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PRESENT STATUS OF PHOTO INTERPRETATION IN EARTH SCIENCE*

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ABSTRACT

Photo interpretation now has the status of an essential method of investigation in both basic and applied earth science, and ranks in importance along with the use of standard surveying techniques, the petrographic microscope, and the various geophysical methods. Its primary function is to obtain geologic, topographic, and pedologic information with greater economy, speed, and accuracy than is possible from ground methods alone. This generally can be done with comparatively simple stereoscopic and stereometric equipment, and does not require the elaborate and expensive instrumentation employed in precision cartography. The personal training, experience, and skill of the interpreter are the important factors in obtaining the desired information from photos.

* International Photogrammetry Congress, Commission VII, Phase 2.

The criteria and procedures used in photo interpretation are essentially similar to those long used by the field scientist, but are applied from a different vantage point, with a vertical rather than horizontal perspective. Features shown on the photos are studied with the aid of all available previous information about the area examined, and the interpreter works from the more familiar to the less familiar, as far as possible. In nearly all cases, it is necessary that photo interpretation be supplemented by ground checking to obtain results of maximum reliability. After a long period of experimentation, procedures are now more or less standardized, and photo interpretation now plays a regular part in virtually all geologic and soil mapping projects where photos are available, and is one of the important tools used in exploring for petroleum and mineral deposits. Its future effectiveness can be still further increased by expansion of training facilities, better dissemination of information relating to its procedures and results, provision of more adequate reference material, and continued research on methods and applications.

THIS paper supplements the report entitled, "Photo-interpretation in Applied Earth Science," which was printed in PHOTOGRAMMETRIC ENGINEERING for June, 1952, and distributed at the meeting of the International Society of Photogrammetry in September, 1952. The latter was based primarily on published information, and approached the subject from the historical standpoint. The present paper is concerned mainly with current activities, procedures, and objectives, and is based largely on the replies to questionnaires sent out to numerous geologists and engineers. A list of persons from whom replies were received is included at the end of this paper, together with additional references supplementing the bibliography which accompanied the earlier report.

The present status of photo interpretation in earth science may be summarized as that of an essential and indispensable tool, ranking with the use of the planetable, the microscope, and the various geophysical techniques. Its benefits have been realized in both basic and applied science, providing the impetus for accelerated progress in many fields of scholarly study and of practical application.

The specific objectives of photo interpretation range widely in detail, but generally have as their common denominator the making of some type of geologic map, and the preparation of this map in minimum time, at minimum expense, with a minimum of field work. Maximum accuracy and completeness may be additional objectives. The map may be reconnaissance or detailed, partial or complete, preliminary or final, according to circumstances. It may be intended primarily to show regional stratigraphy and structure, or soil distribution, in a systematic way. Or, in petroleum geology, it may be intended only to delimit localities for further ground study, for geophysical testing, or for drilling. In mining geology, it may be restricted to features or localities with which mineralization is believed to be associated. In engineering geology, it may be concerned with data on construction materials, foundation conditions, drainage, classification of materials for excavation, location of such features as landslides which present engineering difficulties, and erosional and depositional phenomena of streams and shores as related to engineering operations. In brief, the distribution and disposition of rock and surficial deposits are delineated with reference to particular purposes.

The materials, equipment, and procedures used by the photo interpreter in working toward the above objectives may be considered next. The photos most commonly used are contact prints of single-lens, black and-white verticals made with cameras having focal lengths of from 6 to 12 inches, and using panchromatic film. Enlargements are sometimes used for detailed work, and mosaics are frequently employed to supplement the individual prints. Tricamera photos are sometimes used for reconnaissance. Oblique photos of selected localities are considered valuable by some workers as an auxiliary to the standard verticals. Sharpness of detail together with a proper degree of contrast are essential specifications of the photos, and the time and season of photography are best adapted to insure these characteristics under the existing conditions of vegetation, drainage, and relief.

Continuous strip photography seems to have found little use outside of military operations, having been tried only to a limited extent in such work as highway engineering.

Some interest has been expressed in the use of infra-red photography on an experimental basis, but little seems to have been done in this field except by foresters. Much greater interest has been shown in the possibilities of using color photography, but systematic utilization has been hindered by comparatively high costs, the need for special equipment in handling transparencies, and lack of standardization in the photographic product. One worker (Laylander, 1952), however, has been conducting intensive experiments with color film in connection with mining geology, and considers the results very promising.

