02	84-001	Serrie pegmatite
Field trip, Quartz Creek	02	84-038	Brown Derby pegmatite
Field trip, Quartz Creek	02	84-039	Brown Derby pegmatite
Foord and Simmons	06	84-004	Serrie pegmatite
Foord and Simmons	06	84-007	Serrie pegmatite
Gateway, Mesa Co., Colo.	01	84-032	Gateway;Dolores River
Gold deposit, Gunnison CO.	03	84-023	Good Hope mine
Gold deposit, Gunnison Co.	03	84-022	Good Hope mine
Gold deposit, Gunnison Co.	03	84-031	Good Hope mine
Jacobson & Falster	06	84-002	Serrie pegmatite
Jacobson & Falster	06	84-003	Serrie pegmatite
Jacobson, Mark	06	84-041	Brown Derby pegmatite
Jacobson, Mark (@ Bobcat peg.)	06	84-018	Bobcat pegmatite
Mineral collector-Bobcat peg.	02	84-016	Bobcat pegmatite
Mineral collectors @ Bobcat peg.	02	84-020	Bobcat pegmatite
Mineral structure	05	84-008	Serrie pegmatite
Modreski, Peter (at the Bobcat)	06	84-015	Bobcat pegmatite
Pegmatite (Bobcat)	03	84-009	Bobcat pegmatite
Pegmatite (Bobcat)	03	84-010	Bobcat pegmatite
Pegmatite (Bobcat)	03	84-014	Bobcat pegmatite
San Luis Valley, CO	03	84-011	Bobcat pegmatite
Simmons, Skip	06	84-040	Brown Derby pegmatite
Thompson, Tommy-at Good Hope mine	06	84-029	Good Hope mine
Uranium deposit, Mesa Co.	01	84-033	Abandoned mine
Uranium deposit, Mesa Co.	01	84-034	Abandoned mine
Uranium deposit, Mesa Co.	01	84-035	Abandoned mine
Uranium deposit, Mesa Co.	01	84-036	Abandoned mine
Vulcan Dist. (geol.map)	13	84-025	Good Hope mine
Vulcan Dist. (map)	13	84-027	Good Hope mine
Vulcan Dist. (x-sect)	13	84-026	Good Hope mine
Vulcan Dist.-map	13	84-028	Good Hope mine

Fig. 3. A printout of an alphabetical listing of subjects (size reduced).

```
Field trip (Serrie peg.)  02  84-006
Serrie pegmatite  So. Platte
Jefferson  CO

Field trip (DREGS)  02  84-030
Good Hope mine  Vulcan
Gunnison  CO

Field trip (DREGS)  02  84-024
Good Hope mine  Vulcan
Gunnison  CO

Field camp, Quartz Creek  02  84-021
Brown Derby mine  Quartz Creek
Gunnison  CO

Field trip (Bobcat)  02  84-013
Bobcat pegmatite  Sangre de Cristo
Alamosa  CO

Field trip (Bobcat)  02  84-012
Bobcat pegmatite  Sangre de Cristo
Alamosa  CO

Field trip (So. Platte)  02  84-001
Serrie pegmatite  South Platte
Jefferson  CO

Field trip (Seerie peg.)  02  84-005
Serrie pegmatite  South Platte
Jefferson  CO

Field camp, Quartz Creek  02  84-037
Brown Derby pegmatite  Quartz Creek
Gunnison  CO

Field trip, Quartz Creek  02  84-038
Brown Derby pegmatite  Quartz Creek
Gunnison  CO

Field trip, Quartz Creek  02  84-039
Brown Derby pegmatite  Quartz Creek
Gunnison  CO
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Fig. 4. An example of a second type of format that can be printed, commonly known as "address labels."

USE OF THE RINGLIGHT FOR CLOSE-UP PHOTOGRAPHY

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A ringlight consists of a round flashtube which fits on the front of a macro lens. This enables the photographer to move in close to the subject and have enough light to use smaller apertures for greater depth of field. There is also a power-pack which holds the batteries. These two units are connected by a cord.

Some ringlights are made by the camera manufacturer specifically for certain cameras. These are usually the fully dedicated systems which read through the lens and off the film plane, or TTL. These are by far the easiest units to use as all the metering functions are taken care of automatically. The photographer only needs to focus and shoot. These systems are also more expensive, usually in the five hundred dollar range.

Another type of ringlight does not dedicate to any one system, but rather has a sensor built into it which shuts the flash off when enough light has illuminated the subject. These are fine except you are limited to only a few apertures instead of the full range of apertures with a TTL system.

Then there is the fully manual ringlight. This unit enables the photographer full control of the light reaching the subject, but it is necessary to calculate which aperture, film speed and distance will be used in any given situation. I find it is easiest to chart these variables on a card and carry it with me when out in the field. These units come with full instructions explaining how to calculate the proper aperture and distance depending upon which lens is being used. The macro lens is ideal because the entire frame can be filled with the specimen; also, the ringlight is short range as far as flash distance so the lens must be fairly close to the subject.

Because of the ringlight's design, the light surrounds the subject and gives a soft, even light without shadows. If a shadow is desirable, a piece of tape covering the side of the flash where the shadow is needed will do the trick. This will give the specimen a feeling of depth. It is best to experiment and see what works best for each situation. One more advantage of the ringlight is the dark background which can be achieved fairly easily. Since the flash range is so short, if there is no bright area behind the subject the falloff of the flash will create a black background which makes the subject stand out.

It generally is not necessary to use a tripod with the ringlight because the flash stops motion. However, some people find it easier to focus if the camera is steadied by a tripod. With a little practice it becomes simpler to position the subject in the frame while hand holding the camera. This also saves time.

In conclusion, the ringlight is a tool that saves time, simplifies lighting problems and allows for greater depth of field which is necessary in any close-up photograph. It will enhance the beauty of your specimens while they still have a natural appearance and true color.

PART II

PUBLICATIONS by JEFFREY A. SCOVIL

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1986 - Mineral Photography: Equipment and Vibration, **Rocks and Minerals**, vol. 61, no. 2, p. 70-73

1987 - Mineral Photography: Film and Lights, **Rocks and Minerals**, vol. 62, no. 4, p. 258-262

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1988 - Mineral Photography: Lights and Metering, **Rocks and Minerals**, vol. 63, no. 6, p. 473-477

Mineral Photography

BASICS AND A DIFFERENT APPROACH

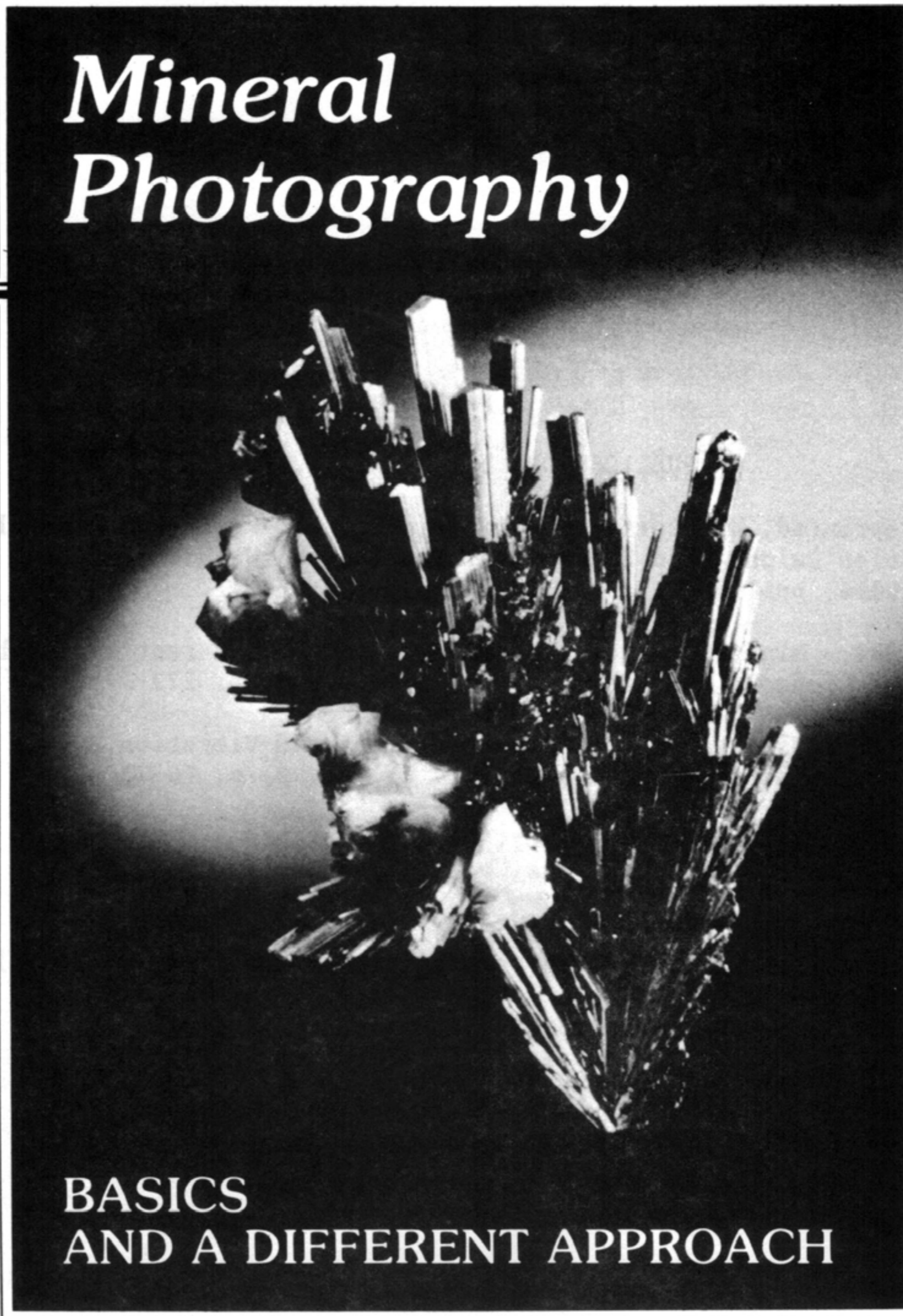

Figure 1: **Stibnite, Herja, Romania, 5.0 cm long. F/16, ¼-second, reversed 55mm. Takumar; Ektachrome. Collection of Bill and Cecil Hoisington.**

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THIS ARTICLE PRESENTS THE TECHNIQUES I USE to photograph minerals and a few pointers on the more subjective aspects of the art. The setup I use can be seen in Figure 2. The specimen lies on the uppermost sheet of glass, with a sheet of opal glass covered by the background material beneath it. In the lower box-like portion are two No. 1 photofloods wired to a dimmer switch.

Lighting for the specimens is provided by 500-watt, 3200K floodlights. For smaller specimens the bare bulbs of microscope lamps are used. Microscope lamps may also be used for spotlighting larger specimens. I usually use only one main light and provide the fill-in light with small mirrors placed on the glass. This saves the trouble of handling a number of hot, not easily maneuverable floodlights. If softer fill-in is needed, I use white cards or aluminum foil,

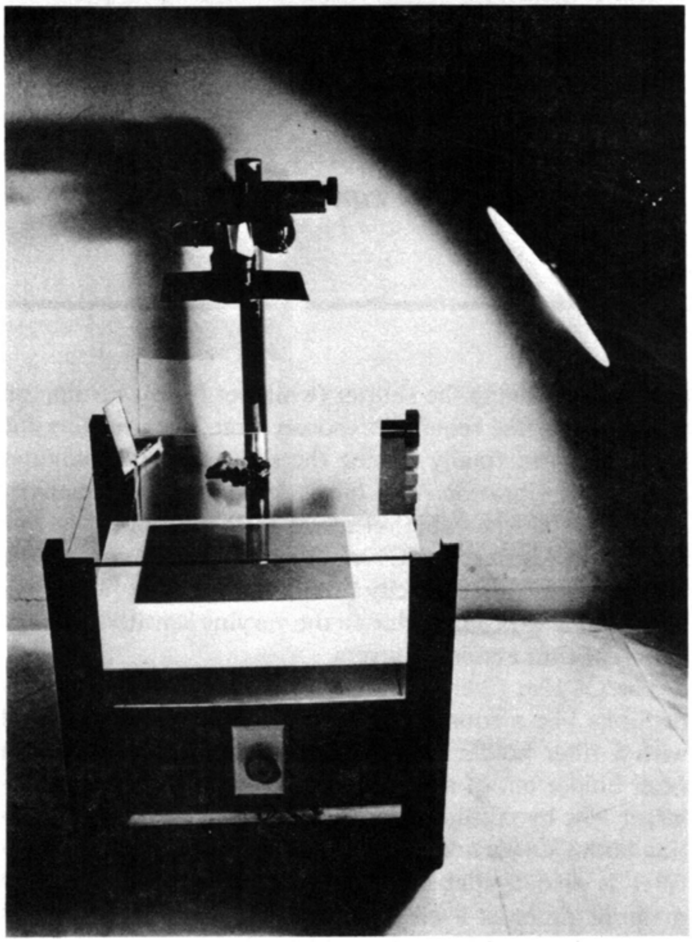


Figure 2: **Setup for photographing minerals.**

matte side out, attached to a card. Sometimes a machinist's small mirror comes in handy.

