

## TRENDS AND NEEDS IN PHOTOGEOLOGY AND PHOTO-INTERPRETATION DISCUSSION FORUM\*

*Panel Members:* H. T. U. Smith, University of Kansas; Charles B. Read, U. S. Geological Survey; A. R. Wasem, Geophoto Services.

*Meeting Chairman:* Philip McCurdy, U. S. Navy Hydrographic Office, First Vice-President, American Society of Photogrammetry.

*McCurdy:* The first part of the program this afternoon is a forum discussion on trends and needs in photogeology and photo-interpretation. Your moderator is Mr. Roger Rhoades who is the Assistant Head of the Research and Geology Division, Bureau of Reclamation.

*Rhoades:* I suspect we will have an interesting airing of views. On the floor yesterday we had a number of controversial issues presented. We heard that a geologist, in order to be a competent photogeologist, must also be at least something of a photogrammetric engineer. On the other hand, we heard that this isn't true at all, and that it suffices for the photogeologist simply to have amongst his acquaintances a photogrammetric engineer to whom he can turn. We have heard one point which was not at all controversial, but may be further aired—the need for adjustment of university curricula to the end that photogrammetric education and photogeological education may be more effective. We have heard that a photogeological map is a perfectly adequate geological document. We have heard that this is not the case at all—at least without extensive field checks, or at least for more than reconnaissance purposes. I hope that we will have these various views, and as many others as may be represented by the audience, freely expounded. I suspect that out of the discussion we will find a settlement of none of the issues, but we may be able to bring them into sharper focus. We may be able to separate the various protagonists into their separate pastures, and I suspect all of us will be enlightened.

On my immediate left is a gentleman who really requires no introduction; he is familiar to the American Society of Photogrammetry: Professor H. T. U. Smith of the University of Kansas, a pioneer in the teaching and profession of photogeology. The other two gentlemen, Mr. Wasem and Dr. Read, have been introduced to you previously. I will call first on Professor Smith.

*Smith:* I desire to speak primarily of the needs of photogrammetry because I think that the one thing that can be said about the trend is toward application of photogeology and toward a more persistent exploration of its possibilities and its limitations. Now, my concepts of the needs are, first a more thorough training for those who are going to practice photogeology; either as an adjunct to the ordinary type of geology or as a specialty in itself, if we admit it is such a specialty. I think that training (I am giving my personal opinion) does involve what might be called elementary photogrammetry—streamlined photogrammetry stripped of its more mathematical phases—in other words, the simple working techniques that one must know to put photos together, make maps, measure heights, and observe the photos under the stereoscope.

I think that the basic geologic training is a much larger order. I believe it requires more emphasis than has previously been given in many geologic curricula, on the subject of geomorphology—what the surface features of the earth look like, how to recognize them, and how to distinguish between those which are produced entirely by erosion and deposition, and those which are controlled

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by structure. Without knowledge of that, there are many pitfalls for the unwary.

I hardly need say that the training in structural geology is very essential, as many photogeologists are concerned primarily with the interpretation of structure.

I should like to emphasize also the need for field geology. It has been my experience that the best interpreter of photos is the one who has the widest field experience. I believe that an interpreter can get more out of a given set of photos if he has already been in the area represented by those photos, but to the extent he has had experience in comparable areas, I believe his skill will be at its greatest. The more he has seen of geological features of all types under most diversified conditions, the more able he will be to analyze and distinguish the things he sees on the photo, which often are far less definitive than might be desired. At that point, the science and art come together; and the art, I believe, is perfected by this background of field experience.

In all of these branches of training—geomorphology, structural geology, and field geology—I believe that if the geologist has used photos, both in the field and in the laboratory, he will obtain the maximum benefit from his training.

I think the next need is for a more adequate background for reference material as a guide to the photo-interpreter. By that, I mean more information about land forms as they appear in various parts of the world—more ground information, more correlation between ground conditions and photographic conditions. I believe for one thing it would be extremely helpful if, every time a geologic report is published on a given area, it were accompanied by photos giving the characteristic surface expressions of a specific formation in the specific area described.

