terials determined then the photos are used to obtain the minute surface details, such as refinements in border, culture, etc. These are items which cannot be shown on most of the maps. Thus, the use of such maps is limited to general orientation—to providing a basic understanding of an area.

In a similar manner, topographic maps can be used to great advantage provided the photo user understands the limits controlling their use. A topographic map, which has been well made, is an expression of the landscape which reflects origin and erosional history, if interpreted properly. Only the best topographic maps, those having large enough scale with small contour interval, are of any real benefit in correlating minute details. At best, most topographic maps provide a clue to regional, and sometimes local physiography. The real advantage is that such maps provide knowledge of physiography of the area which can be a starting point for work with airphotos.

In areas where maps do not exist, the photo user must obtain all information from photos coupled with whatever bits of information he can obtain from other sources. The airphotos, in many instances, do provide a means for checking the maps, and it is up to the interpreter to know or to recognize such a condition and to be able to evaluate maps or literature for their reliability.

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Part of the material in this paper was assembled while the author was on a leave of absence from Purdue working at Army Map Service in connection with preparation of a field manual. The author wishes to thank the representatives of the Army Map Service for their views and their assistance, and for permission to use this material in this paper. He was unable to attend the Annual Meeting of the Society and wishes to express his thanks to Professor O. W. Mintzer, Case Institute of Technology, for reading a summary of the paper.

QUESTION AND ANSWER PERIOD

Mr. Lundahl

Attention will now be given to questions asked by members of the audience. The first questions will be answered by Dr. Macdonald. He will be followed by other participants in this Symposium.

Dr. Macdonald

A question asked by S. T. B. Losee of Abitibi Power and Paper Co. is "Should focal setting for minimum flare replace that for maximum resolution for photos on which accurate measurements are to be made?"

Consistent with the thoughts expressed in my paper, my answer is in the affirmative. If we are accurately to determine the position of an object which is to be imaged at a 1/10-mm. diameter on the film, our best possible setting will be that which gives us the most favorable energy distribution over that 1/10-mm. diameter image, so that it is most clearly and most sharply rendered. This rendition will enable most precise measurement.

Lieutenant Frank Chambers of N.P.I.C. has asked "How are contrast and resolution affected by color? Would you discuss how or whether interpretability is affected in aerial color photographs?"

Although the gray scale in color photography is less than that in black-and-white, it is still adequate to handle the brightness range encountered in the typical aerial scene. Color film adds the dimension of color contrast; this is of advantage to interpretability and this advantage does not rely on the correctness of the color rendition. More important, however, color film has no grain. Because of this grain effect, color film becomes a particularly good example of why a resolution number is particularly not good in measuring the interpretability of a picture. At 12 lines/mm. on color film, one can obtain more detailed information than from a cor-

responding 20-line/mm. picture on Super-XX.

A question by Lieutenant Neasham of N.P.I.C. is "If we could expect an average resolution of 25 lines/mm. on film, what variable magnification would be necessary to exploit this resolution?"

To see 25 lines/mm. (detail would be imaged at the order of 1/50-mm. diameter) requires about six-power magnification. As this is too high for viewing the coarser detail in the photograph, we should also require lower powers of magnification, down to unit or unaided vision. Dr. O'Brien at Georgetown even goes further; he minifies certain photographs to obtain optimum views of texture patterns. Ideally, a continuously variable magnification would optimize viewing conditions for any particular type of detail that might be under consideration. This can perhaps best be achieved through use of a projection system, where the observer, by approaching the projection screen or walking away from it, may continually vary the angular subtense of the object subject to study, and thus have under his control a continuously variable magnification system.

Harry W. Woo of N.P.I.C. asked whether identifying objects through high contrast means processing the film for high contrast?

That is not what I meant in my statement. There is a problem of latitude which dictates the limit to which gamma can be pushed. On the other hand, as we examine the contrast-reduction functions of typical lenses, we observe that, although the large detail is rendered with little or no contrast reduction, the fine detail in the photograph is subjected to considerable reduction in contrast by the system. Thus, the direction for future work in improving the interpretability of photographs is in improved contrast rendition of fine detail, improved microscopic contrast in the photograph. This means that we must strive to keep the contrast threshold low out to the fine detail and this is the region where we must work to improve the contrast characteristics of the system.

Mr. Keegan (by letter)

Dr. S. M. Robinson of the Dominion Forestry Branch of Ottawa has asked my answer to "How much variance is there between the reflectance spectra of young and old leaves compared to variance between species?"

In our spectrophotometric study of wheat, we were not looking for differences between young and old leaves, nor were we looking for differences between species of wheat. The important thing to us was that the spectral differences between rust free and infected wheat leaves were the same regardless of the age of the plants or of the species of plants. Our preliminary study was made on young laboratory grown plants that had been manually infected, and our concluding study was made on field grown plants that had been infected by nature. Thus experiments may be made on young leaves of one species and the results may be applied to mature plants of another species.