After lighting the specimen and while constantly viewing the results through the camera, the background is lighted to complement the specimen. Backgrounds are produced by placing colored sheets of paper, cloth, or translucent plastic on the opal glass. The plastic permits the intensity of the background illumination to be varied by the dimmer switch controlling the lights in the base; however, opaque backgrounds are more versatile. In lighting the specimen, the background is illuminated by the same source, and it can be completely or partially shaded, as in the cover photograph. The background can also be illuminated by a microscope lamp to create a spotlight effect, as in Figure 1.

Plans for a setup such as I use have been published by Kodak (1962). A simplified version may be made by using two inverted L-shaped pieces of wood attached to a base, to support the glass (Blaker, 1965). There are several advantages to this method. First, there are no distracting shadows around the specimen. Also, the specimen can be lighted from above and/or below, making the method ideal for the photography of transparent or translucent specimens. A third advantage is that less support of specimens is required than when they are placed directly on the background material. This is especially true of long, thin crystals. When support is necessary, I use a nonstaining, permanently flexible putty called "Hold-It," made by Eberhard Faber; it is available at office supply stores.

There are a few minor disadvantages to photographing specimens on glass. Dust on the glass is a constant problem, as are fingerprints and putty smudges. The glass should be thoroughly cleaned before each shooting session, and a fine brush should be kept on hand to remove dust before each exposure. Care must be taken not to scratch the glass. Reflections from the camera body can be avoided by fabricating an oversized lens hood made of black cardboard. A hole is cut in the center of the cardboard so it fits snugly around the end of the lens. A small wall made of black paper about one-half inch high should surround the hole. This eliminates reflections off the portion of the lens that projects through the cardboard. This hood should be just large enough to shield any reflections from the camera to the glass. Also, all overhead lights should be turned off during exposures.

Figure 3: **Beryl, Minas Gerais, Brazil, 4.2 cm long. F/16, ½-second, 55 mm. Collection of J. Scovil.**

I use two cameras, a Pentax SP 500 and a Pentax SP 1000. They allow me to photograph all specimens in both color print (Kodacolor II) and slide (Kodachrome 25) film; occasionally I will also shoot in black and white. There are two advantages to using color print film: it is less expensive to have prints made from it, and the quality of the print is better than a print made from a slide. I use these two films for their superb color rendition and fineness of grain. Since both films are balanced for daylight, I use an 80a blue conversion filter.

The lens usually used is a 55mm Super Takumar. For close-up work the Takumar is reversed on extension tubes or bellows. This produces a much sharper image than if the lens were not reversed. Reversal would not be necessary if a macro lens, designed for close-up photography, were used. For really close work, I use a 50mm Schneider Componon enlarging lens, which gives superior results.

The camera is always mounted on a copy stand. Exposures of more than one second are made by turning out the lights, opening the shutter (while set on B), turning on the lights for the required exposure time, then turning the lights off, and finally closing the shutter. This eliminates all possible vibration from mirror or shutter movement or from pressing the cable release. For these long (over one second) exposures, a CC10m filter is used to correct the color shift from reciprocity failure. Reciprocity failure occurs in long exposures, due to the varying sensitivity of the different film emulsion layers.

Figure 4. **Vanadinite, Apache mine, Globe, Arizona. Field of view 10 mm. F/16, 30 seconds, 50 mm Schneider Componon; Kodachrome 25. Collection of J. Scovil.**

Keeping the crystal dead center or perfectly parallel with the picture edges can be boring. . . .

The CC10m filter is available in gelatin in various sizes (it looks like a square of thin plastic), and must be used with a filter holder designed for gelatin filters. I made a filter holder out of a plastic lens cap for my Schneider enlarger lens by cutting most of the cap center out and cutting both CC10m and 80a filters to fit inside. The 80a blue-filter is also available in varying sizes from most filter manufacturers as a glass screw-in filter. Camera dealers can recommend filter sizes and filter holders for your lens.

Photography with an aperture of f/16 or f/22 allows maximum depth of field. It must be remembered, however, that as the aperture gets smaller and the depth of field increases, the depth of detail or sharpness decreases. Therefore, a compromise, such as using an aperture of f/11 or f/8 (Kodak, 1969), must be reached between these two requirements.

Exposure readings are taken off a gray card placed in the position of the specimen after the proper lighting has been set up. A gray card is designed to give an average light reflectance and, therefore, gives more accurate exposure readings. Extremely light or dark specimens or backgrounds can throw readings off. Even with a gray card, it is wise to bracket shots. In other words, take extra shots exposing one f-stop up and one down from that recommended by the light meter. Readings are best if taken by a meter in the camera that reads through the lens. There is occasionally a benefit to using a hand-held spot meter to get an averaged reading if the specimen has very light and dark areas. An incident light meter would be useful for taking readings for transilluminated specimens.

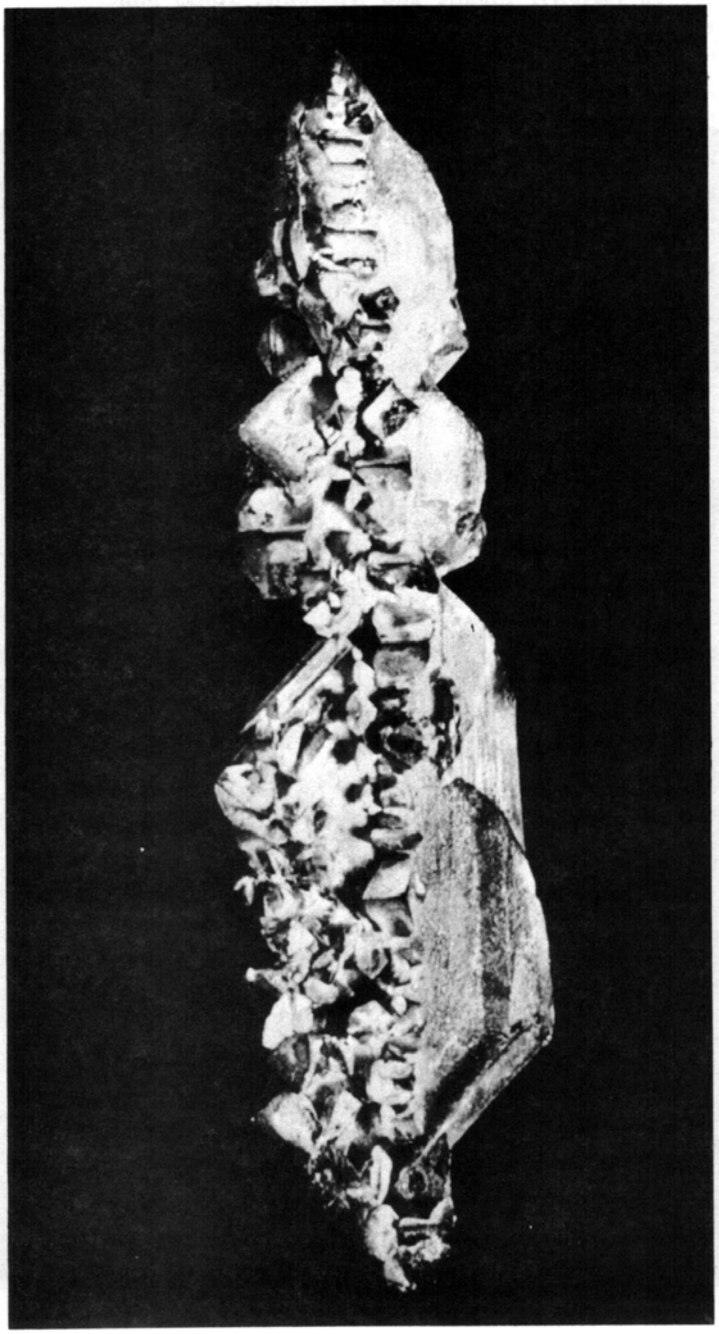
You will find that some specimens which are gorgeous when held are impossible to photograph decently. On the other hand, some specimens that seem not so impressive may photograph beautifully. The more specimens you photograph, the better you will be at assessing a specimen's photographic potential before shooting.

