GEOLOGIC PHOTOGRAPHY

A Thesis

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Master of Science

by

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ABSTRACT

The paper is the study of geologic photography. The conclusions follow: (1) Use the proper equipment at the proper time, (2) Be accurate in focusing, (3) Be accurate in exposure calculations, (4) An electric exposure meter is recommended, (5) Use color film to bring out detail, (6) Color photographs should be taken during the period from two hours after sunrise until two hours before sunset unless artificial lighting is supplied, (7) Use of color film should be justified, (8) Use a scale or some common object for size comparison, (9) Use care in selecting microscope objectives and eyepieces when taking photomicrographs, (10) A 32 mm. objective with a 10x eyepiece will produce an approximate magnification of 50x and this will be sufficient for the study of sand grains, (11) If photographing thin sections, a higher magnification above 50x may be required, and (12) It is a better procedure to re-take a photograph than correct mistakes during the developing and printing processes.

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P.L.B.

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CHAPTER I

INTRODUCTION

The subject of geologic photography has greatly been misunderstood and misused. It has long been known, not only in the field of geology but in other fields as well, that one well presented picture is worth more than many words of written description. The geologist can easily understand how applicable this fact is to the study of geology both in the field and the laboratory.

The majority of geologists now and in the past have relied upon photography, to a limited extent, to better explain their theories, ideas and exploratory work. Even so, this phase of photography used by the geologist has bordered upon the technique commonly used by the laymen in taking snapshots with his "box camera."

Therefore, the purpose of this report is to present data in a manner that the geologist, with limited knowledge of photography, can understand and use it to improve his illustrations.

Methods of Investigation. A trip to the Marathon and Big Bend region of Texas was made during the early summer of 1950. All field color photographs in this report were taken while on the trip. In all, thirty photographs were taken, yet few were selected for illustrations. The remainder of the photographs will be mounted in slides and will be available for use by the Geology Department of the University of Houston.

The two color laboratory photographs represent a small fraction of the total number taken in the laboratory. Due to the experimentation, many of the negatives were not of print quality and could not be used for this report. Black and white photographs were also taken in the laboratory, but for the same reason mentioned above only a small portion were included in this report.

All field photographs enclosed were taken with a Ciroflex Model F reflex type camera equipped with a Wollensak 83mm f/3.2 coated lens set in a Rapax shutter. The laboratory photographs were photographed with a Pacemaker 4 x 5 Speed Graphic camera equipped with an Opter f/4.5 lens set in a Graphex shutter.

CHAPTER II

GEOLOGIC FIELD PHOTOGRAPHY

Introduction. The average geologist will use photography to a greater extent in the field than in the laboratory. This is in the geologist's favor in that geologic field photography is more the elementary of the two and can be carried out more easily and will yield better results with a limited amount of equipment. This does not mean that field photography is simple to master. Whether in the field or in the laboratory each subject should be studied in detail where it is photographed, and guessing should never be substituted in favor of logic.

Equipment. The discussion of equipment will be general and apply only to types best suited under different conditions. The listing of brand names and manufacturers will not be undertaken.

The most important part of the geologist's photography equipment is the camera. There are many different makes and types of cameras that can be used. Of course, the less bulky the camera and other equipment, the less difficult it will be to carry in the field. Any one of several roll film cameras on the market with a f/4.5 or faster lens will be satisfactory. Some geologists report that an inexpensive box camera is quite satisfactory. Possibly a camera of this type can be used under certain conditions, but to obtain a needle-sharp and high definition photograph, a camera equipped with the following should be used: (1) coated anastigmatic lens f/4.5 or faster, (2) variable speed shutter with speeds as high as 1/200 second and diaphragm stops down to at least f/22, (3) reliable range finder or focusing device.

The problem of focus is extremely important and cannot be over-emphasized. Do not guess at camera-to-subject distance, especially in photographing very close objects. Some types of medium priced cameras come equipped with a ground glass focusing device or a coupled range finder. Of the two, the ground glass focusing device is by far the better. In it the field included in the range of the view finder is identical to the view range of the lens. If such a camera is not obtainable the geologist can rely upon a measuring tape or pacing when photographing close objects that are less than fifteen feet from the camera. If the camera is of any type other than a box or low priced folding camera it will undoubtedly be equipped with a simple focusing method. This will enable the user to focus upon objects fifteen feet or less from the camera at one particular setting of the mount and from fifteen feet to infinity at another setting.

The use of the photoelectric exposure meter is very important in assuring correct exposures under all conditions and in the use of any type of film, both black and white and color. The amount of picture failures due to improper exposures will be greatly reduced by the use of the described meter. A photoelectric meter for color work is an absolute necessity and color photographs should not be attempted without one.

A tripod is an important aid to the field photographer but not essential, unless using slow shutter speeds or in photographing close up subjects. If the camera is in a leather case with a shoulder or neck strap, the user can obtain fair steadiness and support. It is advisable to use this arrangement only when lighting conditions, film speed and lens speed allow the use of a fast shutter setting.

One important part of the geologist's field photographic equipment should be a complete and useful set of filters. Filters, for black and white photography, are used to bring out wanted detail or highlights according to the photographer's desires. This is accomplished by the filters' property to stop light of certain colors. Color filters for black and white photography are designed for different purposes and there are over one hundred different types on the market. Only a small portion of these will be used by the geologist in the field, and only this small portion will be discussed. The K2 and K3 yellow filters should be most commonly used. The use of these filters will improve the contrast of the negative in that they will darken the sky to obtain cloud effects and cut haze on distant scenes. Other filters that can be used by the geologic photographer, but to a lesser extent, should be: (1) the X1 or green filter is used to render correct contrast balance of multicolor subjects photographed in daylight, (2) the A or red filter which is used to give a deeper contrast between the sky, clouds and land, and (3) the polarized filter which is used to subdue oblique reflections and improve texture on non-metallic surfaces. K2 and K3 filters can be used with either orthochromatic or panchromatic film. If the X1 or A filter is needed, use only a panchromatic film. An orthochromatic film possesses sensitivity to green, in addition to ultraviolet and blue violet, whereas a panchromatic film is sensitive to red light in addition to all other colors.

Every filter absorbs a certain portion of light, therefore the amount of light reaching the film is reduced. An increase in exposure will therefore be required to compensate for the light absorbed by the filter. The number by which the exposure must be multiplied for a given filter with a particular film is called the "filter factor" of that filter. This number is found stamped on the edge of all filters. "If, for instance, a filter is used with a 'filter factor' of 2 the photographer must multiply his exposure readings by two in order to compensate for the amount of light absorbed by the filter."[1]

The cable release is very helpful in obtaining a photograph that will be free of fuzziness due to moving the camera at the time of exposure. It enables the user to "squeeze off" the shutter mechanism instead of pushing or pulling the built-in shutter release button or lever. Flash gun equipment is helpful, but not absolutely essential. Its advantage in the field is to furnish the necessary light in a dark area such as a cave entrance, in mine workings below ground or extremely shaded outcrops or similar subjects.

In summary, there are many different types of equipment that will enable the photographer to produce better photographs in the field, but their possession is not absolutely essential. The majority of such equipment and accessories is expensive and many of the students of geology cannot afford such luxuries.

Field photography technique. As mentioned before, the primary use of photography by the geologist will be made in the field. This phase of geologic photography will improve any field study thus creating better understanding by the

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1 Kodak Reference Handbook, Section on Use of Filters (Rochester: Eastman Kodak Company, 1948), p. 5.

geologist himself and those who later study his work.

In the main, the subject of field photography can be divided into two parts: (1) the long range view and (2) the close up view. The time spent in the field on either of the two will prove to be about equal with possibly more emphasis given to the latter. When preparing for a new field study the over all subject or area to be photographed must first be considered. With this fact in mind the subject of the long range view technique will first be discussed.

Long range view. The term long range view should be self-explanatory, but if not it can be said that it is the photographing of an over all geologic feature or area from a distance of more than one hundred feet and usually at a much greater distance. The technical knowledge that must be remembered for such a task are less than those required for the close up view technique. For instance, if more than one hundred feet from a subject, the problem of focus is relatively simple. The camera, if it is of the focusing type, can be set at one hundred feet or infinity and any subject with a distance greater or even slightly less than one hundred feet from the camera will be in sharp focus. This depth of field, or focus, will not be as great when photographing close subjects, but this fact will be explained later.