Secondly, I believe there is a need for widespread dissemination and publication of the results of photo-interpretation. The gentlemen who have spoken to you already have been practicing photo-interpretation for a long time. They have benefited by that experience which is not available to the rest of us. Now, if there were some way for them to put before the profession the specific things that they have found did not work, I believe it would be a great aid to all of us who are concerned with photo-interpretation in photogeology. In that connection, I might mention the need for what I might call an "Atlas of Errors." There are many deceptive and confusing things on photos which—I have heard from indirect sources—have even led to structural interpretations of such things as glacial moraines and other serious mix-ups because of the lack of precedents which the person interpreting the photos could use as a guide. So if all of us who make mistakes in interpretation and come to the wrong conclusions for the right reasons could assemble the mistakes we made and why we made them, the compilations might serve as a guide to those who will come after us.

Next, I should like to mention the matter of availability of the photos which are the basic materials for all photogeologists. In this country most of the photos available to government agencies are widely scattered. In Washington, D. C., for example, there are at least a half dozen offices to which one must go to select photos. In addition, some photos are in Salt Lake City; some are in Denver and in other parts of the country. If we could have some central repository, or at least photo-index sheets, for all the available photography in this country assembled in one place, it would greatly simplify things for the teacher and the practicing geologist who wishes to use that material and gain direct access to it. Furthermore, release for general use of some of the photographs made during the recent war for military purposes would be a great help to the photo-inter-

preter. Some of those have been released with various conditions, but we need more of them and we need them more freely available.

Next, I should like to mention my ideas about the potential value of color photography. I am told that this is only in the experimental stage. I believe, however, that it holds enormous possibilities, particularly for the geologist. Often things which are indistinguishable in black and white photography show very clearly in full color, as those of you who have done much flying, are very well aware. Shades of gray are no substitute for having the full color. Many of you, as I have, probably have done some color photography from low-flying planes with a 35 mm. camera. The results were enough to show the possibilities of this approach to photogeology.

I believe also that there is a need for experiments in the use of infra-red photography and the uses of various filters to see whether these, singly or in combination, may help us to detect differences in rocks and surface features which, otherwise, are indistinguishable. In regard to photography, there is a need for more experimentation, and for the use of photographs on larger scales than 1:20,000 which is standard in this country at the present time.

Next, I should like to mention the usefulness of aerial observation as an adjunct to photointerpretation. In working with a geologist on the Canol Project several years ago, we had the unusual opportunity of flying over an area before going into the field, next using photos in the field, and finally flying over it again after our field work was over, to check various things which were not clear on the ground. This was of enormous value in defining questionable points in the interpretation of photos. I believe that where practical, observation from a standard plane, or better yet, from a helicopter, has a great deal of usefulness. In doing this type of aerial checking, the camera serves as a convenient way of taking notes. A 35 mm. camera, either in black and white or in color, will give very good results, as those of you who have seen Professor Rich's book on South America and other publications will recall. The plane ordinarily flies too fast to take notes on paper or on maps, but by means of the camera we can get things from viewpoints not granted by the ordinary vertical photography.

Finally, I believe that there is a usefulness for simplified, streamlined photogrammetric techniques and instruments. The geologist ordinarily has little time for mastering the more complicated and intricate operations and theories that the photogrammetrist takes for granted. I refer to simplification in matters of height finding, removing tilt, and assembling photos stereoscopically.

In conclusion, I should like to say that photogeology in my opinion is here to stay. Its limitations and its possibilities remain to be more clearly defined. If however, we can get out into the open all the available information and techniques now in existence, this will go a long way toward defining more fully its field usefulness.

*Rhoades:* I am literally amazed, Professor Smith, to know that photogeology needs so much. I hope the discussions which follow will indicate that the trends are in the right direction. Dr. Read?

*Read:* My opinion about the use of aerial photographs in geology is indicated by a conversation that I had today. A friend and I were talking about the use of jeeps in the geological field. We agreed that they were all right when we couldn't get around any other way. That just about summarizes my opinion with regard to aerial photographs. They are very useful, but they are definitely a stopgap base for geologic work.

If you have a good topographic base, that to me is the final answer to our

geologic base problem. The aerial photograph is the beginning point, but we should go through the agency of the topographic sheet for our bases. However, we do not have topographic bases of large areas of which we must prepare geologic maps. Therefore, we are forced to this stopgap position of using aerial photographs rather than topographic sheets. I indicated yesterday that, looking at it from my rather narrow point of view, I see two trends in the use of aerial photographs in geologic work. One trend is in the direction of the interpretation of geology, the development of opinions, and the development of qualitative information rather than quantitative data. However, the preparation of a geologic map requires the assembling of a great deal of quantitative information which can be assembled only in the field. For example, the technique of interpretation, while very ingenious, provides us with large quantities of information in only two fields of geology; one in geomorphology, or physiography; the other in apparent geologic structure. Interpretation is one trend. The other trend, as I have indicated, is the direct use of aerial photographs as field bases.