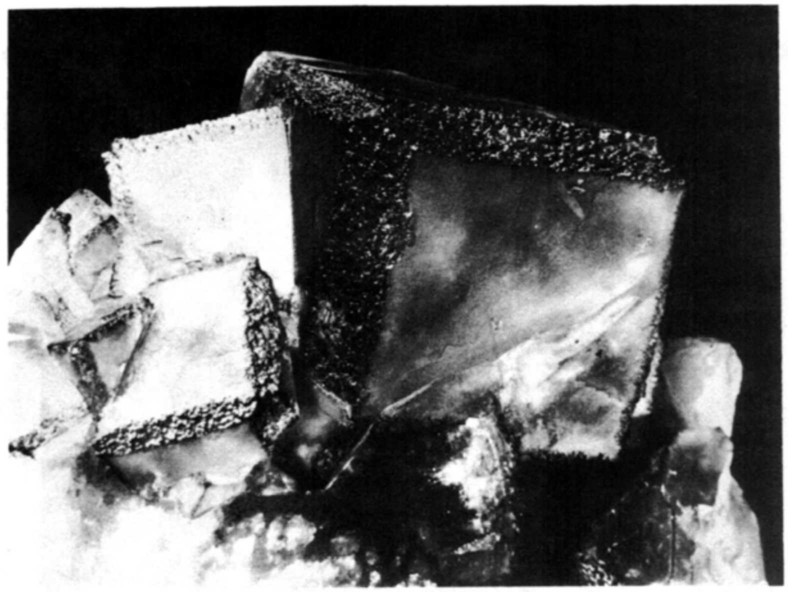
Figure 5 (below): **Copper, Ray, Arizona, 5.8 cm long. F/16, 3 seconds, reversed 55mm Takumar; Kodachrome 25. Collection of Evan Jones.**

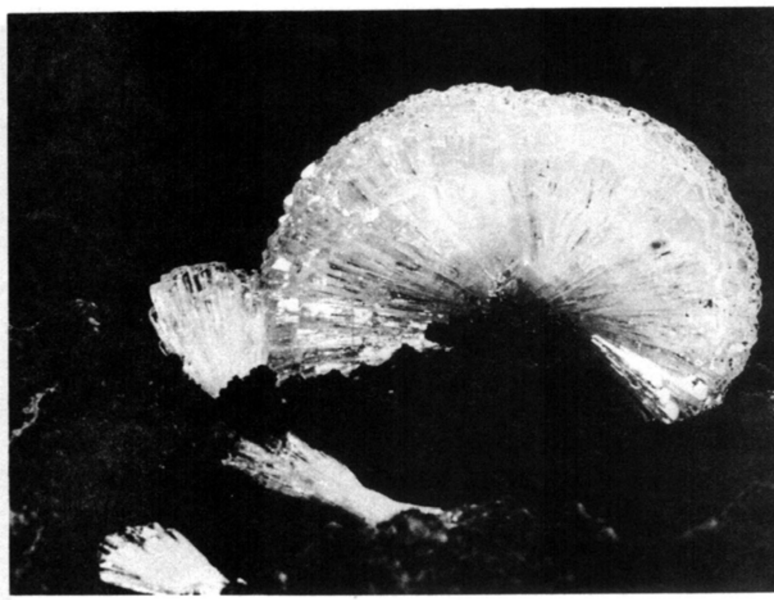
Figure 6 (upper right): **Fluorite, Oviedo, Spain. Large crystal approximately 2.5 cm. F/16, 4 seconds, reversed 55mm Takumar; Kodachrome 25. Collection Harold Michel.**

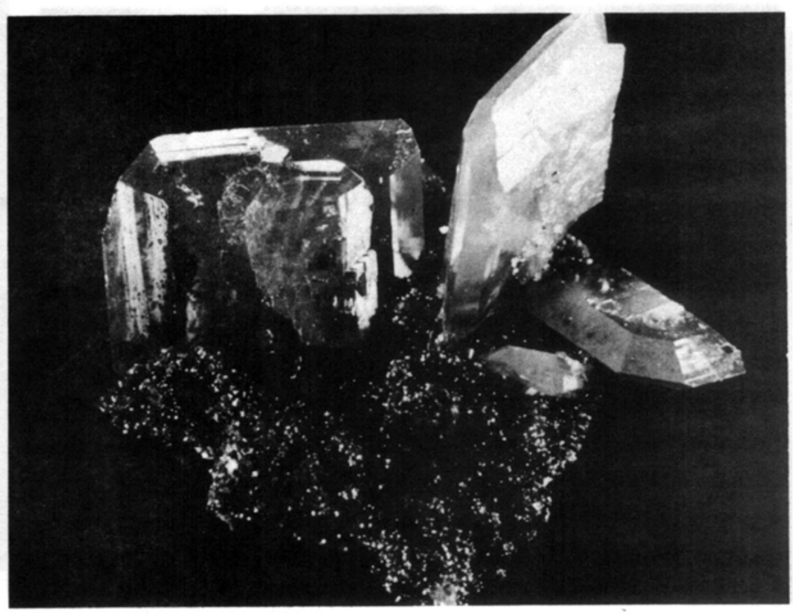
Figure 7 (middle right): **Adamite, Mina Ojuela, Mapimi, Durango, Mexico, 2.5 cm across group. F/16, 4 seconds, reversed 55mm Takumar; Kodachrome 25. Collection Harold Michel.**

Figure 8 (lower right): **Wulfenite, Red Cloud mine, Yuma County, Arizona, 3.7 cm across. F/16, 4 seconds, reversed 55mm Takumar; Kodachrome 25. Collected by Ed Over.**









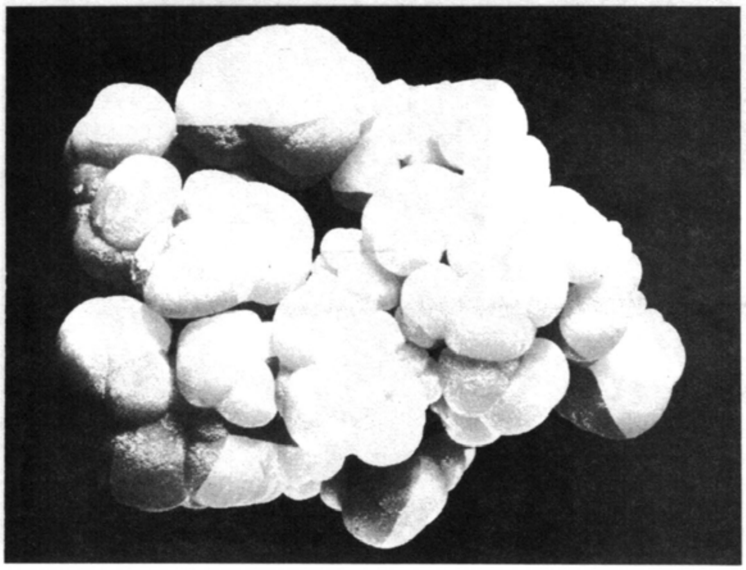
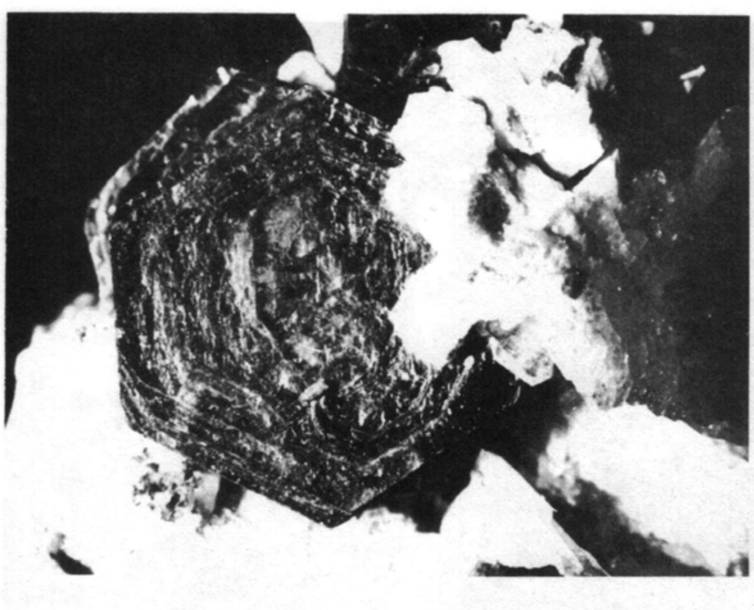


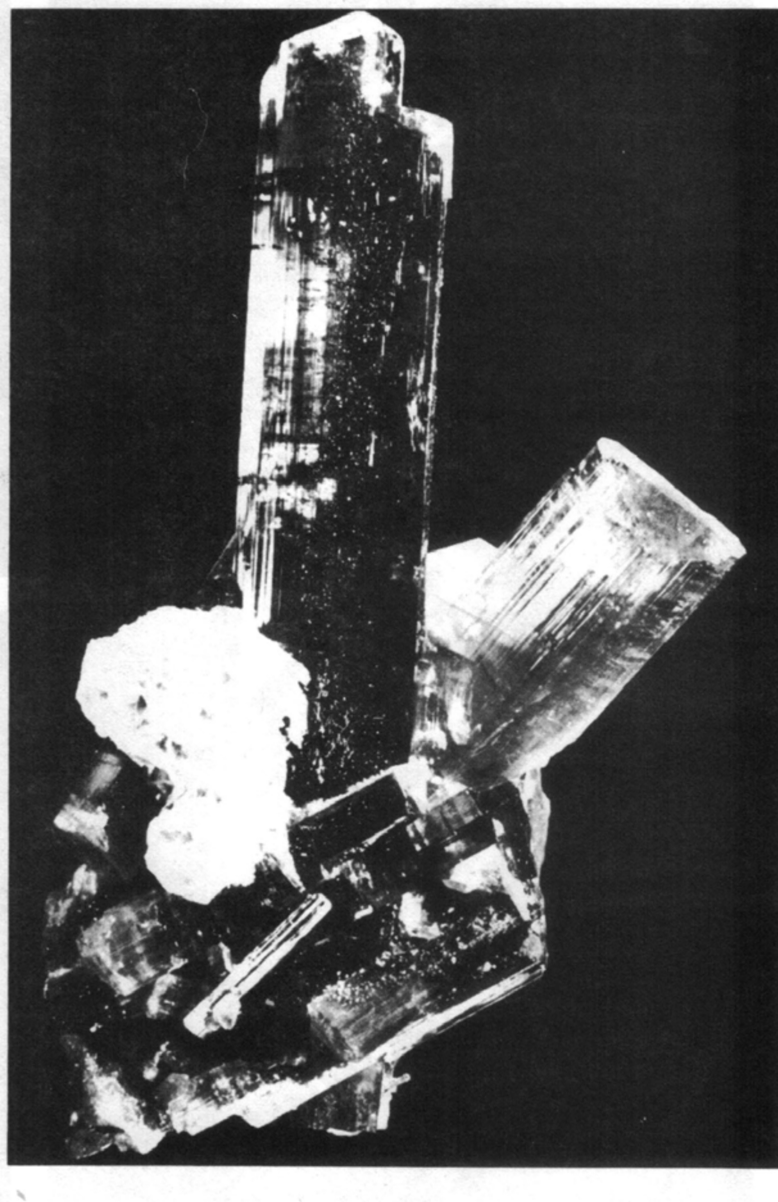
Figure 9 (upper left): **Mimetite, Chihuahua, Mexico, 7.0 cm high. F/16, 3 seconds, reversed 55mm Takumar; Kodachrome 25. Collection of Evan Jones.**

Figure 10 (middle left): **Barite, Grand Junction, Colorado, 2.6 cm long. F/16, 6 seconds, reversed 55mm Takumar; Kodachrome 25. Collection of J. Scovil.**

Figure 11 (lower left): **Muscovite on albite, Cobalt, Connecticut; crystal 1.6 cm in diameter. F/16, 8 seconds, reversed 55mm Takumar; Kodachrome 25. Collection of J. Scovil.**

Figure 12 (below): **Elbaite and lepidolite, Jonas mine, Conselheiro Pena, Minas Gerais, Brazil, 8.6 cm high. F/16, 55mm Takumar; Kodachrome 25. Former collection of Jack Lowell.**





The most important thing to remember about lighting is to achieve definition of the crystal faces; faces should be distinct and not blend into each other.

Subjective Aspects

Let's go through the more subjective aspects of photographing a particular specimen. Which side of it looks best? Place it on your setup, propped so that its best face is toward the camera. Compose your photograph by moving the specimen around, and move the camera toward or away from the specimen. Do not have so much background showing that the subject looks proportionately too small. If framed too tight, the picture will appear overcrowded. The shape of the specimen and the location of major crystals on it will determine its placement in the frame. Keeping specimens dead center or perfectly parallel with the picture edges can be boring. Study photographs and paintings for ideas on composition.

There is something else to keep in mind. If a specimen has many crystals on it, it may be more effective to get in close and photograph just a few of them in detail than to capture the whole piece as a mass of glitter with tiny, unrecognizable crystals.

When lighting the specimen, the main light should be above and to one side if possible. While viewing the specimen through the lens, move the main light until the specimen is shown to its best advantage. The most important thing to remember about lighting is to achieve definition of the crystal faces; individual faces should be distinct and not blend into each other. I have seen too many photographs where all there is is a shape and color and no detail revealing the perfection of the crystals that brings the photograph to life.

Crystal faces on a specimen are defined by varying the amount of light reflecting off them. If faces reflect too much light, they will be distracting hot spots. It is, therefore, important to fill-in light sources for an even balance. Care should also be taken to make sure that the edges of important crystals do not fade off into the infinity of the background. On the other hand, too much contrast is distracting and reduces definition.

Depth of field is limited in close-up work. Thus it is important to keep major crystals on the specimen in a plane which is as close as possible to parallel with the film plane. This reduces the depth of field problems. Compose with the lens wide open—that is, at its lowest f-stop. Focus at a point about one-third of the way into the specimen, then reduce the lens opening to make sure important features are in focus. Nothing is more disconcerting than to have the finest crystal on the specimen out of focus. If you wish to photographically isolate one particular crystal or group from the rest, use a low f-stop for shallow depth of field. You can separate the desired subject by having it be the only thing in focus.

Make sure that your specimens are clean and handle them carefully when shooting. Fingerprints on prominent crystal faces in the photograph cannot be wiped off. Likewise, dust and lint stand out in the final product. When you are ready to take the exposure after all your careful set-up, check the specimen for dust. Blow it off with a syringe. Do not blow on it directly with your mouth or you may have to spend a lot of time rewashing and drying the specimen to remove spittle.

I choose background color after I am all set up. Keep a selection of papers of different colors on hand, and experiment with them. Watch the results through the lens. Then decide if you want to shade or spotlight the background.

Look at the works of many different photographers and see how their styles vary. Use them as inspiration but try not to slavishly copy. It is individual style that sets one photographer apart from another. Analyze photographs to determine techniques. The methods I present here work for me, but they may not appeal to you. Part of the fun of photographing minerals is the creativity. Try new light sources, backgrounds, and lenses. Do not be afraid to experiment. What you come up with may be what sets you apart from the crowd.

Jeffrey A. Scovil was laboratory photographer for the San Juan Valley Archeological Project (Farmington, New Mexico) and the Arizona State University anthropology department.