The exposure setting, the time of exposure and lens opening, can easily be determined by the use of the photoelectric exposure meter. If one is not available, the exposure chart enclosed with each roll or package of film will prove very helpful. These tables take into consideration the speed of the film, type of film, amount of light and subject material. Although these charts are based upon averages, their use will yield the photographer better photographs than would be possible under the guessing method. There is one basic rule that will always enable the photographer to obtain better sharpness and definition in the print whether in the field or the laboratory. Always use a diaphragm opening as small as will be practical in any given case because the smaller the lens opening, the greater the depth of field or focus. This will result in greater definition and sharpness in the negative.

The use of filters in the field should be done with utmost care. The discussion of the use of filters and the various types have been covered in the preceding portion of the text. In addition to the information already supplied, further information is furnished with each filter and is discussed in detail.

The selection of a good view point for the exposure, with respect to the sun, and other objects, is very important. The sun should always be to the rear or side of the camera and never facing directly into the lens. The best time during the day for outdoor photography is from ten a.m. to two or three p.m. and not later than four p.m. It is obvious that if shadow detail is necessary to bring out certain geologic features, the photograph should not be taken just before or just after twelve noon. There will be cases when certain subjects will be enhanced by a shadow produced by a late afternoon sun. Success can be made of such a situation if the time of exposure is checked very carefully. Always strive for the utmost detail and light and shadow effect at the time of exposure and not later in the dark room. If possible, photograph your subject when the sky contains clouds as they lend an air of planning to the work. Better balance will be produced if some nearby object is included in the side of the area to be photographed. This will lend depth and a third dimension effect to the photograph.

During recent years, the use of the wide angle and telephoto lens has become popular. These, of course, widen the scope of the photo-geologist. These lens, if of the better quality are expensive. The telephoto lens requires the use of a tripod and the focus of the camera should be as perfect as possible. The wide angle lens does not require any additional setting than a standard lens but its use enables the camera to obtain a much wider view without increasing the camera-to-subject distance.

<u>The close up view technique</u>. The understanding of the

close up view technique, by the photo-geologist, is very important. It is the method by which the detail of formations and structures can best be presented in a graphic presentation.

The actual task of obtaining close up geologic photographs is more difficult than the processes required in the long range view technique. More consideration must be given to focus, lighting, etc. In addition careful attention must be given to the subject itself and the distance and angle from which the picture is photographed. Focus is primarily the most important part of the set-up. If the camera is not equipped with a range finder or ground glass focusing device, a tape measure must be used. This is especially true if the camera-to-subject distance is less than ten feet. At this distance, or even less, the depth of focus is very small. Close up attachment lens must be used on a box-type or medium priced folding camera in order to photograph a subject less than six feet from the camera. These lens can be purchased in three different sizes. Each size will magnify the subject to a different point. Lens-to-subject distances are given, in a table form, with each lens and these distances can be measured by the use of a tape or rule. The highest power close up lens will enable the camera to be placed as close as one to one and a half feet from the subject.

One very important fact to remember in photographing near by subjects is the effect of parallex. Parallex is the term given to the difference in area covered by the lens and the view or range finder. Since the view finder is usually placed a few inches above or to one side of the lens, its field will not be the same as that of the lens at close distances. If correction is not made of parallex, a cropping or cutting off of a portion of the subject to be photographed will result. Correction can be made by raising or lowering the camera, depending upon the location of the view finder on the camera, to include slightly more area than would ordinarily be required. This correction, in reality, is simply sighting or aiming the taking lens on the center of the subject.

The problem of lights and shadows is also very important in close up photography. There must be adequate light upon the subject to make possible a well balanced photograph. If needed, a reflector can be used to reflect the light upon the subject for greater light control. A flash gun can also be used and would be less difficult to carry about, than the reflector in the field.

The problem of exposure is no different here than in the long range view. The photoelectric exposure meter is the photographer's best tool in the calculation of exposures under all conditions. It is possible of course to obtain far better quality photographs, with respect to exposure, by the use of exposure tables as previously mentioned, but they are not fool proof. The close up photograph should always be taken with the camera upon a tripod or some other support. This is because of the critical focus that is necessary. If the camera is even slightly moved during the time of exposure, a blurred or fuzzy image will result.

Size comparison is absolutely essential in close up photographs. Always include in the field of view some common object, of known size that will show the true dimension of the subject being photographed. A geologic pick or rule is ideal for this, but if the object is very close to the camera, a pencil or other small item will have to be used in order to obtain the correct relationship.

Use of color film. The use of color film in the field is a distinct advantage over black and white. Under any condition, whether photographing a long range or close up view, color film will record all features of geologic interest in all their true relationships. Lithologic features will be brought out more clearly, if photographed on color film because many such features can be overlooked if photographed with black and white film. (See plates I, II, III). It is obvious that the photographing of minerals upon color film will bring out every distinguishing feature and will make identification easier to the person who studies the photograph. (See plate VI).

<u>Summary</u>. The foregoing ideas and recommendations are general in scope. Each photo-geologist will encounter many and varied problems in the field, and experience with the help of proper equipment will solve the majority of these problems. Although the data has been both technical and non-technical, the salient points can be summarized as follows: (1) Use a camera with a f/4.5 or faster lens set in a variable speed shutter, (2) Use an electric exposure meter, (3) Never be burdened with unnecessary equipment, (4) Be familiar with the types of filters discussed and know how and when to use them, (5) Include some common object in the photograph for size comparison, (6) Be accurate in focusing, (7) Use color film to bring out detail, and (8) If possible, photograph the same subject in both black and white and color for comparison.

PLATE I

EAST BOURLAND MT., MARATHON, TEXAS

A view looking northwest showing novaculite ridges on East Bourland Mountain, Marathon, Texas. Exposure: 1/200 sec. at f/8 on Ansco color.

FORT PENA FORMATION, MARATHON, TEXAS

Massive limestone with bedded chert. Fort Pena formation in bed of Alsate Creek, Marathon, Texas. Exposure: 1/200 sec. at f/5.6 on Ansco color.

PLATE II

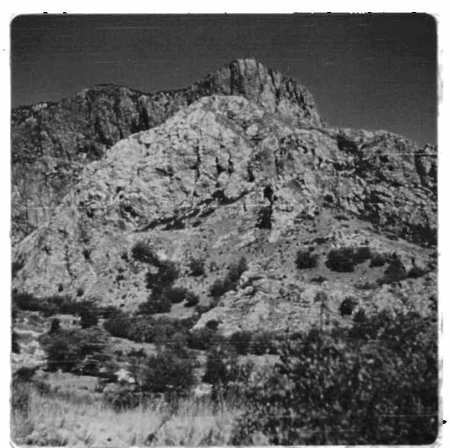
EAST BOURLAND MT., MARATHON, TEXAS

A view looking northwest showing novaculite ridges on East Bourland Mountain, Marathon, Texas. Exposure: 1/200 sec. at f/22 on Super XX. Compare with plate I.

PLATE III

MARATHON LIMESTONE, MARATHON, TEXAS

Marathon limestone in bed of Alsate Creek, Marathon, Texas. Shows thin flaggy limestone with shale partings. Esposure: 1/200 sec. at f/5.6.



IGNEOUS ROCK STRUCTURE, BIG BEND
NATIONAL PARK, TEXAS

Tertiary igneous rock structure, Big Bend National Park, Texas. The park headquarters is located in the basin between the two high peaks. Exposure: 1/200 sec. at f/8.

PLATE III A

MARATHON LIMESTONE, MARATHON, TEXAS

Marathon limestone in bed of Alstate Creek, Marathon, Texas. Compare with color photograph of same formation on Plate III. The above photograph covers a larger area, but even so, it can only show detail in degrees of black and white. It is obvious that the color photograph, with respect to true characteristics of the formation, is the better. Exposure: 1/200 sec. at f/11 on Super XX.

PLATE IV

MUD CRACK FORMATION, BIG BEND
NATIONAL PARK, TEXAS

Erosional remnant of a mud crack formation, twenty miles southwest of Big Bend National Park Headquarters, Texas. Exposure: 1/200 sec. at f/5.6.

PECOS RIVER CANYON, TEXAS

East side of Pecos River Canyon, Texas. Shows the massive Georgetown limestone. Blue color on the limestone is due to weathering. Exposure: 1/200 sec. at f/8.

CHAPTER III

GEOLOGIC LABORATORY PHOTOGRAPHY

Introduction. The use of photography by the geologist in the laboratory has become important in recent years and in the future it will outweigh geologic field photography in importance. The use of many laboratory techniques employed by the geologist to explain physical and chemical processes, can be better understood and shown graphically through the medium of photography.

Basically, the study of geologic laboratory photography is divided into two parts: (1) Megascopic technique and (2) Microscopic technique. These will be discussed in this order.