Obviously, except for differences in instrumentation, the use of aerial photographs as field bases differs in no way from the use of any other field base. The geologist uses aerial photographs in the field as guides to his traverses. He also interpolates between his traverses and identifies his map units. He makes the necessary determinations with rocks, collects specimens where necessary, and accumulates all of the data which must go into a geologic map, if the geologic map is complete. There is no way that he can collect these data, as far as I know, unless he goes into the field and unless he plots his information directly on the map, whether it be a topographic base, a plane table sheet or on aerial photographs. The true technique of making a complete geologic map, in fact the only technique, is the preparation by means of the field map. So, there are your two trends.

However, there is a third influence that affects these trends. This is an extremely glaring weakness which involves the technical knowledge of the geologist. He is, rather obviously, an inadequate photogrammetrist. His future success in using aerial photographs will undoubtedly depend upon the acquisition of a certain amount of photogrammetric knowledge. I would be willing to concede that he will never be a research photogrammetrist, but he certainly should become a high-class amateur.

As to needs, the first point I should like to stress is that our real need is personnel; not specially trained personnel but trained and well experienced geologists. A geologist who is well trained and experienced in general geology will have very little trouble with aerial photographs once he grasps certain fundamentals of photogrammetry which, at least from the practical point of view, I do not believe are even extreme. So our real need, as I see it, is getting experienced geologists. If you are talking about training, train them as geologists without any specialization. Require the fundamentals; let them specialize afterwards; let them study photogrammetry; let them become photogeologists afterwards. But, inasmuch as they are shooting at geologic data, require them to really understand and think in terms of geology, before you start asking them to specialize in anything other than geology.

The second need, as I have stated before, is very rigid technical discipline in the interpretation of aerial photographs, and in the delineation of photographs in the field. In other words, we are in the position of being map makers and geologists without any standards. As a consequence, we can raise a question about any geologic map. There are no standards. Are they really maps? Certainly, the geologic profession is in need of some standards.

A third point which I should like to point out involves one of the functions

of this Society. The geologist is hampered in his field and office use of aerial photographs, by lack of proper field equipment for use in connection with field surveying on aerial photographs, and he is also hampered to some extent by lack of types of compilation equipment in the office particularly suitable to his needs. For instance, take this matter of field equipment. Those of us who first learned geologic surveying by the use of plane tables were provided with rather adequate and moderately sensitive surveying instruments for rough usage. Our instruments were corrected within bounds of graphic accuracy. Our present field stereoscopes are relatively unsatisfactory. From my point of view, an adequate field stereoscope has never been devised. Therefore, right at the start in the delineation of aerial photographs in the field, we have a weakness of inadequate stereoscopes, and, I might also remind you, inadequate ability to properly use those stereoscopes in the field.

Secondly, there is the matter of office equipment. We are pyramiding one inaccuracy on top of another. We are coming up, in many cases, with a product of very poor quality, a product which is good in form but, in many cases, is lacking in either horizontal or vertical accuracy. Ultimately, the remedy in this matter of instrumentation of aerial photographs lies in the hands of the research photogrammetrist, not in the hands of the geologist. His place is that of a high-class amateur at best, but certainly there is need for research in design of equipment of types suited for geologists.

*Rhoades*: Those are strong words. Are they all true, Mr. Wasem?

*Wasem*: In many respects, yes. I think that in the first part of this discussion, each of the gentlemen has indicated what he believes to be the trends and needs as far as photogeology is concerned. About all I can do is to re-emphasize some of their points. In my paper this morning, I mentioned the methods of procedure that we are able to use in the way of photogrammetric techniques, and the rather crude way that we use them. Our limits of error and tolerances are certainly much greater than anybody who is compiling a topographic map or compiling an accurate planimetric map would allow, but I emphasize in that respect, that the work is strictly commercial. In other words, we are putting out what the oil companies want. Given a choice between geology and planimetry, they will take more geology and less accurate planimetry.