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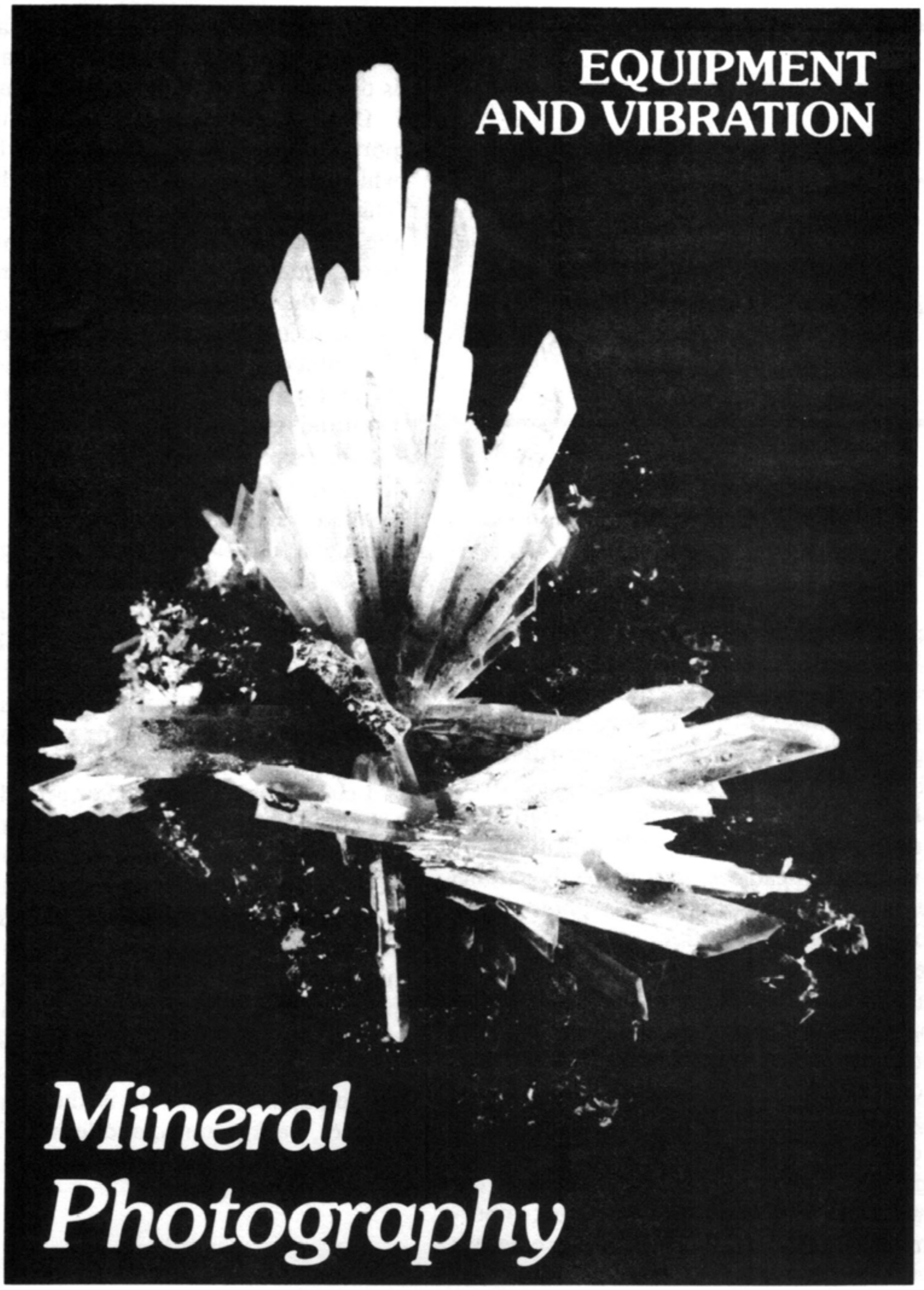
Mineral Photography

EQUIPMENT AND VIBRATION



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THERE ARE HUNDREDS OF CAMERAS with thousands of accessories and features available to today's photographer. This article will help you decide on the cameras and equipment best suited for the requirements of mineral photography and will discuss some of the special problems encountered in close-up photography. We will be considering only 35mm cameras for the present because of their popularity, availability, versatility, and cost. Other types of cameras will be considered in a future article.

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

In a rangefinder camera the lens is only used for picture taking. The viewfinder looks through a small window usually to the upper left of the lens (from the user's position). The optical rangefinder is coupled with the lens mount so that focusing can be accomplished, as illustrated in Figure 3.

Your SLR should have a popular lens mount system. It will enable you to use the accessories needed for close-up work as well as for different focal length lenses. It will also help you keep your costs down by allowing you to use the less expensive accessories produced by independent manufacturers. Generally, the SLR is the camera of choice, offering a much larger selection of lenses and accessories with which to work.

The rangefinders are limited to how close you can get to a subject and still use the rangefinder for accurate focusing and framing. This is because at short distances the rangefinder and lens are looking at different subjects. This is called parallax error. Some rangefinder cameras have a built-in parallax correction to overcome the problem, but it still does not help at very short distances. Due to this parallax problem, I will no longer consider rangefinder cameras in this article. Please see Figures 2 and 3.

Through the lens (TTL) metering is not a must, but it will save you a lot of trouble. With TTL metering you get accurate readings of the light reaching the focusing screen. You do not have to compensate for filters, extension tubes, or bellows, all of which reduce the amount of light reaching the film. You can use a hand-held light meter and then calculate the exposure compensation. This is a lot of extra work and something else to forget to do in the heat of a shooting session. Most SLRs today have TTL metering, but many older ones do not.

Another handy, but optional, feature to have, is a mirror lock. This feature locks the mirror in the up position before taking an exposure. This is helpful as it eliminates the mirror as a source of vibration during the long exposures necessary for close-up photography. Fortunately there are ways to get around this problem, so if your camera does not have this feature, do not worry about it. A problem 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. By this time, however, you have already focused, composed, and set up your lighting and have no further need to view the subject.

Many cameras today have computerized automatic functions. They 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. Luckily, most of these cameras have manual overrides for their auto exposure feature. Some of these features can be handy but, with the possible exception of two, are not really necessary for mineral photography. The OTF flash metering could be extremely helpful when doing close-up mineral photography with the strobe. Such photography can be very touchy exposure-wise and OTF flash metering would make the technique less of a headache.

The data back feature enables you to put important data such as date and exposure directly on the negative along its edge. This simplifies record keeping, and you will not have to worry about misplacing your notes. However, this data is not very attractive on color slides.

When buying a new camera, you may be given a choice of lenses with different maximum apertures. The standard and least expensive is f2, with f1.8, f1.4, and f1.2 also available at correspondingly higher prices. For our purposes, a wide aperture is not critical, but small apertures

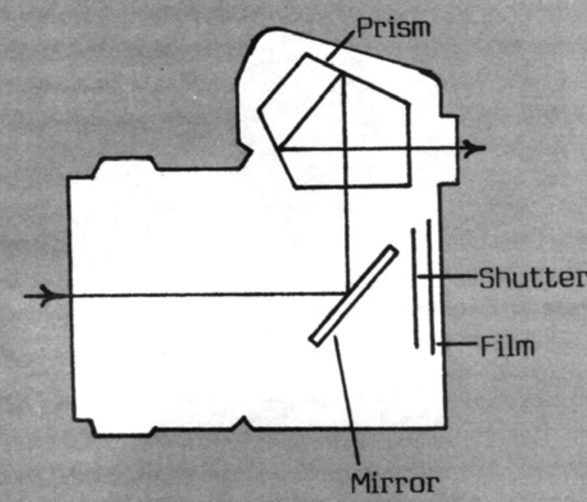

Figure 2: **Single lens reflex camera.**

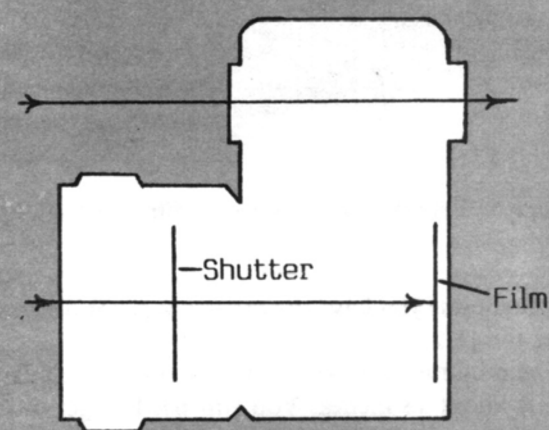

Figure 3: **Rangefinder camera.**

Figure 1 (opposite page): **Gypsum, Magma mine, Superior, Arizona; 6.2 cm high; color, white. F16, 15 seconds, 55mm Takumar lens; Kodachrome 25. Main light from right, mirror fill from left. Solid color background with faint halo from microscope light. Specimen on raised glass.**

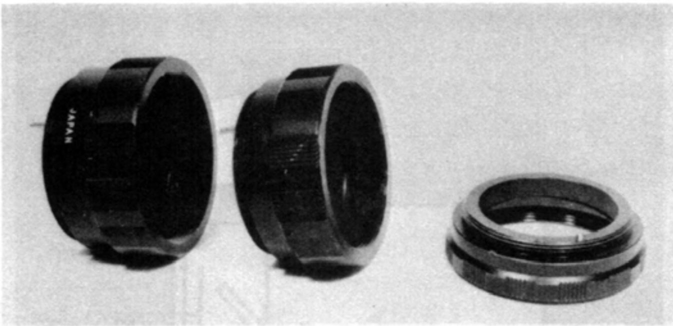

Figure 4: **Extension tubes.**

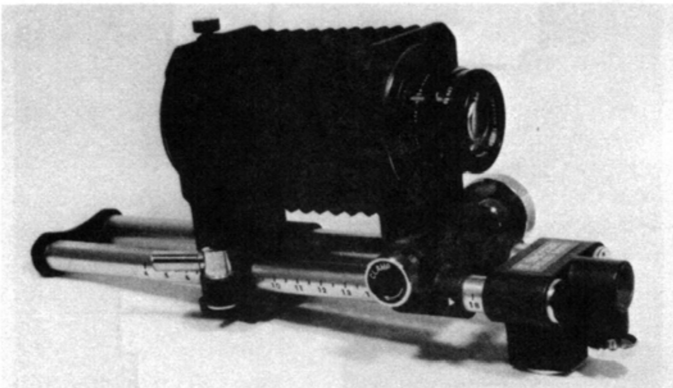

Figure 5: **Bellows with Schneider 50mm enlarging lens.**

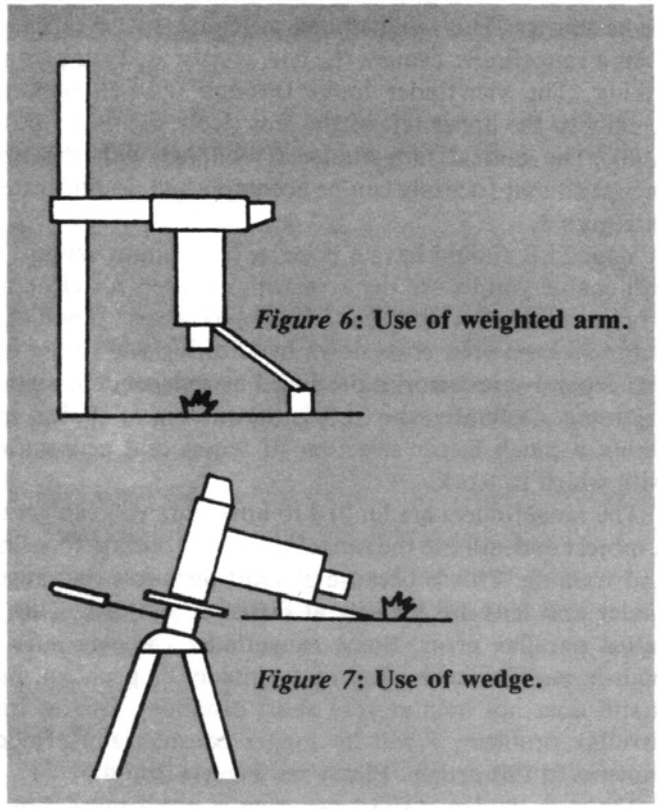

Figure 6: **Use of weighted arm.**

Figure 7: **Use of wedge.**

are. So unless you have the money, it is not necessary to go after the f1.2.