Megascopic technique. Megascopic laboratory photography is the process of photographing specimens without the use of the microscope. In so far as technique is concerned, this type of laboratory photography is less complicated than the microscope technique.

The camera best suited to any type of laboratory photography is the 4 x 5 view or press type camera. This type of camera is one with an adjustable bellows and this enables the user to increase or decrease the magnification of the object being photographed by simply increasing or decreasing the length of the bellows. A camera of this type is also easier to focus because it is equipped with a ground glass focusing plate.

The camera should be suspended in a vertical position from a very rigid support. If the set-up is made in the horizontal position the placing of the specimen would prove difficult. This support can be constructed from common lumber, or if a more deluxe job is wanted, from metal. The support should have a rack and pinion or some other device for raising and lowering the camera over the subject. The height of the support may vary depending upon the average size of objects to be photographed, but for geologic specimen such as rocks, fossils, or similar subjects, it should have an adjustable height from one foot to three feet above the base. A tripod is not recommended for this type of work unless it is a very sturdy type with an elevator thus making it adaptable to quick and easy lowering or raising of the camera. Above all, the camera must be steady in any given position as to avoid throwing the camera out of focus when inserting the film or tripping the shutter. In mentioning the insertion of film it must be stated that the type of camera recommended for this use does not use roll film but rather film sheets or plates. This is an advantage in that each single photograph may be developed separately and thus be observed a short time after exposure.

Lighting is very important in this type of work. Shadows should be reduced to a minimum and at the same time there should be an even amount of non-glare light upon the subject. One convenient method of lighting subject is the use of the light box. For this type of work the box should be 2½ to 3 feet square and 1 foot deep. Inside of the box, surrounding the sides, are placed lights of either the common mazda bulb or the more desirable fluorescent tube. In the top of the box is cut a square opening smaller than the inside dimensions of the box thus concealing the lights from the direct view of the camera lens. The specimen to be photographed is placed in the box upon a stage and the camera is lowered over the opening. The exposure settings are determined by holding a photoelectric meter near the camera lens and facing the specimen in the box. An exposure meter is not always available and in such a case the exposure is best determined by developing a trial film which has been given a series of exposures. Such a film shows the proper time and aperture settings for a given lighting set-up, and as long as conditions and specimens are unchanged, no further trials are necessary.

Usually, when photographing very close subjects under this arrangement, the camera bellows is in an extended position. When the bellows is extended in this manner, the effective "f" value of the lens has undergone a change. This change is called the relative aperture change and correction for it must be made when calculating the exposure or poor photographs will result. The exposure increase required can be determined conveniently without calculations by the use of published aperture guides sold by camera dealers.

If a light box is not available a combination of two or more reflector lamps may be used. One common type is the "goose neck" or desk lamp. The construction of this type of lamp permits it to be adjusted to almost any position needed to throw the maximum amount of light upon the subject. It is advisable to use a 75 or 100 watt bulb in each lighting fixture and arrange them around the specimen as to reduce shadow and glare.

It is a common practice to place beside the specimen a ruler or scale to show size relationship. If the specimen is a fossil, it should be orientated in such a manner as to have the head or front portion towards the top of the photograph. This arrangement, if carried out faithfully by the photographer, establishes a standard procedure which will enable the observer of the photograph to know the true shape of the fossil.

The geologist will, at times, want to photograph very small objects without the use of a microscope and still have some degree of magnification in the print. This can be done by the use of the close up attachment lens as described in the preceding chapter. Of course, the close up lens will not magnify to as great an extent as will the microscope, but it will enlarge the specimen to a size that will enable the observer to recognize it if the original size is not less than $\frac{1}{2}$ or $\frac{1}{4}$ inch in length or width.

The use of color film in this type of work has definite advantages over the black and white type. This can easily be understood if one particular specimen is photographed upon both color and black and white film. Many fossil and rock specimens can more easily be identified in photographs if their true color is shown. (See plates V and VI). On the average each color film or sheet will cost the geologist more than ten times that of black and white. Additional cost is necessary to obtain the final prints. If the photographer can use a 35 mm camera the cost of color film will be greatly reduced and in this instance it will be approximately three times that of black and white.

Microscopic technique. The more difficult of the two phases of geologic laboratory photography is the one requiring the use of the microscope. There are two types of microscopes that can be used successfully by the geologist in the laboratory. The most common type is the compound monocular microscope. This is a single eye piece microscope with one or more objectives. The other type is the petrographic microscope commonly used in the petrographic study of rocks minerals. The set up with both is essentially the same except with the latter, there are more adjustments to be made before the photograph can be taken, and for the most part these are technical adjustments common to the student or optical mineralogy and will not be discussed.

The same type of camera used for the megascopic technique may be used in this case but not without reservations. When photographing through a microscope the camera lens is not used. This does not mean that the camera lens may not be used, but the problem of picture definition, focus and clearty will be better solved without its use. When the camera lens is not used a lens board in which is centered a hole with a slightly larger diameter than the diameter of the microscope barrel, is inserted in its place. The camera is supported on the same type of device as described in the preceding technique. The vertical distance from the camera to the top eye piece of the microscope will have to be adjusted for each given case to allow for the lowering and raising of the microscope barrel and camera bellows during the focusing procedure and at the same time, have the eye piece protruding through the lensboard of the camera. This set-up will reduce the amount of light entering the camera bellows from around the side of the microscope barrel and eyepiece.

The next step in aligning is to obtain the maximum amount of light on the ground glass of the camera. If transmitted light is used, tilt the microscope mirror in the position where it will throw the light up through the objective and upon the center of the ground glass. If reflected light is used, the microscope light or lights must be tilted so the maximum amount of light will be reflected from the surface of the specimen. After this has been done, insert the specimen or slide and focus first with the microscope adjustment and then with the camera adjustment. If the lens board is used in place of the camera lens there will be no shutter or diaphragm to rely upon. In this case, the stopping down of the light will correspond to the diaphragm and the action of the shutter will have to be substituted by the turning on and off of the light source. As discussed before, the smaller the diaphragm opening the more definition and sharpness the picture will possess. At certain times this rule may not be absolutely true especially when related to laboratory photography or when the object to be photographed has a high relief or elevation. In this case, it is the usual practice to focus, with the lens wide open or with the lights full on, upon a point on the specimen one-third the distance down from the upper surface. After this has been done reduce the diaphragm opening or the intensity of the light until the whole specimen is in the sharpest focus. When photographing a particular specimen, this point of sharp focus will not be found at the smallest possible diaphragm setting or at the fullest reduction point of the light. This same "one-third rule" will apply to close photography of a specimen without the use of the microscope.

In photographing specimens, such as thin sections and sand grains where transmitted light is used, the light should be diffused before it reaches the microscope mirror. This is done to avoid glare and increase the sharpness and can be accomplished by placing a piece of diffusing glass or cloth between the mirror and the light source.

The problem of obtaining the sharpest focus through the microscope will be quite apparent to the photo-geologist upon attempting the photographing of sand grains or other objects that do not have a flat surface. The microscope has very little depth of field or focus and when using an eye piece of 8x or 10x in conjunction with an objective of 16mm. or higher power, it will be almost impossible to obtain a sharp focus over the entire specimen from top to bottom. The eye piece and objective best suited for this type of work is an 8x or 10x and 32mm. respectively. (See plate XIII). A 48mm. objective can be used, but it will not produce the required magnification that would be necessary for complete study of the specimen. There are many and varied cases along this line and each one has to be solved accordingly. Very often, the using of both transmitted and reflected light will bring out detail and improve the focus. (See plate XIII). In other cases, the insertion of agreen filter between the microscope and light source will prove of equal value in producing a picture of good definition. There is no standard procedure for photographing all specimens, and as stated above, each case will have its own problems and one set of rules will not solve all of them satisfactorily.

The exposure, in the microscope technique, may also be determined by making a trial negative with a series of different exposures or by the use of an exposure meter used in the following manner: "move the slide to one side so that only clear glass shows in the field. Place an exposure meter at the level of the film plate (after removing the ground glass). The exposure is read from the meter set to the emulsion speed of the film used at the f/2 setting on the meter. This is an arbitrary value that gives good results for the average specimen slide. Very dense or very transparent slides may take somewhat longer or shorter exposure."[2]

__Use of color film__. The use of color film for microscopic work is just as advantageous as in any other technique. Color film does require a finer adjustment of the microscope and additional care must be taken when calculating the exposure. The condenser of the microscope must be properly

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2 Oscar W. Richards, __The Effective Use and the Proper Care of the Microscope__ (Buffalo: American Optical Company, 1941), pp. 82-83.

focused, when natural color photomicrographs are taken, otherwise the background may be tinted from chromatic aberrations of the condenser and the colors of the specimen may be effected. There are two basic types of color film on the retail market. One type can be used with natural light (daylight) and the other is so balanced as to render the proper colors under artificial light. Always use the latter in the laboratory or off-color photographs will be the result.