As far as trends are concerned, I think it has been well summarized, but to add my statement, I think the biggest trend is that there will be more and more photogeology as time goes on. Our present needs are many.

The subject of education has been thoroughly discussed, but I wish to emphasize that we feel that most college graduates who come to our office are inadequately trained as geologists. Primarily, we want geologists, particularly with an emphasis on training in the field, because a man who works on photographs is doing nothing more than changing his point of view from the horizontal to the vertical. He applies the same criteria, although he recognizes his formations and his dips from a different point of view, in using the aerial photograph rather than being on the ground. Consequently, we would like to see more and more emphasis on the practical application of geology in the field in present-day graduates. I realize that is asking a good deal, but we, of course, have in mind only our own requirements.

We would like to have new instruments—instruments that at no extra expenditure in time, consequently no extra cost, would enable us to improve our planimetric accuracy in maps. It all boils down to a cost basis. If new instruments can be designed that will more adequately and more accurately do the job than those that are currently available, we would be very happy to use them. In referring to new instruments, I speak of both instruments for planimetric

mapping and for height finding. In connection with height finding, the one obvious need is some way of taking aerial photographs with no tip or tilt. Whether this problem will ever be solved I do not know. We would like to see it happen. If so, our problem of height finding, without the expensive proposition of going into the field to lay out vertical control for the use of the height-finding instruments, might be obviated.

Color has been mentioned in this forum, and I should like to say one or two words about color photography. Here again the advantages of color and the ease with which many things can be followed on color film are certainly obvious to most geologists. The two requirements that we would specify in this respect would be (1) that the prints be on some sort of base that we could quickly and easily work with and annotate. (2) It seems improbable that the color transparencies with the special equipment that is necessary for using them, and the special overlays that must be made to compile the geologic information from color transparencies, would ever permit their use in photogeology, particularly in a reconnaissance survey. However, the present cost of color photography with respect to black and white is so high that most oil companies would not be interested. So, there again is a matter of new developments in that it is desirable to have a workable product at a cheaper cost than is presently available. These few remarks more or less summarize my feelings in respect to the present trends and some of our needs in photogeology.

*Rhoades:* The meeting is now open for general discussion.

*Lt. Col. Helk* from the Geodetic Institute in Denmark, Chief of the Photogrammetric Division: I have been in this country a few weeks in order to see your different surveying institutions. I have very little idea of geology, but these two days have given me a lot of information and also some confusion on geology. I understand the objective here, in talking of photogrammetry in connection with geology, is the use of photogrammetric methods. But I understand also that you have two absolutely different ways of using the air photography. There is a strategic and tactical way of using the pictures. You have your reconnaissance pictures and you have your real map making.

Another point of confusion is about the word "photogeologist," or "photogeology." In my opinion, there is nothing of that kind. Go back to the Army, for instance. In the early days, there were soldiers without field glasses, without maps, without photos. Today, we do not refer to field-glass soldiers, map-soldiers, and photo-soldiers. They are using the different means that modern science has given them.

As I understand it, the geologist wants to finish up with a geological map, and this map he will make in any possible way with any possible means. He is going into the field in a jeep if necessary, but he is going even if it means going on his feet. But he may fly over the area in an airplane looking down on the field, and if he happens to have a camera with him, he takes some pictures. If he has a good surveying camera, he will take a lot of pictures to be able to make a stereoscopic model out of them. But he is not another sort of geologist. This is confusing to me because in Denmark we do not have these problems. Denmark is very, very small. We have the country very well mapped, but we have rather a large island called Greenland, which is a paradise for the geologist. There is no vegetation and that helps a lot. There we have air photos, but we would never call our geologists "photogeologists." If they are to use the air photos, they use them for reconnaissance, and, of course, they use stereoscopes also. They would use, perhaps, a small instrument for plotting, but I would not call that being a photogrammetrist. If they are to make their observations into a finished geological map, they have to do that closely connected with

the Geodetic Institute. We are working hand in hand with the geologist so that they list their needs in a specific area, which we photograph and compile a map in cooperation with them.