The minimum focusing distance for the standard 55mm lens is about 18 inches. You will need to get much closer than that to do your specimens any justice. If your budget can take it, it would be wise to buy a macro lens; they are designed to focus much closer 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 your photographs will be much sharper using one.

Macro lenses fall into roughly two groups, those of about 50mm and those of about 100mm focal lengths. The 100mm lenses give you a little more working distance. This means you will not be getting in the way of your own lights. Those in the 50mm range will afford higher magnification with less extension and slightly better depth of field. On the other hand, a 100mm will give you slightly better perspective and representation of the subject.

Most macro lenses come in two parts: the lens which can get you quite close to the subject, and an extension that allows you to get a life-size image (a 1:1 magnification ratio). Some lenses do not require this extra tube to go to 1:1. As you can see, a macro lens does everything your standard lens will do, plus more. So if you can afford one, get a macro instead of the standard lens.

What if you have one of those macro zooms? First of all, they will not get you as close as a macro lens, and their optical quality is not as good as a macro. Macro lenses are fairly expensive, but they can save you a lot of time by not having to juggle extension tubes or bellows for much of your shooting.

I have mentioned extension tubes and bellows. In order to get closer to a specimen (and thereby get a larger image of said specimen), the lens must be extended from the camera. In a macro lens there are built-in provisions for this. If you do not own a macro lens, you have two options. Extension tubes, which are usually a series of three solid rings of varying lengths, can be inserted between the lens and the camera body (Figure 4). Used in different combination, they can vary your close-up capability. A bellows is a similar idea but is a single expandable paper or fabric bellows mounted on rails (Figure 5). It is infinitely variable in positioning between its minimum and maximum points of travel. Better quality bellows allow independent movement of both lens and camera, plus they allow moving the camera and lens together as a unit. The latter feature is necessary so as not to change proper magnification, once attained. The bellows in Figure 5 do not allow this. Bellows are usually larger than the standard set of extension tubes but much more versatile. I keep both tubes and bellows on hand.

When you buy tubes or bellows, keep in mind that some will allow you to continue to use your automatic functions, and others will not. Price again is the variable here, plus convenience. Either type will do the job, but you have to think more with manual bellows and tubes.

Because of the longer exposures involved in close-up photography, a steady camera mount is necessary. A sturdy tripod is the answer, and the heavier the better. A light 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 will allow you to clamp the camera to the edge of a table or other convenient support.

Some photographers use a set-up looking straight down at the specimen. For this arrangement, a sturdy copy stand is needed. The more attachments you have on a camera, the heavier and less stable it is. This also makes it harder to adjust vertically on the copy stand. To best deal with this, a copy stand with a gear drive is very helpful. A friction drive is less dependable because it is subject to slipping with heavy equipment.

It is also wise when using heavy equipment or tall copy stands to brace the stand. It can be bolted to the table top or floor and braced against a wall.

The longer the bellows or extension tubes, the more subject they are to vibration. To correct this you can attach a moveable weighted arm to the end of the tubes or bellows. To the strut is attached a heavy weight that rests on the table surface, stabilizing the equipment. This is good for copy stand set-ups as in Figure 6. Tripod mounted set-ups can be braced by inserting a wedge between the end of the bellows or tubes and the table top. Refer to Figure 7.

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 camera set-up or the table the specimen is resting on.

The camera itself is a source of vibration. The shutter opening and closing and the mirror flopping up and down can cause trouble. 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 shoot at night. With the camera set on B with a locking cable release attached, open the shutter, wait a few moments for vibration to cease, then turn on the photographic lights for the required exposure time. Close the shutter, turn the room lights on, and you are done. This 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.

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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 problem with exposures of only a few seconds. With long exposures, vibration time is short relative to the total exposure time, and therefore vibration has minimal effect.

In summary, use a good 35mm single lens reflex camera that has a popular interchangeable lens mount system to make the most of the accessories you will need. If possible buy a macro lens: it will be your most useful lens. For magnifications greater than 1:1, get a good bellows and/or extension tubes. And to keep your photographs as sharp as possible, avoid vibration by using a solid camera support and cable or air release.

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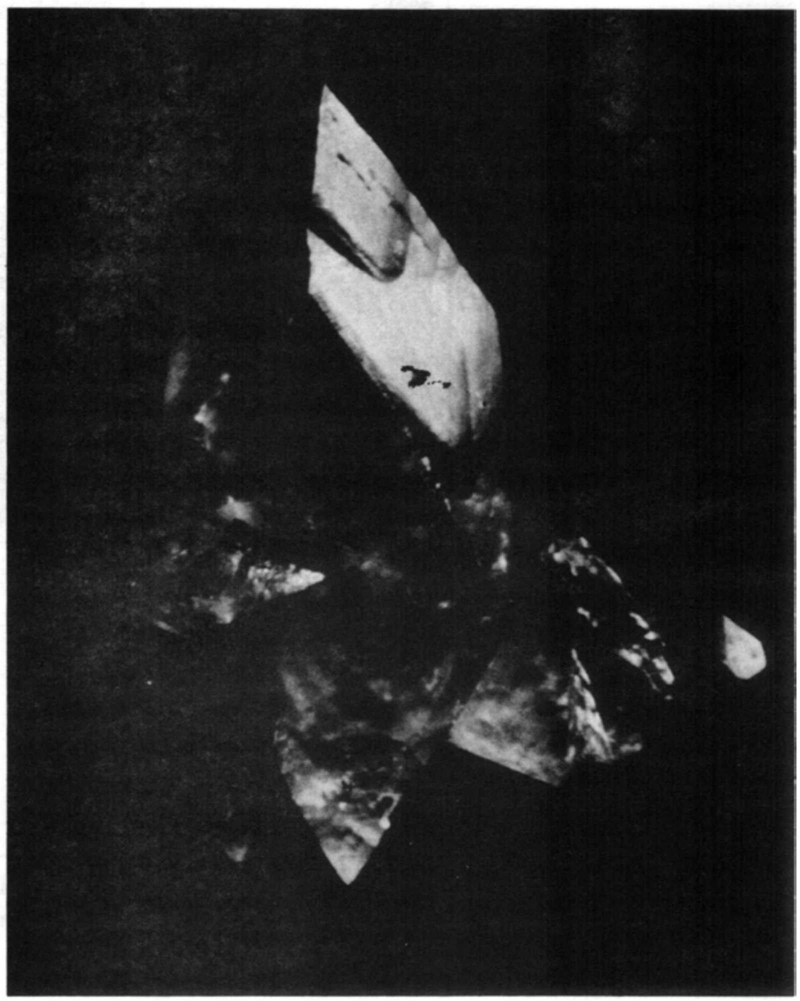
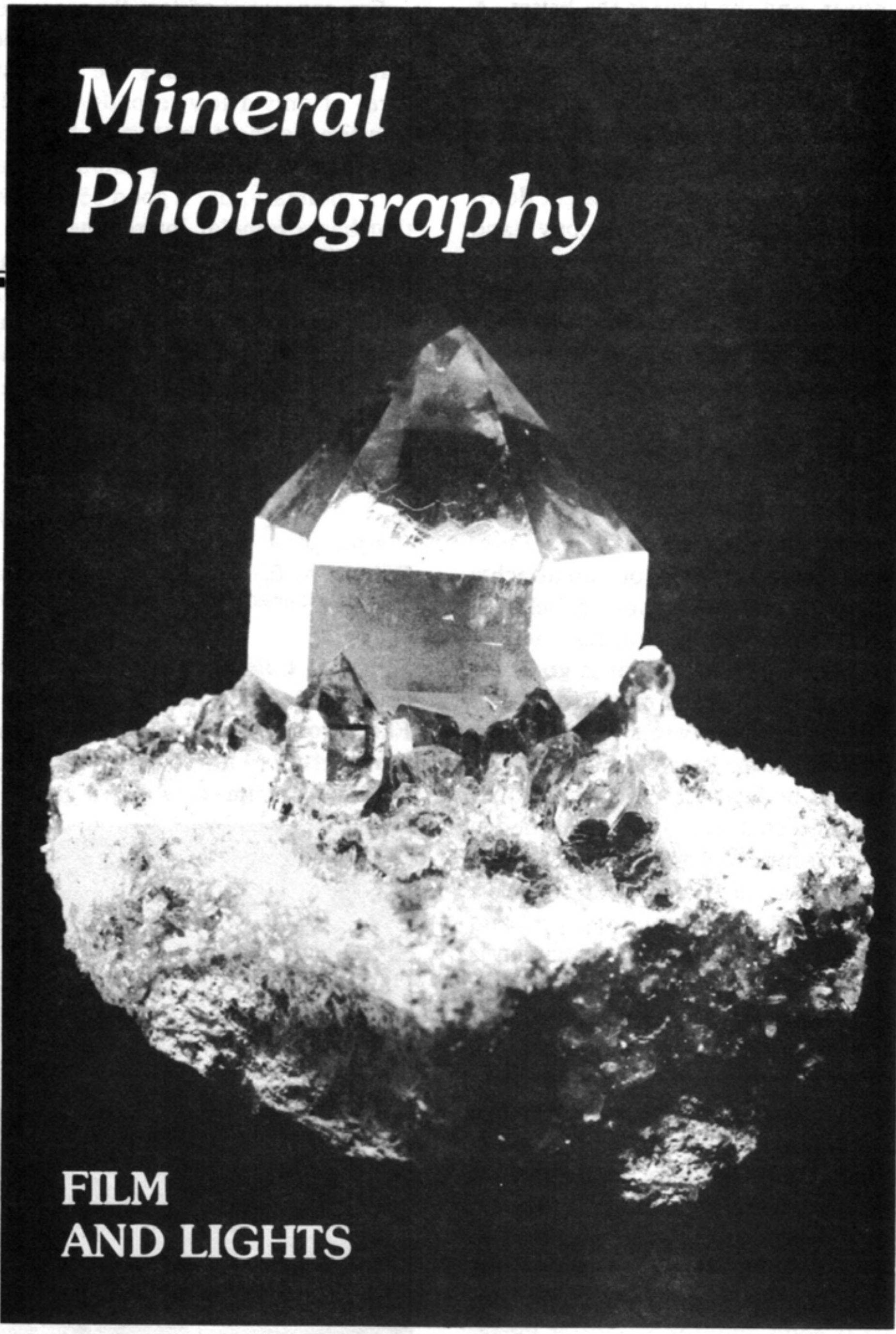
***Figure 8*: Calcite, Woodbury, Connecticut; 2.3 cm high; color, honey yellow. F16, 1 second, 55mm Takumar lens; Ektachrome. Main light from upper right, fill-in from lower left. Gradation of background lighting from partial shading. Specimen on raised glass.**



Mineral Photography



FILM AND LIGHTS

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ONCE THE BUDDING PHOTOGRAPHER has determined what kind of camera to buy, he is faced by a bewildering number of films and light sources. In this article I hope to assist tomorrow's fine mineral photographers in making intelligent choices.

Film

General Considerations

In any type of photography, film choice is important and is dependent on subject material, lights, and the purpose of the photographs. This article will cover films for use in 35-mm cameras. Color film is usually the choice for mineral photography because of the incredible range of colors found in the mineral kingdom. Many photographers, however, feel that black and white is better, as it forces you to work with just form and line. If you have your own darkroom, black and white film is less expensive and easier to work with, and there is much greater control over the results. Black and white photographs are also more readily accepted for publication because they are less expensive to print.

Films with lower ISO (ASA) numbers generally are better choices. A lower ISO number means a slower film, resulting in longer exposures. The advantage is that slower films have much finer grain and better color rendition. Fineness of grain is important if you plan on making large prints.

Color Film

Color film is available as either slide (transparency) or print (negative) film. If you lecture, use slide film. If you wish to display your work, use print film. If you want both slides and prints, you can always have prints made from slides. The quality of such prints can be quite good, but prints from print film are better. I solve the problem by having two camera bodies on hand, one loaded with print film and the other with slide film. I can then shoot specimens with both films by just switching bodies.