Coating of fossils. The coating of fossils by ammonia chloride gas, in order to bring out details of lights and shadows, is an old technique long used by the geologic photographer. This is done by constructing a "gun" composed of two bottles containing ammonia hydroxide and hydrochloric acid together with a series of glass tubes and rubber hose. In one sense, this set-up is nothing more than an atomizer whereby air is blown into the mouthpiece tube thus forcing the gases from each bottle to rise and unite at the nozzle forming the white ammonia chloride gas or fog. When the fossil is coated with this fog it increases the surface detail and causes the high and low points to stand out in more contrast, and in better tones of black and white.

One other type of coating is by the burning of ribbon magnesium and holding the fossil in the released vapor. This method is very good, but care must be taken when burning the magnesium because it is consumed very rapidly by the fire and the coating has to be done quickly.

In case the two above methods cannot be used, the fossil can be coated or dusted with a thin coating of talcum powder. This method can be used with less difficulty than the other two, but the results will not prove quite as effective.

If using color film, any type of coating will prove unsatisfactory because the film would register it as white in color and the color balance would be false.

LABORATORY PHOTOGRAPHIC DATA

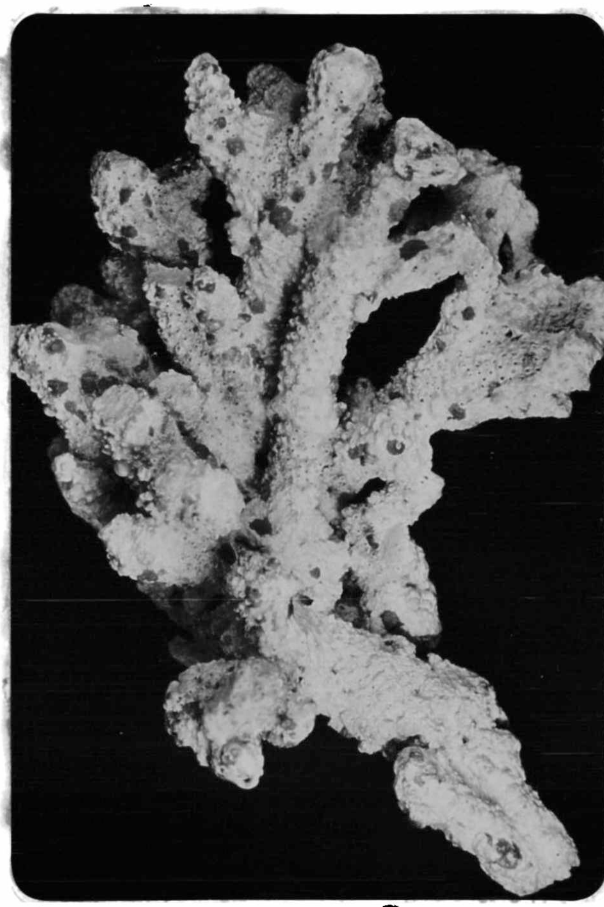
	Microscope Data				Diffusing Light Filters				Without Microscope				
Subject	Objective	Eyepiece	Transmitted Light	Reflected light	Color Film T.L.	Color Film RL	B & W Film TL	B & W Film RL	Color Film	B&W Film	Camera Lens	Close-up Lens	Light Source
Fossil Specimens (Smaller than 1/4")	32mm.	10x	No	Yes	-	W	-	W	-	-	No	No	Two Micro-scope spot-lights
Fossil Specimens (Larger than 1/4")	-	-	-	-	-	-	-	-	W	W	Yes	1+, 2+, or 3+	Light Box or 3 Desk Lamps 100 W. Each
Sand grains	32mm.	10x	Yes	Yes	W	W	B or G	W	-	-	No	No	Two Micro-Scope Spot-lights
Rock Specimens (1-4" dia.)	-	-	-	-	-	-	-	-	W	W	Yes	1+, 2+, or 3+	Light Box or 3 Desk Lamps 100 W. Each
Rock Specimens (larger than 4")	-	-	-	-	-	-	-	-	W	W	Yes	No	Light Box or 3 Desk Lamps 100 W. Each
Thin sections	16mm. or 8mm.	10x	Yes	No	W	-	B or G	-	-	-	No	No	One Micro-scope Spot-Light

Legend

T.L.	- -	Transmitted light
R.L.	- -	Reflected light
W	- -	White
B	- -	Blue
G	- -	Green

Exposures are not shown because of varying conditions.

PLATE V



BRANCHING CORAL

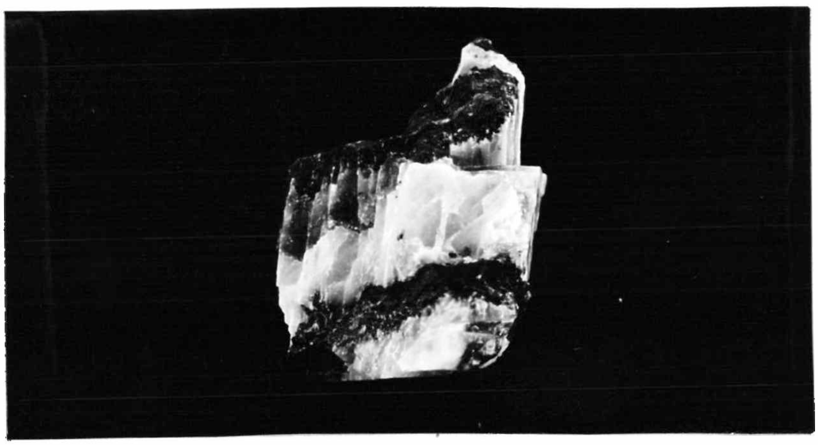
Branching coral. Specimen is eight inches long and four inches wide at its widest point. The scale was omitted during printing. Photographic data: Kodachrome, Type B. Light source consisted of three desk lamps. Exposure: 3 sec. at f/22.

PLATE VI

ROCK SALT

Rock salt specimen showing the reddish stain. Note scale for size relationship. Photographic data: Kodachrome Type B. Light source consisted of three desk lamps. Exposure: 5 sec. at f/22.

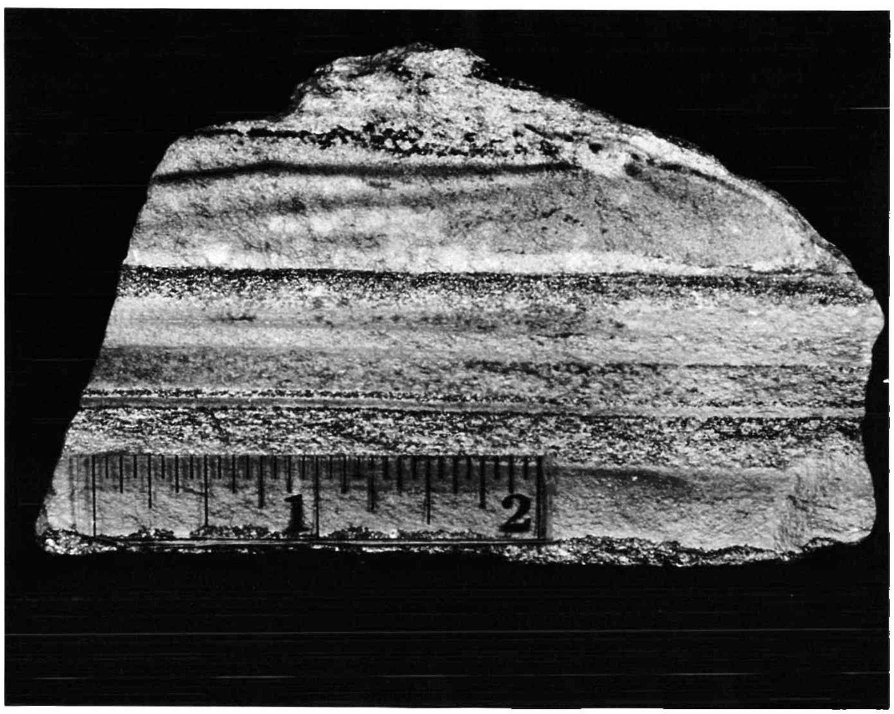
PLATE VI A



CALCITE

The light green color of the calcite or the size of the specimen cannot be determined in this photograph. Compare with Plate VI. Exposure: 1/10 sec. at f/16 on Super Panchro-Press Film, Type B. Light source: Light box.