Mr. Tarkington

Mr. Amrom Katz, of the Photo Reconnaissance Laboratory states that "we don't want true color aerial photography, we want false color."

Depending on how the term is defined, I either agree or disagree with Mr. Katz. If "false" is meant in the sense that all greens appear red, and all reds look green, etc., I disagree, except under special conditions. If "false" is meant in the sense that from 30,000 feet we don't see much color on the ground at all, then I agree, and from this point of view we should have false color photography, i.e., colors should be more saturated on the film than they actually appear to the eye from the air.

Professor H. T. U. Smith

I am asked by R. J. Hackman of the U. S. Geological Survey what was my final explanation in my photo study of the scablands and "were they formed by normal processes or by catastrophe?"

Recent studies on the Channeled Scablands were carried on in collaboration with Prof. J. Harlen Bretz, and were based on the combined evidence of field studies and photo interpretation. It would be premature to announce final conclusions at this time, but it may be remarked that any attempt to explain the features shown on the slides, together with the other phenomena of the region, by so-called normal processes, encounters formidable difficulties.

Dr. Belcher

The question of Mr. Weiner of N.P.I.C. is "What advantage, if any, exists in using color photography in determining the type of soil in a given area?"

We ran color photographs of five different areas in the United States and compared them with black-and-white photographs of the same areas. We found that there was very little, if any, advantage in using color photography for determining the type of soil. This answer is specifically concerned with the use of color in determining soil types and emphatically *does not* exclude advantageous uses of color in mineral search, crop disease studies and other special applications.

Dr. O'Neill

Five questions have been given to me. The first question is by Dr. John Roscoe of the U.S.A.F. and reads "How was 2% contrast as limit of visibility determined?"

This subject has been discussed by W. E. K. Middleton in several able articles. One, called "Conspicuity," was published in *Illuminating Engineering*, I think about March 1952. Another paper, "Color of Distant Objects," by the same author, was published in the *Journal of the Optical Society of America*, Volume 40, Page 373, June 1950. See also: Visibility in Meteorology, Edition 2, by the same author, 1947, Chapter 3, Contrast and the Threshold Contrast, page 28 etc.

The second question is by R. G. Bowie of the Eastman Kodak Company who asks "In using filter techniques for increase in separation in viewing of color photographs, do you use a filter with a spectro photometric transmission matching the spectro photometric reflectance of the object or matching photograph? Wouldn't the results be better with the latter technique?"

You are quite right. A filter made to suit the object as it appears on a color transparency is often much more useful than one based on the spectrophotometric curve of the object itself. We have used both of these kinds of filters.

Mr. J. W. Gardner of N.P.I.C. asks the third question "In testing usefulness of vegetation keys on photo interpretation students (as at PIC) how rapidly do the students learn to successfully utilize the keys?"

There are so very many factors involved in answering this question that no satisfactory answer seems possible. The time available for practising with these keys during the curriculum is extremely short; the previous training of the students varies so greatly, e.g. a few may be foresters, some may have had training in architecture, others in geology, others in pedology, some in ecology, etc., etc. Even so, we have scored a number of tests given to ascertain how much can be expected from such keys. The results are encouraging but leave much to be desired. A new set of keys stressing the patterns of zones of vegetation recognizable on aerial photographs is to be tried in the near future. They were recently completed.

Question four by G. A. Hoffman of N.P.I.C. is "Could your inspection of color film with a filter to increase its color for better identification be of any use in underwater depth determination where the bottom is hardly discernible?"

In some cases where the water is reasonably clear and especially where there is growth of seaweeds. The depth to which light penetrates the water seems to be the principal limiting factor.

The last question is by James A. Kowalski of N.P.I.C. and he asks "Have the photo interpretation keys been planned using color photos as well as black-white?"

I have made keys using panchromatic photography alone, infra-red photography alone, color photography alone and finally keys using all three types of photography in one and the same key. Each type has its own special use.

Dr. Young

The question of Mr. Kowalski of N.P.I.C. is "Would not the use of oblique photography get under the interlocked crown cover?"

As I have no comparable data on oblique photography, I cannot answer the question. It would please me to have the type of study described in my paper expanded to include both vertical and oblique photography.

Dr. Garver

The question of S. M. Johnson of N.P.I.C. is "Do your fire fighters receive formal schooling or training in photo interpretation?"

Prior to the opening of the fire season,

much effort is made to train the fire fighters. This training includes instruction in photogrammetry and at least elementary use. In most fire fighting crews there are one or more men, who have been able to learn something about photogrammetry and the interpretation of aerial photographs. The number who have such knowledge should be greatly increased. Also many should have much more than an elementary knowledge.

Dr. Whitmore

Several questions have been given to me.

The first question is by Amrom Katz. If time permitted a full discussion, the result might be a Donnybrook. His slip reads "I say the concept and use of the photo-reader is the most pernicious, reactionary and subversive notion ever offered to the intelligent community. This should be discussed from the floor."