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 fluorescent light is greenish. In order to use outdoor film indoors, you must use flash which emits a daylight-type light, or a conversion filter. (I will speak more on filters in a future article.) Indoor film used outdoors requires a conversion filter too. 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 will give the information you need on color balance and light sources.

I usually use daylight-balanced Kodachrome 25 with an 80a blue conversion filter. This allows me to use it indoors with lights rated at 3200°K. I use this combination of film and filters for several reasons. Kodachrome is one of Kodak's finest grain films, has superb color rendition, and is a slide film. (I prefer slide film for most of my work.) There is an advantage to using a daylight-balanced film. If you do not use the whole roll on specimens, you can take off the conversion filter and use the rest for outdoor photography, or use it indoors with a flash.

The disadvantage of using a slow daylight-balanced film with conversion filters is that exposures can be very long. The longer an exposure, the greater the chance that vibration may blur 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, they have shifts in color and speed. As a result, the color will be incorrect and the photograph improperly exposed.

An alternative to Kodachrome and its attendant problems would be the use of a tungsten film, such as Ektachrome Professional 50. It has a grain comparable to Kodachrome and does not require filtration. At ISO 50, it is a full stop faster than Kodachrome, and a total of three stops faster if you take into consideration the two more stops lost by using the blue 80a conversion filter. Another advantage to using the Ektachrome Professional 50 is that you can process it yourself. You can finish a shooting session, process the film, and see if the results are satisfactory before tearing down your set-up. This Ektachrome is designated Professional because it was designed for immediate use and processing and therefore must be kept refrigerated until used.

Another consideration is that of permanency. Kodachrome will retain its color almost indefinitely, while Ektachrome dyes are less permanent.

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

When it comes to color print (negative) film you have considerations similar to those with transparency film. One big difference is that the vast majority of print films are daylight balanced. As a result, you will be using a conversion filter, unless flash is used.

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, faster films can be used. They will allow shorter exposures and give less concern for 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.

Film choice is important and is dependent on subject material, lights, and the purpose of the photographs.

Black and White Films

There are numerous black and white films from which to choose. They have a range of ISOs from 25 to 4,000, and many 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 learned in the darkroom. You do not have to worry about color balance, so nearly any

Figure 1 (above left): **Quartz, New Britain, Connecticut. The crystal is 4 cm across. F-16, ½ second, Panatomic X. Lighted with one 600-watt quartz halogen above and reflector fill.**

kind of light source can be used without filtration. There still is reciprocity failure, but it only affects the film speed. With black and white film you have much greater control over the end results. 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 between black and white and color films 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 the lighting ratio.

Generally, color films have much less latitude than black and white films. For color work the light areas should be no more than three times as bright as the dark areas, a ratio of 3:1. For black and white work the ratio should not exceed 7:1. Some of the new color-print films, such as Kodak's VRG 100, have an extended range and can tolerate a 4:1 ratio.

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

Fine grain and low ISO also go hand in hand with black and white film. I usually use Kodak Panatomic-X (ISO 32). There are many other options available in the low ISO range, as well as much faster films, such as Tri-X (ISO 400). If short exposures are a major concern and your prints will not be too large, you might wish to use the faster, grainier films.

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, detail is lost and contrast increases. So, if at all possible, use black and white film in the first place.

***Figure 2 (from left to right)*: Quartz halogen with barn doors, baby spotlight, and photo flood on homemade stand.**

Lights

Incandescent Lights

There are many different kinds of artificial light sources available. The most common is tungsten, such as that found in the standard household light bulb. Tungsten lamps for photographic purposes are rated in two ways: by wattage and by color temperature. The most common wattages are 250 and 500. Color temperature is usually 3200°K for use with Type B color films. Slightly bluer 3400°K bulbs are suited for the less common Type A professional films that must be kept refrigerated until use. Tungsten bulbs with a blue tint that approximates daylight (5600°K) are also available. These bulbs can be used with daylight film without the use of conversion filters.

I had better explain color temperature here. Different kinds of light sources emit light with varying color characteristics. This variation is measured in degrees Kelvin (°K). It is based on a hypothetical heated material which at red-hot would be about 2000°K, at white-hot about 5000°K, and blue-hot over 6000°K (Freeman, 1984). It is this Kelvin scale by which 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 can be chosen by checking a reference such as Kodak's *Filters for Black-and-White and Color Pictures* (1969).

The problem with tungsten lamps is that as they are used, the color temperature changes. For accurate color rendition the lamps should be changed before they get too old (about three hours' use for 500-watt lamps). Another type of lamp, called a quartz halogen, maintains its color temperature throughout its life. Halogens are much smaller than tungsten lamps and have higher wattages, generally 750 or 1,000

Some minerals are very sensitive and may crack when exposed to hot lights; others may change composition and color.

watts. Their disadvantage is that they get much hotter and are more expensive than standard photoflood lamps.

Earlier I discussed control of the lighting ratio. If you are using color film, do not be tempted to do this by varying the voltage (and therefore the brightness) of your lights. When you change the voltage, you change the color temperature. Control the lighting ratio by moving your lights toward or away from the subject. Another control method is the use of neutral density filters placed over the lights. They act like sunglasses, reducing the light without changing the color. These filters come in different densities, reducing the light by ⅓ to 3⅓ stops. If you are shooting in black and white, you need not worry about color balance. Varying the light voltage might be an ideal way to control the light ratio.

Incandescent lamps (i.e., tungsten or quartz halogen) can be used in different ways to modify light output. When in a large metal reflector they are floodlights, and the light is spread over a fairly wide area. When a lamp is mounted in a cylindrical housing with a focusable lens in front, it is a spotlight. Spotlights concentrate light and keep it within a small area.

These lights have other characteristics besides coverage which 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.

Any household light can be used for photography, especially black and white photography. Color temperature can be a real problem, though, because household lights come in so many varieties. Since they were not designed for photographic usage, their color temperature is not generally known. Often the dealer or manufacturer of the light source can tell you its color temperature. If this information is not available, the color temperature may be determined by the use of a special color temperature meter. Several brands are available at better camera stores. Be forewarned, however; they are not cheap. Other sources of such information are photographic data books that publish ranges of color temperatures for different types of light sources.

Flash Lighting

Another source of light is electronic flash. Flash produces a very short burst of intense light, with a duration from 1/100 of a second to 1/50,000 of a second, depending on the unit. Flash comes in an enormous variety of small portable units or as larger, more powerful studio units. The studio flashes have the advantage of having 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. Small portable flash units are of limited use because you cannot see exactly how the subject will be illuminated until after the film is processed.

An advantage of flash is its low temperature. This is especially important with close-up work that otherwise requires long exposures with hot lamps. Some minerals, such as sulfur, are very sensitive to heat and will crack when exposed to hot lights. Some minerals, such as realgar, are photochemically reactive. They will permanently change composition and color. Heat can also dehydrate some minerals, causing them to turn milky and even powdery.

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

Flashbulbs are also a source of light. I will not discuss them here, as they are not useful for mineral photography. They are seldom used any more except in inexpensive snapshot-type cameras.

Daylight

The most obvious light source is the sun. It is 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 will also vary, depending on how overcast the sky is and whether it is foggy or smoggy. This means that it is difficult to maintain constant color rendition. Another problem is long shooting sessions under a hot light source that cannot be turned off. You may find experimenting with

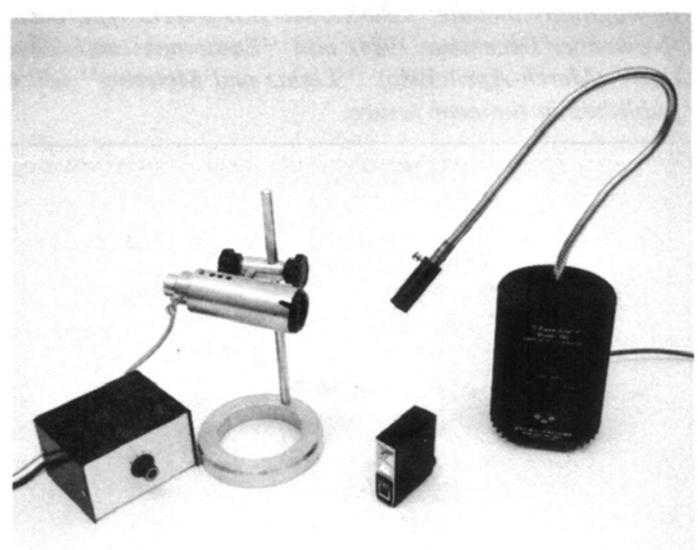

Figure 3 (left to right): **Focusing microscope light, flash, and focusing fiber optic microscope light.**

the sun as a light source worthwhile though. Dr. Eric Offermann, who is a fine Swiss mineral photographer, uses sunlight almost exclusively for his work (Wilson, 1975).

Direct sunlight is often too bright to use, producing deep shadows and high contrast. The shadows can be filled with white cards or a wrinkled aluminum foil collar around the lens. If you photograph in the open shade, the light is diffused and more even. If you have no suitable place to shoot in the open shade, you can shoot under a diffusing material, such as a white sheet or ripstop nylon. To concentrate light, use small mirrors, especially concave shaving mirrors.

Other Light Sources

It is wise to keep the size of your lights proportionate to specimen size. The larger the light, the more difficult it is to control and maneuver. The use of smaller lights also makes for smaller catch lights—those small reflections you see on shiny objects. The smaller the catch lights, the less obscuring and distracting they are.

Microscope lights are excellent light sources for illuminating small specimens, such as thumbnails and micromounts. Many microscope lights are focusable, with variable light output. A much better alternative is a fiber optic light source. Most 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.

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 long exposures. If the unit does vibrate, you may be able to place it on a separate surface from that of the camera and specimen. Another option is to place a vibration damping pad beneath the light unit.

If you cannot 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 knowledge. The basic light source can be constructed 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. See Figures 2 and 3 for illustrations of different light sources.

Whatever light source you use, control is the key word. You must be able to get your light on the subject, keep it off what you do not wish illuminated, and concentrate or diffuse it to get the desired results.

To achieve a spotlight effect, a cylindrical tube or "snoot" is placed over the light source. Movable flaps called barn doors can be attached to the reflector to keep light where you want it. Pieces of cardboard taped to the reflector, propped, or hung in the appropriate place can also serve the same purpose. To diffuse light, a number of materials can be used: double matte drafting mylar, fine white cloth, thin tissue paper, opal glass, opal Perspex plastic, Lexan plastic, and white ripstop nylon are among the many choices. Some of these materials are flammable and should not be placed near very hot light sources, particularly the photofloods.

A painter uses a brush to create an image on his canvas. A photographer's canvas is his film, and he paints with light. He must learn to control this light to create his masterpiece. To get the best results a photographer matches the proper film to his lights to optimize results and suit his needs.

Jeffrey Scovil was laboratory photographer for the San Juan Valley Archaeological Project (Farmington, New Mexico) and the Arizona State University anthropology department. His previous articles in this series on mineral photography include: "Basics and a Different Approach" (November-December 1984) and "Equipment and Vibration" (March-April 1986). "Lights and Metering" will be published in the near future.