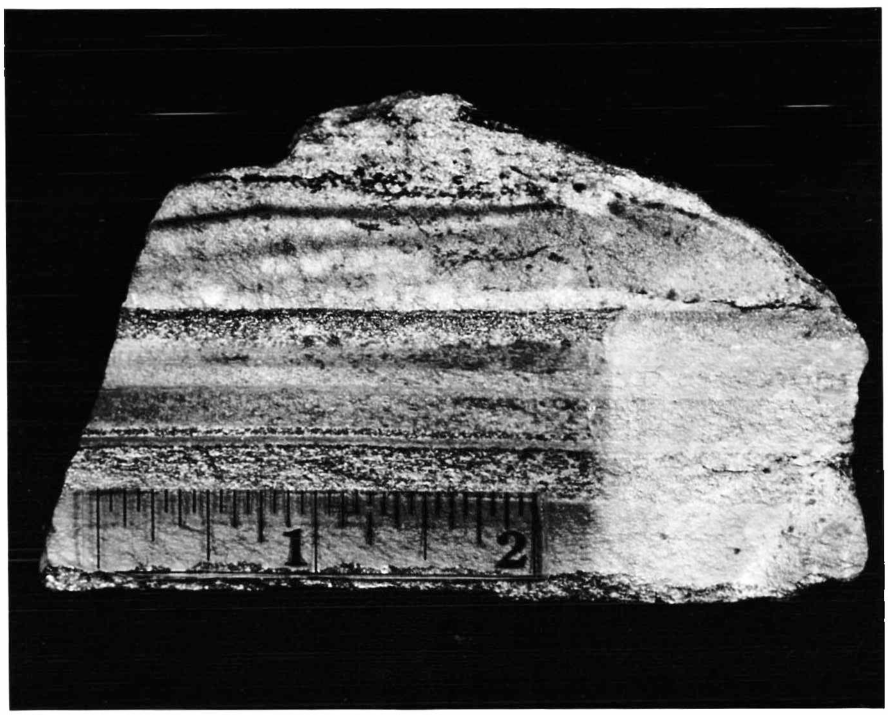
PLATE VII



UNIDENTIFIED SANDSTONE SHOWING LAMINATIONS

Slightly larger than true size. Note scale. Exposure data: 2 sec. at f/16 on Super Panchro-Press Film, Type B. Light source: Light box.

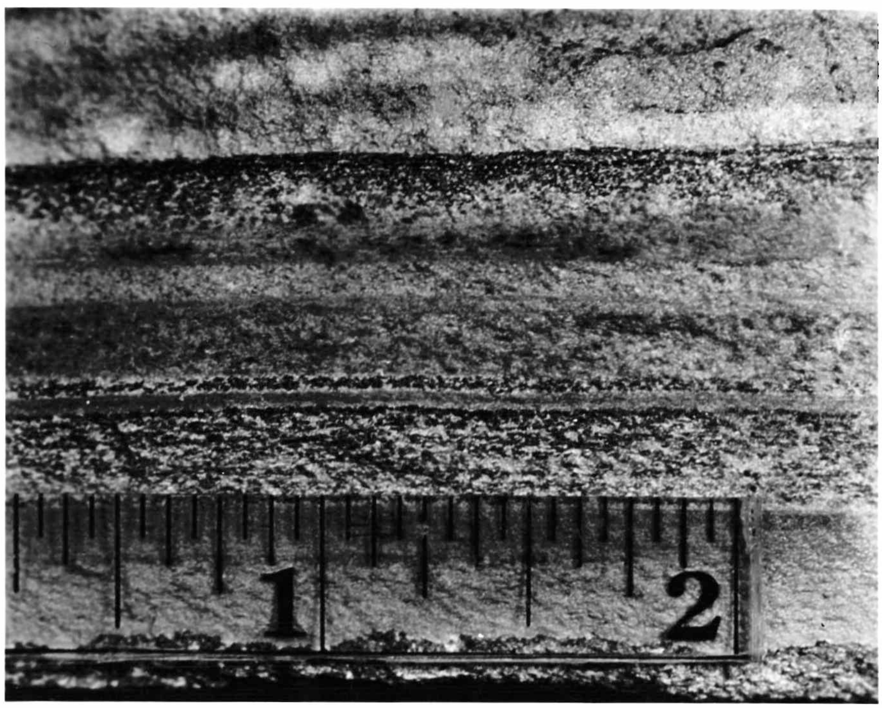
PLATE VIII



LAMINATED SANDSTONE

Same specimen as previous plate showing difference between coated and uncoated area. Coated area is small portion to the right. Exposure date: Same as previous plate.

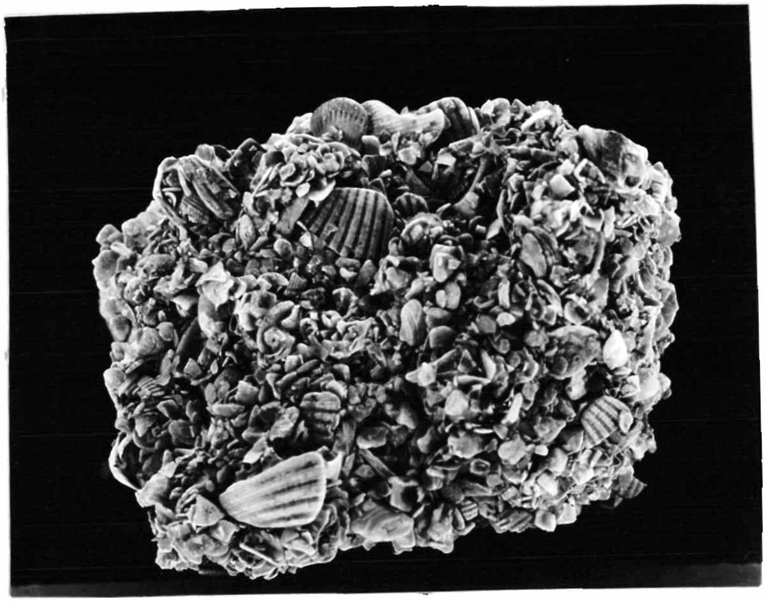
PLATE IX



LAMINATED SANDSTONE

Portion of previous plate showing enlarged section of specimen. Magnification: 2x. Exposure data; 3 sec. at f/11 on Super Panchro-Press Film, Type B. Light source: Light box. Magnifier: 2x close-up lens.

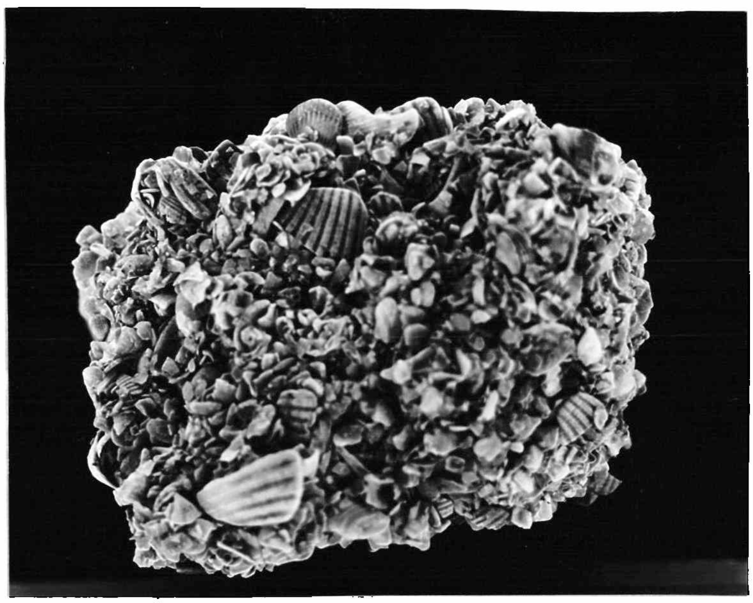
PLATE X



COQUINA SPECIMEN

True size. Exposure data: 1/10 sec. at f/16 on Super Panchro-Press Film, Type B. Light source: Light box. Note that entire specimen from top to bottom is in focus.