As I understand it, most of the geologists who have been talking here have told us that they could go to a certain limit, and that it is too slow and expensive to use real photogrammetric methods of plotting their geologic maps. That is not true. It is only because at the moment, the geologist wants to get the results quickly and accordingly he doesn't have the same accuracy he expects to get from photogrammetric means. But no one ever thinks of training a geologist to be a photogrammetric worker and to use photogrammetric instruments on a par with specialists. The photogrammetric technician is a man who can handle his instrument and know what he is doing with it. It would be absolutely a waste of time and a waste of the geologist's knowledge to train him in this study. Therefore, I think that what the geologist will have to do is to be trained toward the use of air photos. This applies not only to the geologist but to all engineers. We have used maps for a long time; we also had to be trained to use maps; the geologist will have to be trained in using a stereoscope, perhaps a little in the airplane, to plot a little, and then to be taught to go no further. He will have to know all the errors he can make in using air photos. There is certainly a lot of work to be done. An air photo is just a little section of a map with certain errors. If you engage a geologist and he is able alone to do the whole reconnaissance work, and then turn over the work to the photogrammetric section of the Geological Survey; this, I think, will get the quickest and best results.

*Rhoades:* I gather your views are not too far from Dr. Read's. Any further discussion from the floor?

*G. C. Tewinkel,* Coast and Geodetic Survey: I want to echo a couple of other comments previously made. I am not a geologist, but it seems to me that if geologists have seen the Schneider stereoscope, or one like it, they would prefer to use it a great deal. Consequently, it might be a good idea for the geologists to consult some of the instrument manufacturers and tell them what they want in types of stereoscopes. Another item I couldn't help noticing, is the desire to have more accurate maps, and less and less complicated instruments. Those two things are quite opposite, and the achievement of one is almost an obstacle to the other. We must realize that there is a division there. If we want more accurate maps, we must have more complicated instruments to use with the photographs. Maybe that is another reason for making a division, or a break, in where the work of the geologist stops, and where the work of the photogrammetrist begins.

*Rhoades:* More and better maps with less effort seems like a very human desire. There is no harm in asking, is there? If I were an instrument maker, I, too, would be a little uncertain as to exactly what is required.

*Marshall Wright,* Department of Agriculture: It may be of interest to you that the Department has now photographed 4 million square miles. As the area of the United States is only about 3 million, the other million represents re-coverage. This work has been done at a total cost of 12 million dollars. Last year we awarded contracts for over 398,000 square miles. That is the biggest amount of photography we have ever done during one fiscal year; prior to the war along in '39 and '40, there was an impression, even among ourselves, that we were in big business; but actually we are doing more aerial photography now than we ever did before. Undoubtedly all of you use Department of Agriculture prints. They are always available to anyone who wants to secure them.

Professor Smith suggested a central laboratory for making the materials available readily; that is a very desirable objective. We would like to do it our-

selves; if you can get Congressional authority to incur the expense of building such a laboratory and hiring the people, you certainly will have our backing. In the Department of Agriculture a few years ago, we considered establishing in the Library of the Department such an index as Dr. Smith mentioned—an index of all the counties in the United States. The cost of buying the steel cases and procuring all the material and installing it, and hiring somebody to serve the public, would be a considerable amount. Of course, you can well say that this cost is incurred anyway, but it is a cost that is incurred incidentally to our work, whereas if it were a central establishment, personnel would have to be hired for that purpose.

I also wish to comment on infra-red photography. The Department has probably used more infra-red photography in the identification of timber types and tree species than any other Federal agency. Recently I was in Milwaukee, where they are now identifying over 15 species of trees alone by the use of infra-red photography. That doesn't mean that a man can pick up a photograph and identify the species without first, as you geologists do, knowing your subject. In other words, he has to take these pictures into the field and identify a certain tree; having seen what it looks like in the photograph, he can readily recognize it the next time.

Color photography is very desirable, but the cost is prohibitive, and after all, at present, all you get is a transparency. When color prints can be made that are equal to the transparency and at a nominal cost, I am sure we will all prefer them to the black and white.

I want to manifest a little concern in the smiles that arise whenever anybody mentions the geologist and his difficulties in interpreting photographs. We, in the Department, have used photographs for 12 years. Our soil scientists, foresters, grazing men, flood control men use them, and the old AAA, now called the PMA, uses them very extensively in all land use studies, etc. None of those agencies are expecting the soil scientist to be a photogrammetrist. He takes the photograph in the field and does whatever he has to do in interpreting soils, or timber, or whatnot; the photographs, as Mr. Blakey indicated this morning, are then turned over to the cartographic section where the photogrammetric engineers delineate upon maps, information portrayed on the photographs. While very desirable, and even necessary, for the geologist to be able to interpret these photographs, I can't see that his problem is so much greater than that of these other men.