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Mineral Photography

LIGHTS AND METERING

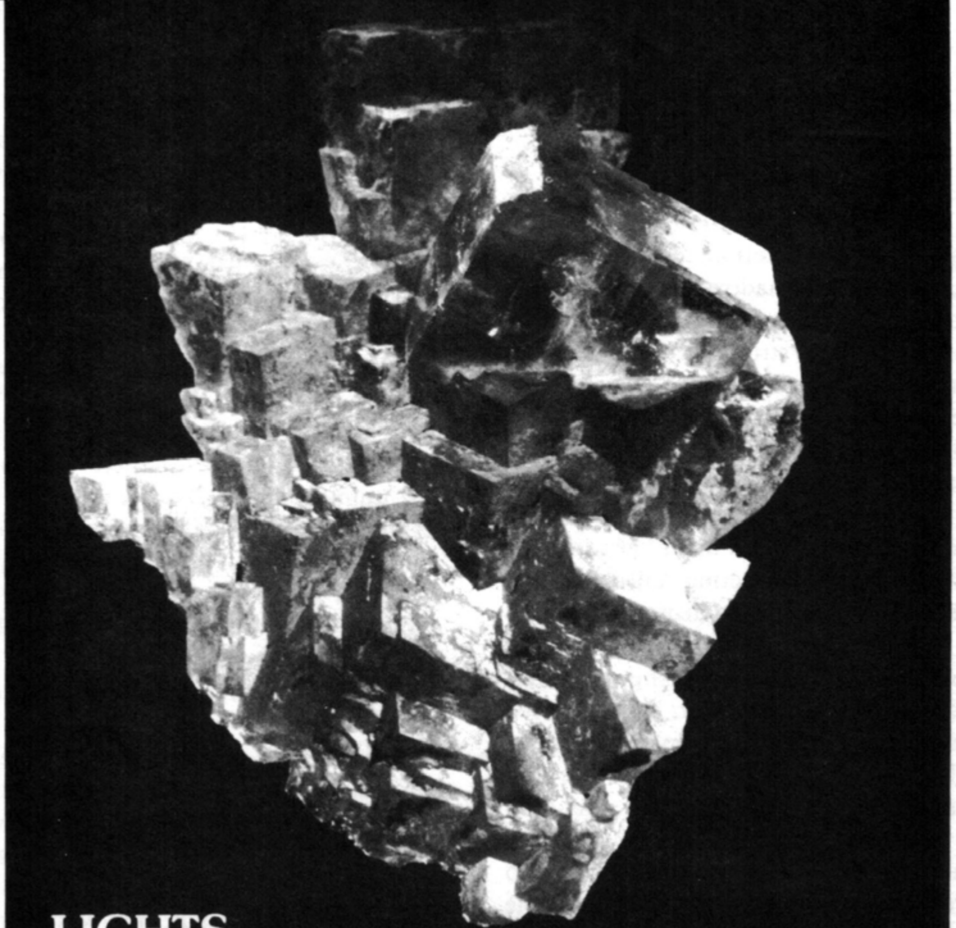

Figure 1: **Quartz (2.5 cm high), from New Britain, Connecticut. F-16, 8 seconds, Kodachrome 25. This specimen is defined by alternate lighting of the faces.**

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IN MY PREVIOUS ARTICLE (July-August 1987), I discussed the types of light sources available to the mineral photographer. This article will tell you how to put the lighting to use. My focus is on color photography, though remarks apply equally well to black and white photography.

There are basically four steps in setting up the lighting of a subject: (1) main light; (2) fill light; (3) highlights; and (4) background light.

Main Light

First, orient the specimen so that it presents its best face, placing what logically or esthetically looks to be its "right side" up. Our society's ethestic preference is to see things lighted from above and slightly to one side (usually the left). Keep this in mind when locating the 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 those having a triangular shape) tend to have the smaller end up so that it does not look top heavy. Obviously, the best crystals should face toward, and not away from, the camera. If there are damaged crystals, locate them so the damaged areas are not seen, or are minimized by their angle or by shadows.

Set the main light above, slightly in front of, and to the left of the specimen. If this does not look quite right, adjust the light further left or right until the setup looks good through the camera viewfinder.

Fill Light

After the main light has been positioned, add fill lighting. Fill lighting illuminates the shadowed areas (on the specimen) that are 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 the three-dimensional quality of the specimen is weakened. Shadow location also helps the viewer orient the specimen right side up.

It is important that the fill light placement not create a strong second shadow around the specimen. People are accustomed to seeing one shadow from a main light (usually the sun); multiple shadows are distracting and unnatural looking. To avoid this, keep fill light intensity low and/or diffused.

Instead of using other lights for fill, try using small mirrors or white index cards to reflect the main light onto the subject. This avoids dealing with a dangerous tangle of wires or additional hot lights. Mirrors and cards are also much more maneuverable than lights with their attendant stands.

Mirrors can be held in place with putty or with two clothespins clipped together at right angles and then to the mirror, or with an electrician's helper. Index cards can be bent at right angles so they stand by themselves. Aluminum foil, matte side out and taped to a card, also makes a good fill light reflector.

Each of these reflector materials creates a different quality fill light. The mirror provides a bright fill with sharp edges and intense highlights. The matte foil has a softer, more diffuse light, and a white index card creates an even softer diffused fill. If the specimen is metallic and gives harsh, bright highlights and a lot of glare, use a matte foil or white index card to reduce the problem. Similar problems may occur with highly reflective nonmetallic minerals.

You may also wish to diffuse the main light. To do this, place a neutral-colored material, such as double matte drafting Mylar, rip-stop nylon, or commercially available diffusing materials, in front of the light. Diffusion spreads the light more uniformly and softens it so that highlights are not as harsh. Working with diffused light is like photographing outside on an overcast day when the lighting is very even and shadows are almost nonexistent.

Highlights

The next step in lighting is to create highlights. This is done by positioning small cards or mirrors to produce edge lights and soft reflections that define the faces. Edge lights separate the subject planes, giving the subject depth, and help differentiate between the specimen and the background.

Generally, it is a good idea not to let any part of the specimen disappear into the shadows or into a dark background. If this happens, the viewer has a difficult 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 the specimen fade into the background.

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

If lights and reflectors cannot be reached from the camera position, and you have no assistant, use the following procedure. Place the fill light in front of the camera and aimed at the specimen. Then walk around the specimen looking at it from all angles. When a good highlight is noted, relocate the light that was in front of the camera to this exact position. Then check and fine-tune the results from the camera viewfinder. This is the procedure recommended in Kodak's *Studio Lighting for Product Photography* (1959).

The lighting setup should accurately define the specimen. Being able to see just its shape and color is not enough. It is important to see the individual faces of the crystals. Correctly illuminated faces make the crystal identifiable and give it much of its beauty.

In order to define the crystal faces, it is necessary to highlight them with reflected light. Conversely, an unlighted face surrounded by lighted faces will also be defined. Be careful not to get too much light reflecting off a face or it will become a distracting white hot-spot.

There are several ways to highlight crystal faces, ranging from a soft, diffused highlight, discussed earlier, to a gradational highlight. These can be produced while looking through the viewfinder by locating a sharp, bright reflec-

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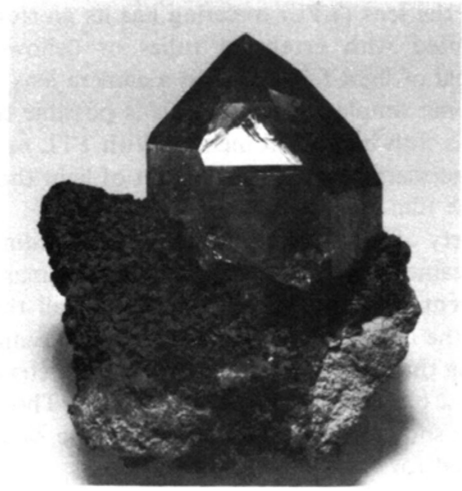

Figure 2: **Quartz (5 cm high), New Britain, Connecticut. Main light placed above and slightly in front of specimen, creating highlight on front termination face.**

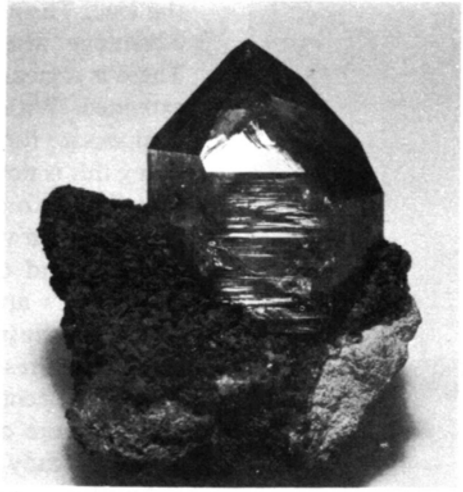

Figure 3: **Fill light from mirror placed low and in front of specimen, highlighting and bringing out texture of front prism face.**

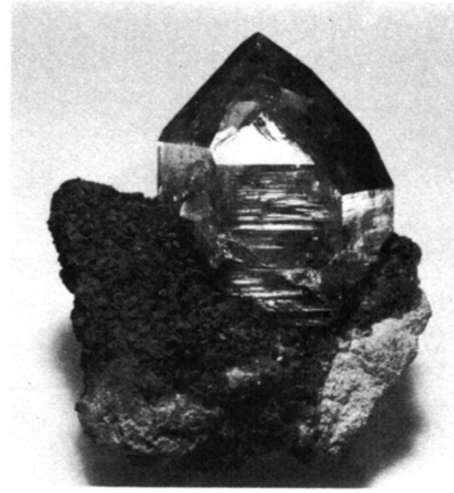

Figure 4: **Highlight off right prism face from mirror placed to right of specimen.**

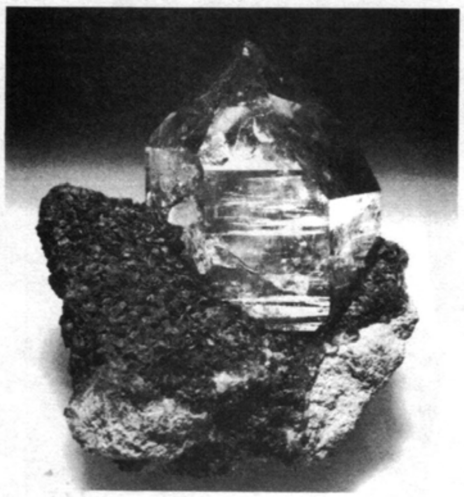

Figure 5: **Gradational background lighting created by partially shading background with barn doors.**

tion off the face, then slowly moving the light source or reflector until the reflection diminishes and grades in intensity across the face.

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

Try not to get highlights off adjacent faces; if this occurs, be sure that they are of different intensities. If they are of the same intensity, the faces will blend into one another, and the two faces will appear as one. This will cause confusion as to the shape, number, and placement of the crystal's faces. It is preferable to light alternate faces, which will then define the intervening unlighted faces. Imagine, if you will, a checkerboard; the red squares are the lighted faces, and the black squares the unlighted faces. 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.

Internal highlights can sometimes be produced. The light will often reflect off internal fractures and inclusions. This can add great depth and interest to a specimen. You may wish to concentrate on these interior details. Keep exterior lighting to a minimum, and blast a bright, concentrated light, such as from a microscope illuminator, into the back or side of the specimen. This 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).

If you are trying to bring out the surface texture of a specimen, a low-angle grazing light is best (see figure 8). On the other hand, if color is more important, keep the light angle higher and the lighting more diffused. These considerations also are important when photographing objects other than crystals. Flat fossils in matrix, such as leaves, fish, tracks, etc., need a low, grazing light to bring out the low relief. Lapidary materials often require a higher, diffused light to subdue reflections off polished surfaces.

Background Light

Lighting of the background is important too. Even though the background is lighted at the same time as the specimen, some control can be exercised over it. Most specimens are shot sitting directly on a background material, such as colored paper or cloth, that curves up behind the specimen. Lighting the background is often just the opposite of lighting the specimen. Typically, a background is brightly lighted at the bottom and graduates to light at the top. This provides a contrast for specimens which have brightly lighted crystals at the top and a darker base.

This effect can be achieved by keeping the main light aimed at the specimen and not on the curved upright portion of the background, or by spotlighting the specimen. If a floodlight is used, movable flaps, called barn doors, help focus the light where it is needed.