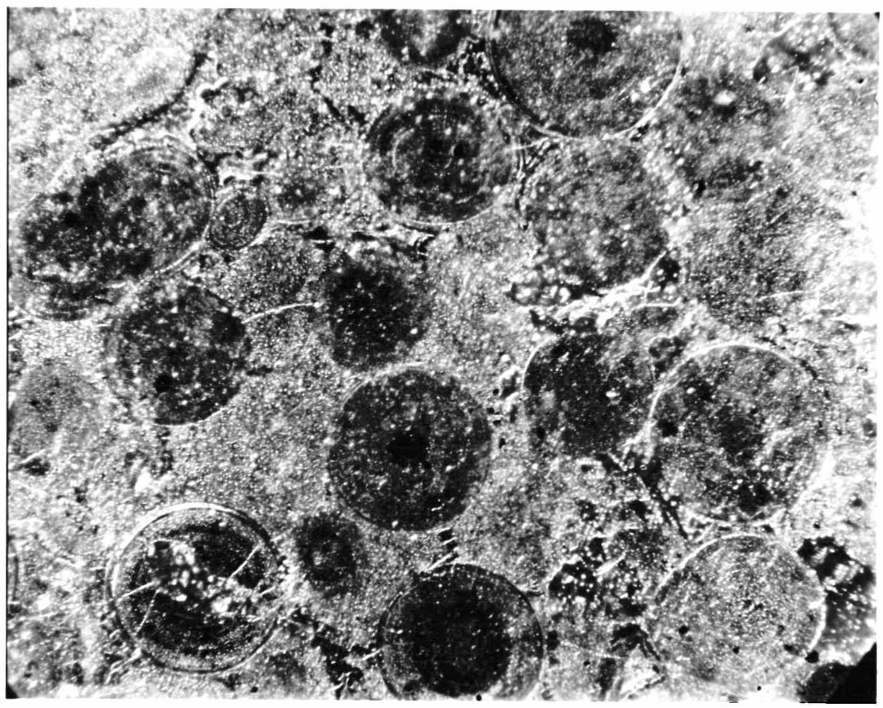
PLATE XI



COQUINA

Same specimen as previous plate. Exposure data: 1/50 sec. at f/8 on Super Panchro-Press Film, Type B. Light source: Light box. Note the lack of sharpness on upper portion of specimen. This is due to the larger diaphragm opening. This picture illustrates the rule of using the smallest convenient lens opening to obtain a higher depth of field or focus.

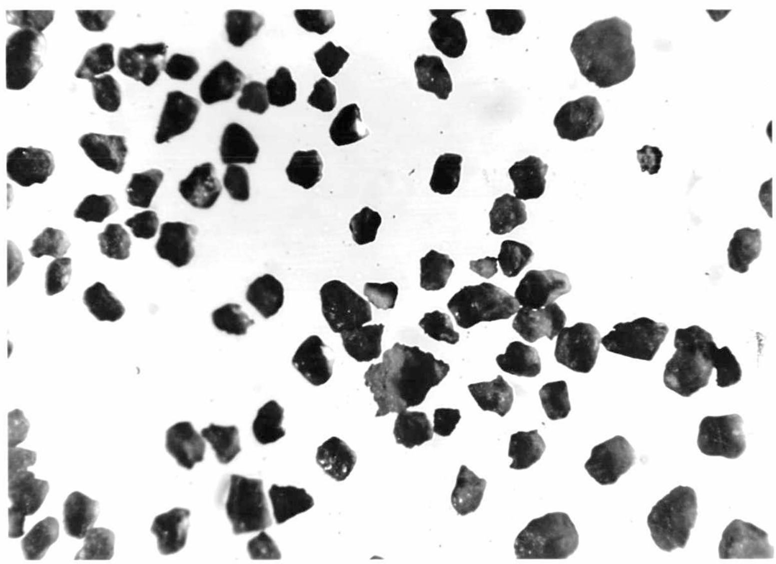
PLATE XII



THIN SECTION OF OOLITIC LIMESTONE

This photomicrograph shows the enlarged oolites in the limestone. Magnification: 22x. Exposure data: 2 sec. without camera lens on Super Panchro-Press Film, Type B. Light source: Spencer Microscope Light with blue diffusing filter. Microscope: Spencer Compound Monocular with 48mm. objective and 10x eye piece.

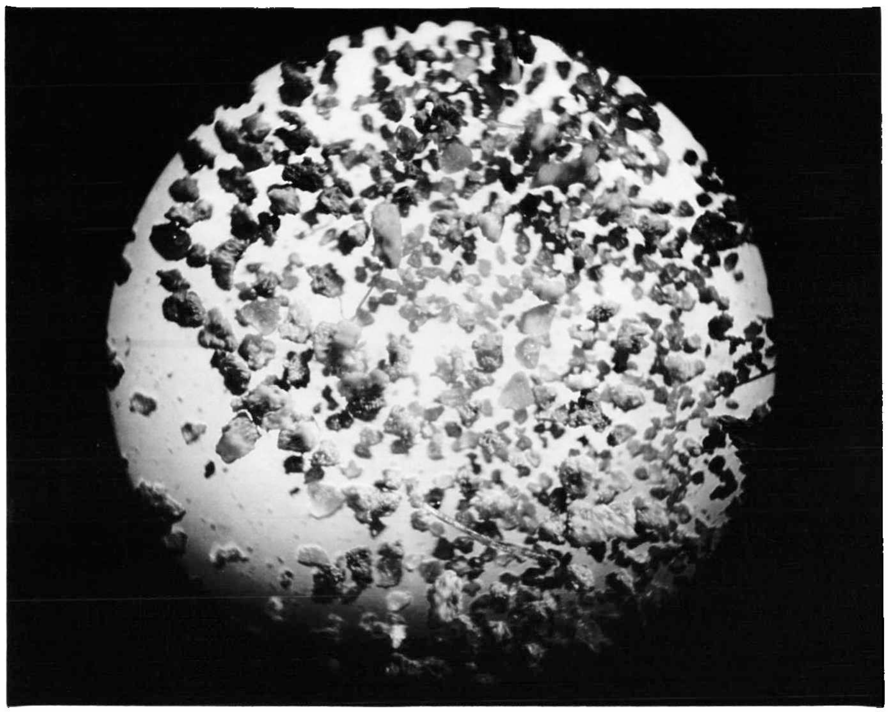
PLATE XIII



PHOTOMICROGRAPH OF SAND GRAINS

This photograph illustrates the use of both transmitted and reflected light in a microscope set-up. The reflected light is main source and is used to show surface detail of the grains. The transmitted light is the secondary source and is used to improve sharpness. The shallow depth of field is illustrated by the fact that not all of the grains are in focus. This is due to the varying degree of size of each grain. Exposure data: 2 sec. without camera lens on Super Panchro-Press Film, Type B. Light source: Two Spencer Microscope Spotlights with blue diffusing filters. Microscope: Spencer Compound Monocular with a 32 mm. objective and 10x eye piece. Magnification: 40x.

PLATE XIII A



PHOTOMICROGRAPH OF SAND GRAINS

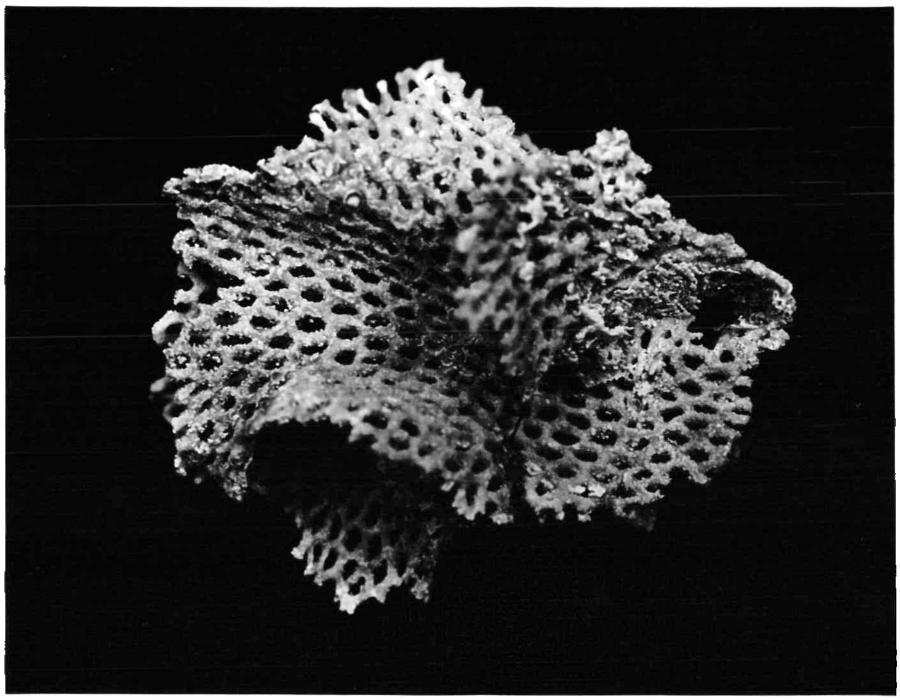
Photograph illustrates the use of the wrong size objective on the microscope. These sand grains are the same as shown on photograph plate XIII. The magnification is 22x, which is too low for sufficient study. Exposure data: 3 sec. without camera lens on Super Panchro-Press Film, Type B. Light Source: Two Spencer Microscope Spotlights with blue diffusing filters. Microscope: Spencer Compound Monocular with a 48 mm. objective and 10x eye piece. Magnification: 22x.