I should like to mention that a few months ago I visited the Tennessee Valley Authority. It has \$185,000 to conduct a natural resource survey of the entire valley, comprising about 40,000 square miles. It has very accurate topographic maps, made by the most modern photogrammetric methods. The conference was called for the purpose of approaching the subject from an entirely new viewpoint, using the photographs, not for making maps, but for studying the natural resources of the valley. There are over 5,000 small saw mills in that valley and I couldn't attempt to estimate the number of board feet of lumber. Technicians from the various Federal agencies and from industry were invited to discuss this entire matter from the approach of aerial photography, aside from mapping, in studying the resources of the country. It was decided, after about three days' deliberation, that actually nobody knew anything about it, and that we might just as well start from scratch. They decided to take an area of about 50 square miles, which was representative of the entire valley, and fly it at various altitudes, using various focal length cameras, with various kinds of film from the panchromatics to the orthochromatics and using all the combinations of available filters; then, to take all of the pictures, study them, and see



which would give the best results. They are getting pictures with scales of from 1:10,000 to 1:25,000. A certain portion of the study is in the laboratory. They are bringing in limbs from the conifers and from the deciduous trees, and photographing them outdoors where they have natural light. These photos are taken at different hours of the day, using various combinations of film. Whatever error might be inherent in the work, caused by atmospheric conditions in a plane at 10,000 or 20,000 feet, will be eliminated. They can match those pictures against pictures taken under similar conditions from the air, and then possibly determine the effect of smoke and other atmospheric conditions. As a result of this study, I think they will come out with an answer which will be very helpful to all of us, and I hope that those pictures can be made available to the Society and to others.

*Rhoades:* Have you gentlemen on the panel any comments to make on the discussion from the floor?

*Read:* I should like to clarify one point on which I apparently have been misunderstood. I very definitely agree that it would be ideal if the photogrammetrist would plot our geologic data and make our bases. However, such an arrangement, up to now, has usually been impractical and has not worked. We have, therefore, been forced, very much against our better judgment, to go into the matter of preparing our own bases over a large area. I agree that it isn't ideal, but it is the best solution we have. This is not to be interpreted as a criticism of the photogrammetrist; it simply has worked out that way. The geologist in making the average geologic map has had to make his own base.

Another point on which I may have been misunderstood. I do not mean to imply, in connection with the statement about photogrammetric equipment, that it is designed especially for the special map maker. Also I do not mean to imply that it necessarily has to be particularly simple. I think that there are certain types of photogrammetric equipment that are practical for the special map maker; there are certain other types that are not. The problem of the special map maker, such as the geologist, is very frequently the problem of the small office and limited space. He has to concern himself with portable or semi-portable equipment and not equipment that you set on a sill of concrete and build a house around. We must be able to move ours. There is a special need for semi-portable equipment which can be torn out in at least a few days and moved elsewhere.

*Smith:* I should like to say first that I was very much interested in Mr. Wright's remarks about infra-red photography. It would be very useful to those of us who are experimenting, if an index map were put out showing those areas in which this infra-red photography is available. Then we would know whether in areas of geologic interest we could make comparisons in photography. I think his remarks also have illustrated one of the useful functions of a meeting like this for getting information into a common pool. Most of us had no inklings of the experimental photography in the Tennessee Valley; discussions like this which elicit that sort of information help us all to make progress more rapidly. I will be very interested in seeing those photos when they are available. I hope at some future meeting we can have a chance to look at them and appraise them.

In regard to the use of the term "photogeology," I think it is a term not to be taken as necessarily too rigid or for comparison with the other adjectives applied to geologists. We have in the field of geology many subdivisions. We have petrographers and paleontologists and others. However, we are geologists first. A petrographer is a geologist whose approach is through a petrographic microscope. A paleontologist is a geologist who is using the study of fossils as a geological tool. We also have such terms as armchair geologists, field geologists,

and horseback geologists, etc. So it helps to emphasize a particular method of approach if we use this term "photogeology" but not necessarily making it comparable in scope or meaning, to petrography. We always need shorthand expressions for conveying ideas, and I believe this term fills the bill.