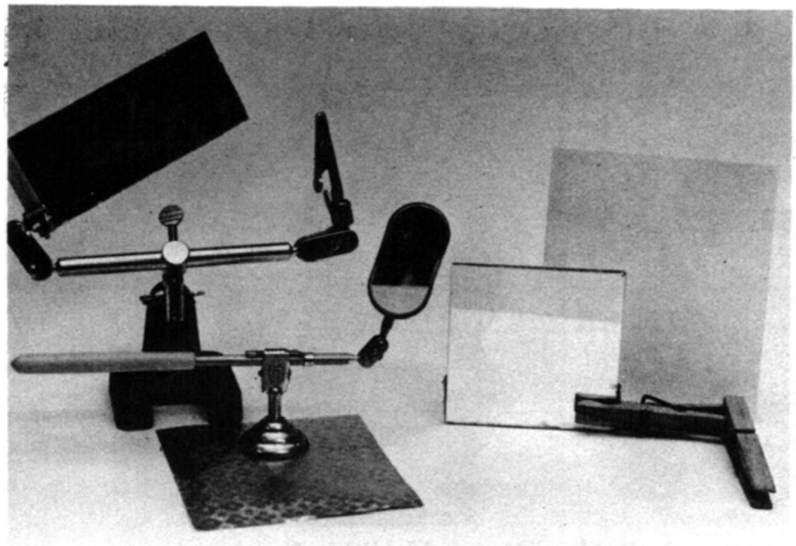

Figure 6: **Reflectors and stands.** ***Left to right:*** **Mirror held in electrician's helping hands; machinist's mirror in weighted alligator clip stand resting on matte foil; mirror in clothes-pin stand; and white index card.**

Metering

Light is the most important element in photography. In order to use it to advantage, however, it must be measured accurately. For this, a light meter is used.

There are basically two types of meters: hand-held and camera-mounted. Hand-held meters can be divided into two types: spot meters and standard meters with a wider angle of coverage. The spot meter has an eyepiece and lens like a camera. The specimen is viewed with it. Readings are taken in the dark and light areas, and the results are averaged. The angle of coverage on a spot meter is very narrow so small areas on the specimen can be read.

The other type of hand meter does not have the view-through features; rather it has a much wider angle of coverage meant to take in the whole photographed area. It has an opening to a light-sensitive cell that produces an average reading. The meter must be held close to the specimen so that it gets only light reflected from the specimen. The result is a reflected-light reading.

Some meters have a translucent white dome that is placed over the sensor to take an incident-light reading. To use this mode, place the meter in the position of the specimen, aimed at the camera. The meter reads the amount of light falling on the specimen, as opposed to that reflecting off the specimen. This method is usually more accurate, as it does not get thrown off by the luster, lightness or darkness of a specimen, or the background on which the specimen is sitting.

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 a camera lens is extended. With some simple calculations, it is possible to compensate for this with hand-held meters. With TTL metering this is not necessary because the amount of light that actually falls on the film is measured.

There are a variety of TTL metering options, depending on the brand of camera. Some average the whole image area; others are center-weighted average, reading all the light but favoring the central portion. There are also semi-spot meters, reading the center 13 percent, and spot meters, reading the central 2 or 3 percent of the image area. Those that are more of a spot meter are preferred, for the same reasons already cited for hand-held spot meters.

Another advantage to TTL metering becomes evident when filters are used. Filters can reduce the amount of light reaching the film by as much as three f-stops. The

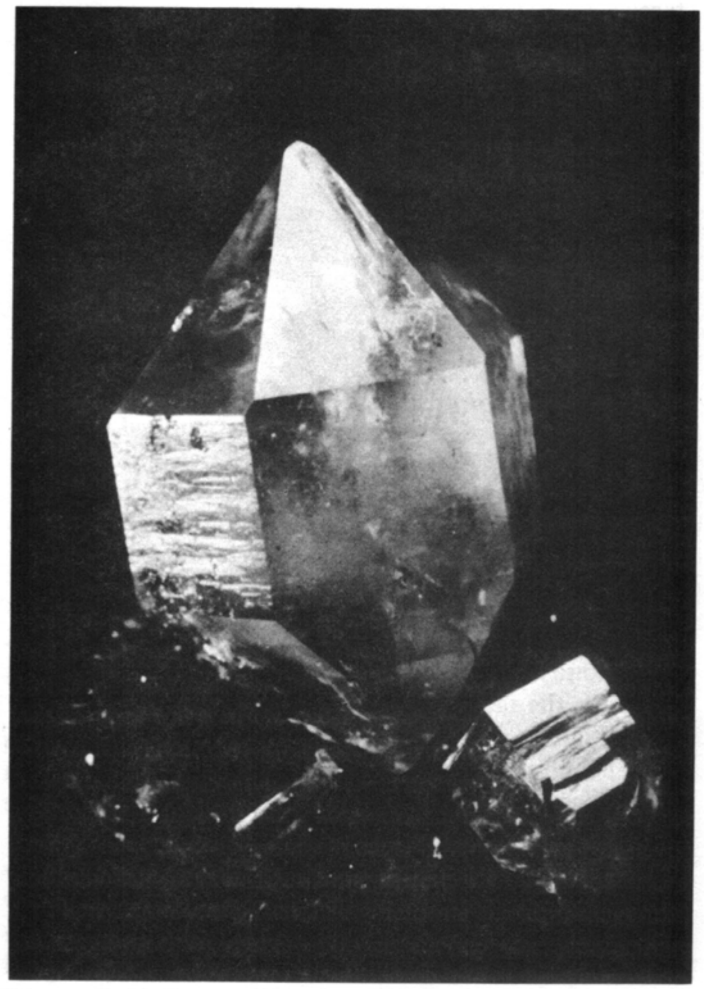

Figure 7: **Barite on fluorite, Rock Candy mine, Grand Forks, British Columbia. The specimen is 5.1 cm high. F-16, 2 minutes, Kodachrome 25. This shot illustrates several lighting techniques. The right face of the barite crystal has a graded highlight. The top face has a uniform highlight. The fluorite is transilluminated from beneath by a mirror. The specimen was photographed on raised glass.**

amount of light reduction is expressed as a filter factor. Filter factors for different films are usually supplied with the filter or can be found in books—Kodak's *Filters for Black-and-White and Color Pictures* (1969), for example. A filter factor of two means the light is reduced by two more stops of exposure than a hand meter indicates. This is assuming the camera does not have TTL metering which would compensate automatically.

Various filters may be necessary, depending on what kind of film and lights are being used. An outdoor film must be used with a conversion filter to use with tungsten lighting indoors. A polarizing filter may be useful to reduce bright highlights on very reflective specimens. A future article will deal with filters in greater detail.

Taking meter readings directly off the specimen can be inaccurate. This is because of differences in color, reflectivity, brightness, and the amount of background in the picture. Any of these things can throw readings off. This is where an incident light meter can come in handy. However, the same results can be obtained with reflected light meters (including those built into a camera), as outlined next.

Once the lighting is set up, substitute an 18 percent gray card for the specimen and then take the reading. Eighteen percent gray cards are available from photo supply stores. The card is gray on one side with 18 percent reflectance, white on the other side with 90 percent reflectance, and is 8 × 10 inches in size. It is designed with a reflectance that has been determined to be the average for most subjects.

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 an underexposed photograph. The use of a gray card makes metering easier, but it 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). In any case, always bracket shots by taking extra exposures, over and underexposing a couple of stops, just to be safe.

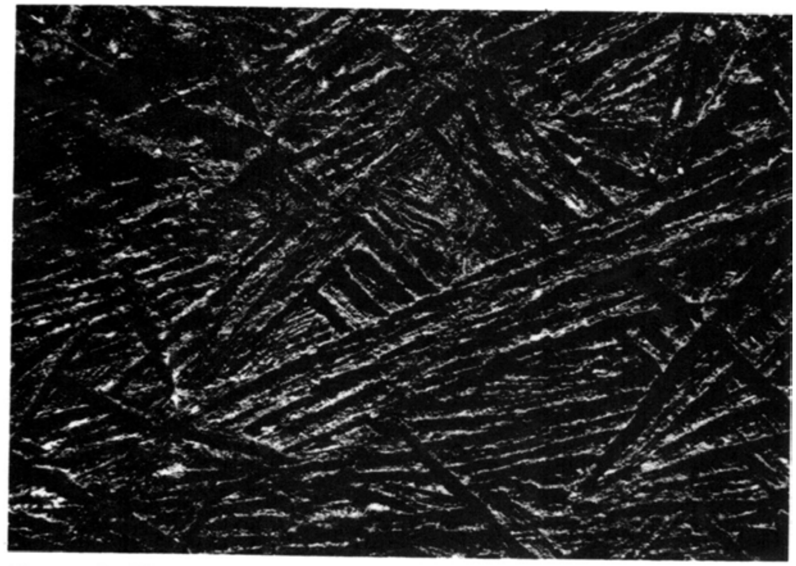

Figure 8: **Weathered peridotite, Monroe Township, Ontario. Field of view is approximately 3 cm. This illustrates the use of a low grazing light from the upper left to bring out texture.**

Knowledge of light and its control is the most important factor in good photography. Look at mineral photography in books and magazines, and try to determine how the specimens were lighted. As you experiment and try to duplicate the lighting, you will learn to master the photographer's most important tool—light.

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FRIENDS OF MINERALOGY - COLORADO CHAPTER

WHAT IS FMCC ?

Friends of Mineralogy - Colorado Chapter is an organization devoted to the advancement of mineralogy and related collecting, educational and scientific activities. Its members included professional geologists, mineralogists, curators, and private collectors.

The Colorado Chapter has established the following goals:

1. Protect and preserve mineral specimens and localities.

2. Advance mineralogical education and research.

3. Support and disseminate mineralogical knowledge with seminars, publications, and educational projects.

4. Promote high ethical standards for collecting, exhibiting, and dealing with mineral specimens.

5. Build a spirit of cooperation and participation in the region for collecting, sharing and using mineral specimens.

FRIENDS OF MINERALOGY, INC. AND THE REGIONAL CHAPTERS

FM, Inc. is a national and international organization with several hundred members. Many people belong to one of the seven regional chapters, including, Pacific Northwest, Southern California, Great Basin, Colorado, Indiana, Southeast Michigan and Pennsylvania.
Fm, Inc. and the Chapters are all non-profit educational organizations governed by elected Boards of Directors and Officers. There are local and national meetings.

ACTIVITIES OF THE COLORADO CHAPTER

The Colorado Chapter is an active group that holds 6 regular meetings each year where high quality lectures are presented. Much of its work is a resource for other mineral organizations and museums. For several years mineralogical symposia have been presented at the annual Denver Gem and Mineral Show, at the Colorado School of Mines and at the Denver Museum of Natural History. The chapters goals are directed toward several long range projects, including:

1. Revising and compiling information on minerals and localities for publications. A comprehensive volume on "Minerals of Colorado," updating U.S.G.S. Bulletin 1114, is a major project being supported by the chapter.
2. Presenting programs, classes, and activities for schools, mineral societies or community organizations.
3. Acquiring mineral specimens for preservation in museums and also to make duplicate materials available to collectors at public sales or auctions.
4. Holding seminars and meetings to discuss and present topics related to mineralogical activities or research.

WHAT HAS FRIENDS OF MINERALOGY, INC. ACCOMPLISHED ?

FM, Inc. has sponsored field trips to preserve important minerals from localities where the specimens would otherwise be destroyed. The organization supports awards for educational exhibits at mineral shows, for articles published in national periodicals and for informative papers presented by a student at a Friends of Mineralogy-Mineralogical Society of America symposium. Projects have included revitalization of historic mineral collections that have fallen into disrepair; the study of ways in which mineral localities can be preserved for the future; and help in the preparation of a cumulative index to the **Mineralogical Record**. Currently FM, Inc. is supporting preparation of a "Locality Index" that will be a source of accurate information about mineral names and localities.

WHAT ARE THE BENEFITS OF MEMBERSHIP?

FM members include in their ranks eminent mineralogists, scientists, curators, and scores of collectors who have a common love of minerals and related activities involving collecting, research, exhibits and publications and programs. There is a close fellowship in the regional chapters with associated meetings, field trips and mineral shows. Both FM, Inc. and FMCC activities are published in news letters. Membership provides the opportunity to participate in many interesting activities.

HOW DO I JOIN?

To join the Colorado Chapter a person must have a desire to participate in and support the Chapters goals and activities. To formalize your membership you will need the signature of a sponsor (a member of the Chapter). Dues for FMCC are ten dollars per year; this includes membership in the national organization, FM, Inc.

WHEN AND WHERE DOES FMCC MEET?

Unless otherwise stated, FMCC meetings are held 6 times a year beginning in January, on the second Thursday of the month from 7:30 to 10:00 p.m. Meeting are held in one of the meeting rooms or in the Ricketson Auditorium at the Denver Museum of Natural History, 2001 Colorado Blvd., City Park, Denver, Colorado.

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