I agree with Mr. Katz as to the advisability of floor discussion. Also at times, but not always, I and others would agree with the "pernicious, reactionary and subversive." One gets very angry when a photo reading key is misused, resulting in incorrect interpretation and even endangering lives. We have such very strong pro- and anti-feelings because of not exerting sufficient control over the preparation of keys and how criticized before publication. One of the great weaknesses of our keys is the way a key is prepared and that it is published without opportunity for criticism by those of higher knowledge or experience.

I also believe we are going backwards in trying to develop photo interpretation. The greatest emphasis is now placed on the development of the simplified reading key. Then, subsidiary to that, we are trying to develop a sort of specialized personnel and more competent and subtle techniques. In an emergency we will have to read photos. For the entire photo interpretation job we have insufficient highly trained specialists. So our first and primary effort should be to develop the greatest possible potential of highly competent, well-trained photo interpreters.

(The reply to other questions asked Dr. Whitmore was received in a letter. The questions and answers are as follows—Ed.)

The question asked by S. M. Johnson of N.P.I.C. is "Should military interpretation be included in ROTC programs in Universities?? Has anything been done along this line or is it just in the thinking stage?"

As far as I know, military interpretation is not included in the regular ROTC program of any University. I expect that it is given more or less informally in some schools where interest in photo interpretation is strong in the regular faculty and is represented in the curriculum. I feel that including military photo interpretation in ROTC courses would be a major forward step.

The question asked by Robert W. Richman of N.P.I.C. is "You advise use of other data as well as photos. Which, in your opinion, is most productive, or potentially so: (1) 'Centralization', i.e. bringing other data and scientists and students to bear on photo interpretation and use. (2) 'Decentralized photo interpretation', i.e. bringing photos and photo interpretation into each of the applied areas, as geology, forestry, etc., and into their schools? This is most important to those planning the increased training and/or development of applied photo interpretation and photogrammetry."

I think that in training, particularly, your "decentralized photo interpretation" will be the most effective. I think that it is best to give the student his initial photo interpretation training in as close conjunction with his subject-matter training as possible. In preparing him specifically for military photo interpretation his centralized training should perhaps be followed by a decentralized training phase in which specialists in a number of subjects are all given the elements of strictly military photo interpretation. However, I believe that the basic subject-matter photo interpretation is the most valuable and the hardest to acquire.

Mr. J. A. Whittle of the Eastman Kodak Company asks "Are we not hampering our own defense training efforts by overclassifying military photo interpretation studies? Obviously any potential enemy can make the same studies—except possibly of some of our most advanced weapon installations."

I agree, and feel that the progress of military photo interpretation in this country would be greatly aided by declassification of most military photo interpretation training material.

The question of J. W. Gardner of

N.P.I.C. is "In light of work on keys, techniques, materiel, etc., how do you feel concerning the indiscriminate selection of military personnel for photo-interpretation training—what are your recommendations on screening of prospective trainees?"

I feel that the best method of screening prospective trainees for photo interpretation is on the basis of adequate training in a subject-matter specialty such as geology, soil science, forestry, botany, civil engineering, and similar subjects. Probably the candidate should also be given some sort of aptitude tests for photo interpretation or photo reading itself, but I feel that the subject-matter screening is by far the most important and should be leaned on very heavily.

The last question asked is by Lieutenant R. S. Neasham of N.P.I.C. "Cannot much of the photo-reading information actually be done by electronic separation and by use of many of the new methods such as magnetometry, spectrophotometry, etc.?"

I am afraid that I am not technically qualified to answer this question. It may be that such techniques will contribute to routine photo reading. It is my own opinion, however, that such techniques can do little in identification of landforms.

Mr. McNeil

This question is from Mr. F. N. Johnston, U. S. Corps of Engineers. "How can a photo requiring daylight and a photo of stars requiring darkness be taken at the same time?"

The terrestrial and star exposures are not taken at the same time. The procedure for day and night exposures are the same as that utilized in the past. The innovation is basically mechanical. Three instruments are integrated into one. Present-day usage would require a zenith camera for position, a photo transit for secondary control, and possibly a theodolite for azimuth. The MM-101 Camera (Merritt Metrical 101mm. focal length camera) is designed to establish position, secondary control and azimuth in one small package for exploratory and reconnaissance purposes.

Dr. Minzer

Mr. I. W. Brown of the Mississippi Highway Department has asked "You state that large area coverage is necessary in soil interpretation. What do you consider large area coverage—50 square miles, 500 or 5,000?"

The question is very interesting. I cannot give a specific area for all cases. The area depends entirely upon the terrain to be surveyed and the coverage required by the using agency. I will add that in a 9 inch print, 9 inches wide across the plot line, coverage with a scale of 3 inches to a mile is quite sufficient for soil survey.