I should like to say finally that I think our discussion has brought out two viewpoints in regard to photogeology. One might be termed the idealistic, the other the realistic. The ideal would be very nice if we had perfect base maps on which to map our geology, or if we had unlimited time to go into the field and explore every square foot of the ground surface. However, there are many large areas in this country and in Canada and other parts of the world where the mapping is such that it would take centuries for geologic maps to be made in that way. I should like to emphasize my idea that photogeology is one way of shortening the time in which we can obtain available geologic information in areas which are imperfectly mapped or otherwise unmapped.

In regard to field versus the photogeologic methods, I might say that the students in my classes using photos can find many errors in ground maps made by experienced geologists using the standard ground method without benefit of photos. There are many things you can see on photos that you cannot see on the ground in some areas. I think there is a danger of overgeneralizing that photogeology should do this, or should not do that, whereas in a specific area we can do this, and we cannot do that. In some areas, we can do a great deal more than in other areas; in some areas, we can do practically nothing, from photo-interpretation. So I believe that photogeology, if these limitations of area, funds, and time are considered, is going to prove to be one of the most useful methods in advancing geologic knowledge, both theoretical and applied.

*Rhoades:* Your moderator has assumed that in using the term "photogeologist," we weren't meaning to describe a new species of cat. We simply were taking a single word to designate the man who, in one way or another—that of Dr. Read or that of Mr. Brundall—is using photographs in his operations. Naturally, I think we would all agree that we don't wish to have a separate species set apart for the man who is skilled in the use of a particular tool, because, after all, he is studying general geology. He is simply using another mechanism because it has now become possible and expedient to do so. Nonetheless, I dare say it might be easy for the non-geologists to assume that we were giving birth to a new specialization in geological science; I don't believe that is the intent of the professional geologists who have spoken.

*Harry Osborne,* consulting geologist, Colorado Springs: I want to vigorously second what Professor Smith said. I would carry it a little further and say that the best photogeologists will be the best geologists, and, conversely, the best geologists will be the best photogeologists. I think there has been some confusion among some in attendance at this meeting, that there is some conflict between geologists, photogeologists, and photogrammetrists. The terms are not conflicting, nor are the sciences, but they should be complementary. In the matter of education, I would say that perhaps some additional attention should be given to descriptive geometry and physics. As to the light planes that Professor Smith mentioned, there again we get into photogeology and not photogrammetry. The use of light planes for photographic work in geologic reconnaissance has been sadly neglected because of the prevailing opinion that pictures should be taken from approximately 15,000 feet above the land surface. For reconnaissance photogeologic work, very beautiful 35 mm. colored pictures can be taken, and are being taken from light planes. The light plane has a number of advantages in that it can fly close to outcrops at low speeds, and a further great advantage that a skillful pilot can set a light plane down almost anywhere

without much danger to the occupants. He may wreck the plane but he will save the occupants. There is a great feeling of safety in the larger planes and rightly so for some reasons, but in rugged terrain, the light plane in the hands of a skillful operator can be a very safe means of conveyance.

*Wesley Hupp*, Geological Survey: I should like to have brought out, before this discussion is closed, just what the geologist requires of the topographer. There are apparently two schools of thought; one is that the old idea of topographic expression should be followed, and that land forms should be generalized to produce a nice appearance; the other school is that the geologist wants exact detail, regardless of appearance from a topographic standpoint. It may be that we should make two kinds of maps, a topographic map for other uses and a topographic map for specific geologic use.

*Wasem*: I should like to make a comment or two on that matter. If and when the mapping program that Bob Davis is undertaking at the Denver Federal Center is completed, our work in this area will be a good deal easier; in the first place, because of the elevation information that is available, and secondly, because of the accurate base maps that have been prepared. In response to the last question; in our work we would much prefer to have the exact delineation of the land forms, because they usually follow the outcrop pattern that you can see on the aerial photograph; consequently it would be much easier to determine and to estimate elevations for structural work, if those land forms are accurately delineated on the contour map rather than generalized. The more of those we can have, the happier we will be.