PLATE XIII B

PHOTOMICROGRAPH OF SAND GRAINS

Illustrating the opposite extreme of selecting microscope objectives. The magnification is too large for sharpness and detail. Compare with plate XIII and XIII A. Exposure data: 2 sec. without camera lens on Super Panchro-Press Film, Type B. Light source: Two Spencer Microscope Spotlights with blue diffusing filters. Microscope: Spencer Compound Monocular with a 16 mm. objective and 10x eyepiece. Magnification: 100x.

PLATE XIV

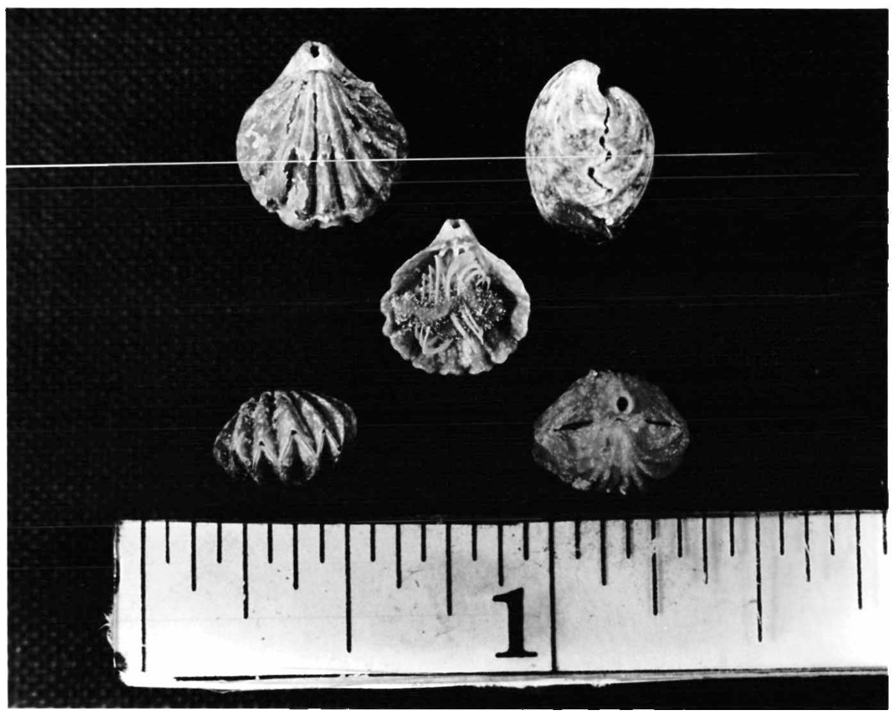


BRYOZOA

Polypora mexicana Prout? This photograph illustrates the limit of the depth of field. The lens was reduced to the smallest opening, but the entire fossil could not be brought into sharp focus without decreasing the length of the camera bellows. If this was done the specimen would be reduced in size in the photograph. Exposure data: 1 sec. at f/32 on Super Panchro-Press Film, Type B. Light source: Three desk lamps. Magnification: 2x close-up lens.

Courtesy of E. F. Monk.

PLATE XV

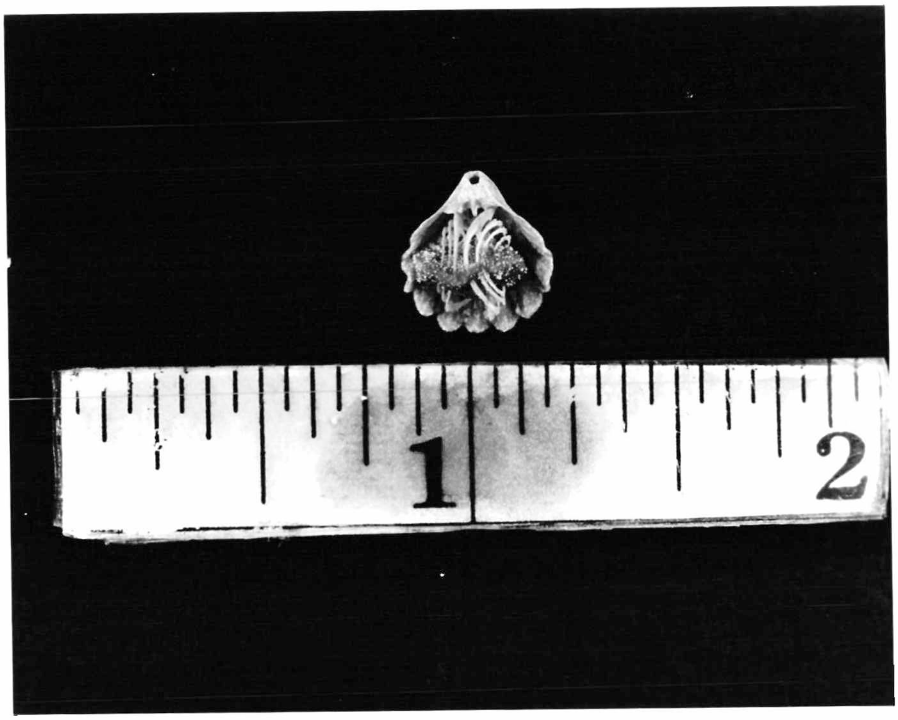


BRACHIOPODA

All specimens in this photograph are of the same genera and species: Hustedia meekana Shumard. This illustrates the incorrect practice of including more than one fossil in one photograph even if all are of the same type. Each fossil cannot be given the correct exposure and lighting because of the difference in surface detail and density. Exposure data: 1 sec at f/22 on Super Panchro-Press Film, Type B. Light source: Three desk lamps. Magnification: 2x close-up lens.

Courtesy of E. F. Monk.

PLATE XVI



BRACHIOPOD

Hustedia meekana Shumard. Correct method of photographing an individual fossil specimen. Note the difference in detail and density of the above and of the same fossil on the preceding plate. Exposure data: 2 sec. at f/22 on Super Panchro-Press Film, Type B. Light source: Three desk lamps. Magnification: 2x close-up lens.

Courtesy of E. F. Monk.

CHAPTER IV

DEVELOPING AND PRINTING

Introduction. The geologic photographer should always, if at all possible, develop and print his own pictures. Much better control over negative density and print quality can be assured if the geologist will do his own work because he alone knows what parts of the print should be highlighted or subdued for better contrast.

Field developing and printing. The geologist should not develop or print the photographs in the field. There are several portable field darkrooms on the market, but their use would add to the amount of equipment carried into the field and their use is not worth the effort or the expense. Therefore, it is to the geologist's advantage to develop and print his picture upon his return home or in the company laboratory.

Laboratory developing and printing. If at all possible, the geologist should have access to a darkroom near the location of the laboratory where the photographs are to be made. Any darkroom, regardless of its location, must be lightproof because the entrance of any light will fog the film being developed. This is especially true if using high speed film, and for most of the work, this will be the case.

Darkroom procedure, involving types of chemicals, films, papers and temperature used, will not be discussed. Procedures will vary depending upon the above factors and this detailed information can be obtained by the purchase of developing and printing publications or by the study of the information charts furnished with all types of films, papers and developing chemicals. It is the best practice, however, to use a fine-grain developer and glossy paper. The use of these will increase the contrast between black and white tones in the final print.

It is the best practice to have all color film processed by the manufacturer or some reliable color processing plant. The purchase price of many brands of color film includes the cost of developing, but only if the film is returned to the manufacturer. After the color film is developed, it is returned in the form of a transparency which in turn can be mounted in a slide and projected upon a screen. For additional cost, positive prints can be made from these transparencies. The photographs included in this paper are of this type.

CHAPTER V

SUMMARY AND CONCLUSIONS

Photography is one of the most versatile tools of the geologist. It enables him to present to others graphic illustrations of both field and laboratory work. As described, the subject of geologic photography is divided into two main divisions; field photography and laboratory photography. These divisions are broken down into their component parts and the study of each one is necessary to assure good results.

Color film should be used as much as possible in all types of geologic photography. The limited number of color photographs included in this report might lead the reader to believe that color work is not important, but this is not the case. New types of color film are being developed that will enable color photography to be placed within the reach of all. The present cost of color film is the limiting factor placed upon its widespread use at this time.