*O. S. Reading*, International Society for Photogrammetry and the U. S. Coast and Geodetic Survey: I have heard the word "practical" used several times during the two days' discussion, and I cannot let the impression that it made on me go by without a word or two about it. I understand that time is of the essence, and that very often you cannot wait for an accurate base map, but eventually you must have such a map if you want to develop your country properly. I think we should get a sense of timing. Although there may be atomic bombs, our country has to last a long time; the supremely practical thing to do is to get an accurate base map before we develop the country and make all these special surveys so that we won't be measuring the same ground more than once. I wouldn't for a moment diminish in any respect the importance of getting the information on time, but I suggest that, through photogrammetry, we have a means of getting it on time, if we can convince the fellow who has the purse strings that it is the supremely practical thing to do—namely to get your basic survey ahead of your needs.

*H. L. Cameron*, Nova Scotia Research Foundation: In keeping with the thought that information should be disseminated as widely as possible, there was one remark by Dr. Smith that really impressed me, and that is the availability of photographs. I believe that much wider use could be made of the photographs if anyone or everyone could get his hands on them when he wants them. I must say we are in a very happy state in Canada in regard to availability. We have a central agency in Ottawa called the National Air Photographic Library. It has on file at least two prints of every photograph ever taken in Canada. It has index maps showing the entire map area of the country, which can be consulted by anyone, either by letter or in person, and within two weeks you can get a set of prints of any part of the country which is not restricted in a military sense. I might say that there are very few areas which are restricted. We have on file some  $2\frac{1}{2}$  million prints, and we have mapped, in one way or another, and photographed some  $3\frac{1}{2}$  million square miles of country. However, because of the great population difference between Canada and the United

States, I don't think any one central agency could handle your problem; we have found that even for our 12 million, it is necessary to set up some provincial organization which will distribute photographs. It might be a good idea if the States were to take up the establishment of air photo libraries for their State areas. That might break the problem down to a size where it could be handled.

In the matter of experimentation, we have been conducting a few modest experiments with color filters. The main idea was to enable us to take certain features—the most important one, so far, has been under-water detail, especially plant material. We take photographs simultaneously, using two cameras mounted about a foot apart, or as close as we can get them, using a red filter in one and a green filter in the other; then if we leapfrog the prints, use a red left-hand print and a green right-hand print, we get a most amazing depiction of detail, both rock and weeds, under water. We tried the same thing on land areas and we find that if we use a pair of colored filters on our glasses, or in the stereo, when we look at these two different prints, we will get a garish color depiction of the ground. It is a mixture of two of the primary colors and the blue is left out. I pass this along for your information. Someone might be interested to hear a little more about it. I am certainly very happy to know that there is some experimentation along these lines going on in this country.

Going into the realm of things wished for, I might suggest that some experimentation might be carried out in regard to rock patterns, or the outcrop patterns of various kinds of rock. For example, we have found that granite can be differentiated from certain other igneous rocks by the fracture patterns. I wouldn't say it is 100 per cent accurate, but we have found a definite difference in pattern. A very worthy research project, I think, would be a study of all available photographs depicting igneous rock to see if there is any definite correlation between rock type and fracture pattern. The field of experimentation is wide open. The question, of course, always arises as to who is going to carry out the experiments. Shall the universities try it? Shall the government try it? Shall the American Society of Photogrammetry do something about it?

*Rhoades:* I should like to ask if our chairman has something to say on the matter before turning the meeting back to him.

*McCurdy:* I have two matters before you dissolve your panel. One is the Canadian method that Professor Cameron spoke about. I believe that 10 or 15 years ago our Society recognized the fact that we should have a central library of film and prints. We made, at that time, a study of the method used in Canada, and we came up with a specific recommendation for our own country; but unfortunately, nothing was done. Professor Smith asked about photoindexes. I, generally, am not too much interested in photography or maps of the continental limits of the United States. Usually, our work is outside those limits. I have a vague recollection, and maybe someone in the Interior Department can correct me if I am wrong, that the Geological Survey, following the last war, compiled, not exactly an index, but a portfolio of maps on which were shown the coverage throughout the entire United States and its possessions, giving the scale, altitude, and the people that own the film. I think that type of information would be helpful to you if you haven't already had access to it. It is not an index of the coverage; it merely shows the coverage and tells you where you can write to get the detailed information on the coverage.

*Rhoades:* Thank you, Mr. McCurdy. Before turning the meeting formally back to the chairman I wish to thank the panel members and to express my own gratification that, as a moderator, I didn't have to moderate.