In the main, geologic photography is an exacting science. There can be no half-way measures. Exposures, lighting, subject material, use of filters and attachment lenses, etc. must be calculated to a fine degree. It is very bad practice to correct mistakes in the developing process that could have been avoided at the time of exposure.

In conclusion, there are several books and publications on photography in general and photomicrography in detail and it would be impossible to cover all phases in a paper of this type and scope. Just the more important problems and their solutions have been presented and discussed.

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APPENDIX

EXPOSURE INDEXES

The Exposure Index of any type of film is used in the calculation of exposure. Each type of film, whether black and white or color, has two exposure index numbers. One number is based upon daylight illumination and the other on artificial light. These numbers give a numerical rating to the light absorbing ability of the film, which is in reality, film speed. "Speed is a unique characteristic of a photographic material which refers to the minimum camera exposure which will yield a final print having excellent quality." These "speed numbers" are based upon a standard set by the American Standards Association and they range in value from 0.8 to 650. The higher the number, the faster the film.

In using any exposure meter, the film speed has to be known and set accordingly on the meter's calibration system. The following chart gives the exposure index of the common types of Eastman Kodak Films.

TYPICAL EXPOSURE INDEXES FOR KODAK FILMS

Film	Exposure Index	
	Daylight	Tungsten
Roll Films & Packs		
Verichrome	50	25
Plus - X Panchromatic	50	32
Super - XX Panchromatic	100	80
Super Ortho - Press	100	50
35 mm. and Bantam		
Super - XX Panchromatic	100	64
Plus - X Panchromatic	50	33
Panatomic - X	25	16
Sheet Film		
Super Panchro-Press, Type B	125	100

Eastman Kodak Company, 1948.

COMMON TYPES OF BLACK AND WHITE KODAK FILMS AND THEIR USE

Roll Films:

Verichrome: A high speed, orthochromatic film for general use. It is satisfactory for night photography with Photoflash and Photoflood Lamps. Speed: Daylight-50, Tungsten-25.

Plus-X: A high speed, fine grain, Type B panchromatic film: it has excellent gradation and wide exposure latitude. The speed and balanced color sensitivity suit it to a wide range of outdoor conditions. The low graininess and high resolving power permit high quality enlargements many times the size of the original negative. Speed: Daylight-50, Tungsten-25.

Super-XX: A very high speed, Type B panchromatic film, for indoor and outdoor use under adverse lighting conditions. Speed: Daylight-100, Tungsten-80.

35 mm. and Bantam:

Plus-X: Same as roll film.

Panatomic-X: An extremely fine grain, moderate speed, Type B panchromatic film. It is particularly valuable when great enlargement is intended or when extreme detail or texture is desired.

Super-XX: Same as roll film.

Sheet Film:

Super Panchro-Press, Type B: A very fast, Type B panchromatic film. Intended primarily for press work. It is also useful for commercial and illustrative photography as well as photomicrography using either tungsten or fluorescent lighting. Speed: Daylight-125, Tungsten-100.

AVERAGE DAYLIGHT EXPOSURE GUIDE

FOR

ANSCO COLOR DAYLIGHT POSITIVE FILM

Shutter Speed	Bright Sunlight Front Lighted	Bright Sunlight Side Lighted	Bright Sunlight Back Lighted	Hazy Sun-light, Soft Shadows	Bright Over-cast No Shadows	Dull Over-cast
1/100 sec.	f/4.5	f/3.5	f/2.5	f/3.5	f/2.5	f/1.8
1/50 sec.	f/6.3	f/4.5	f/3.5	f/4.5	f/3.5	f/2.5
1/25 sec.	f/9	f/6.3	f/4.5	f/6.3	f/4.5	f/3.5

The Ansco Company

This guide can also be used for Eastman Kodachrome Film, Daylight type with exposure index of 10 daylight.

DEPTH OF FIELD

The "zone of sharpness" or depth of field varies with the type of lens and the camera-to-subject distance. The following table gives depth of field for a Kodak Anaster Lens, 80 mm., f/3.5. only, but will serve as an example in showing the relationship between focus distance and lens opening and how they affect depth of field.

DEPTH OF FIELD FOR A KODAK ANASTER

LENS, 80mm., f/3.5

Camera to subject distance in feet	Depth of Field f/3.5		f/5.6		f/8		f/11		f/16		f/22	
	' "	to ' "	' "	to ' "	' "	to ' "	' "	to ' "	' "	to ' "	' "	to ' "
Inf.	84-6	Inf.	52-9	Inf.	37-	Inf.	27-	Inf.	18-6	Inf.	13-6	Inf.
50	31-6	122-	25-9	Inf.	21-3	Inf.	17-6	Inf.	13-6	Inf.	10-6	Inf.
25	19-3	35-6	17-	47-6	15-	77-	13-	350-	10-9	Inf.	8-4	Inf.
18	14-9	22-9	13-6	27-3	12-	35-	10-9	54-6	9-	Inf.	7-9	Inf.
15	12-9	18-3	11-9	21-	10-6	25-3	9-6	34-	8-3	79-3	7-	Inf.
12	10-6	14-	9-9	15-6	9-	17-9	8-3	21-6	7-3	34-3	6-3	110-
10	9-	11-3	8-3	12-3	7-9	13-9	7-3	16-	6-6	21-4	5-9	39-
8	7-3	8-9	7-	9-6	6-9	10-6	6-6	11-6	5-6	14-	5-	22-
7	6-6	7-6	6-3	8-	6-	8-9	5-6	9-6	5-	11-3	4-6	14-6
6	5-8	6-6	5-4	6-9	5-3	7-3	5-	7-9	4-6	9-	4-3	10-9
5	4-9	5-3	4-6	5-6	4-4	5-9	4-3	6-3	4-	7-	3-9	8-
4	3-10	4-2	3-9	4-4	3-8	4-6	3-6	4-9	3-3	5-	3-	5-9
3½	3-4	3-8	3-3	3-9	3-3	3-10	3-2	4-	3-	3-3	2-9	4-9

Eastman Kodak Company, 1948.

SELECTION OF FILTERS FOR OUTDOOR USE

SUBJECT	EFFECT DESIRED	SUGGESTED FILTER
Clouds against blue sky	Natural	K2
	Darkened	G
	Almost black	A
Marine scenes under sky of blue	Natural	K2
	Water dark	G
Distant landscapes	Natural	K2
	Haze reduction	G
	Greater haze reduction	A or F
Red, "bronze," orange, and similar colors	Lighten to show detail	A
Dark blue, purple and similar colors	Lighten to show detail	None or C5
Green, such as foliage	Natural	K2 or X1
Stone, wood, sand, snow, etc., when sunlit and under blue sky	Natural	K2
	Enhanced Texture rendering	G or A

Eastman Kodak Company, 1948.

<u>Legend</u>

A - - Medium Red
C5- - Blue
F - - Deep Red
G - - Deep Yellow
K2 - Medium Yellow
X1 - Light Green

DEVELOPING, PRINTING AND MOUNTING DATA

Developing

All negatives, with the exception of color, were developed as follows:

Developer:	DK-50 stock solution
Method:	Tank
Time:	8 minutes
Temperature:	68°F (20°C)

Printing

All photographs, with the exception of color, were printed as follows:

Method:	Contact printing in 5 x 7 printing box
Paper:	Velox, Glossy, White, 4 x 5 inches. Single weight
Time in box:	1 to 15 secs. depending upon negative density
Developer:	Kodak Dektol (1:1 solution)
Time:	60 sec. (approximately)
Temperature:	68°F (20°C)

Mounting

Color prints:	Mounted with Carter's Rubber Cement
Black and White:	Mounted with Kodak Dry Mounting Tissue, 200°F for 30 sec.

RELATIVE APERTURE CHANGE

The distance from the lens to the image is increased for short subject distances so that the indicated relative aperture (that is, the "f" number) is no longer effective. The exposure increase required can be determined conveniently by the following formula:

$$\text{Effective "f" value} = \frac{\text{Indicated "f" value} \times \text{Lens-to-subject distance}}{\text{Focal length}}$$

For example, a 10 inch lens racked out 5 inches from the infinity setting (to 15 inches from the film), and set at f/8, would have an effective "f" value of f/12.

$$\frac{8 \times 15}{10} = f/12$$

Since the effective "f" value in the above example is 12 instead of 8, as indicated by the lens diaphragm scale, the exposure time must be computed at this value to avoid under-exposure.

Eastman Kodak Company, 1948.