Scale of the photos used ranges from 1:10,000 or larger to 1:40,000 or smaller. A scale of approximately 1:20,000 is perhaps most widely used in America for general purposes, owing partly to its availability. The use of larger scales is generally limited to detailed study of restricted areas, for engineering or mining operations. The smaller scales are used mainly in reconnaissance work. In general, the smallest scale suited to a particular project affords maximum economy of effort.

The equipment most commonly used in photo interpretation is comparatively simple. Most important is some type of stereoscope. Both reflecting and refracting types are widely used, the latter seemingly being preferred by a small majority. Some type of stereometer, such as the parallax bar, height finder, or stereocomparagraph, is widely used also. Other equipment used by some interpreters, mainly for transferring the results of interpretation to base maps, include the Sketchmaster, Kail radial-line plotter, K. E. K. plotter, Multiscope, and Kelsh plotter. Other equipment occasionally used comprises a light airplane and hand camera for supplementary photography. A need has been expressed for the following additional equipment not currently available: (1) a device for rapid and accurate dip determination on strata; (2) some reliable means for eliminating or for automatically recording the tilt of the photo; and (3) a direct method for drawing topographic profiles.

In photo interpretation, instrumental equipment is subordinate in importance to the operator's mental equipment. In many types of interpretation, the quantitative aspects are overshadowed by the qualitative, and for the latter the primary requisites are sound professional training and experience, coupled with keen powers of observation and rigorous faculties of analysis and synthesis. No amount of instrumentation can take the place of human eyes and brains.

The procedures in photo interpretation are comparatively simple in principle, but frequently are of infinite complexity in practice. In many situations, interpretation is as much of an art as a science, drawing upon a broad background of knowledge and experience, and requiring a fine cultivation of the powers of judgment.

From the mechanical standpoint, interpretation consists basically of identifying rocks, surficial deposits, and soils, tracing outcrops, measuring dips, and endeavoring to synthesize the whole geologic picture from its more or less separate components. Generally the results of observation and inference are recorded by annotation of the photos in color, and this is followed later by transfer of the essential data from the photos to a base map.

The criteria used for identifying the desired geologic features are many and varied. In general, they are the ones long familiar to the field geologist, although applied from a different perspective. The shape, size, distribution, and orientation of individual landscape elements, both major and minor, are naturally important. In many places, vegetation is indicative of soil and subsurface drainage conditions, and the distribution of vegetation provides a clue to the occurrence of hidden geologic features. The over-all pattern of landforms, drainage features, and vegetative zones reflect broad geologic trends, and critical analysis of local details, particularly where these seem anomalous or discordant with the broader pattern, frequently gives a clue to important geologic features, such as structural traps for oil. All of these criteria are familiar to the well-trained scientist, but can be used far more effectively and rapidly on photos than on the ground or on maps. Perhaps the only types of criteria which are peculiar to photos are such things as color tones and textures, which symbolize various phenomena not directly discernible on the scale of the photo, and with the monochromatic limitations of the photo.

In carrying out the interpretation procedure, the interpreter works from the better known to the less known or unknown, in so far as possible. He first endeavors to correlate photographic detail with all available data on the surface geology of the area studied, or of the nearest comparable area. He consults topographic maps, geologic maps and reports, soil maps, drilling records, ground photos (both black-and-white and in color), geophysical traverses, and any other types of information to which he has access. This stage of the work aids in establishing criteria for subsequent study.

In undeveloped or unexplored territory, the above aids may be lacking, and the interpreter must rely wholly on his basic knowledge of his subject, supplemented by such generalized books, manuals, or interpretative "keys" as may be available. Realization of a need for the latter has been growing, and some progress has been made, but much remains to be done to set up adequate standards of comparison for geologic features in different geographic environments. What is needed is an atlas of typical landforms and geologic features in all parts of the world.

It is generally agreed that some degree of ground checking is essential to secure maximum results from photo interpretation. Many interpreters prefer to do the field work after office interpretation, and follow this with such restudy of the photos as may be needed. Others feel that preliminary field reconnaissance, with photos in hand, is a desirable prerequisite for office study, even when the latter is to be followed by more rigorous field checking. Still others prefer to carry on interpretation and field study more or less concurrently. The conditions under which the interpreter works, particularly the accessibility of the area studied, commonly are deciding factors in determining the relative roles of field and office study. In some instances, circumstances may even require that field checking be entirely dispensed with, and the interpreter's best judgment (or guess) be the sole guide in planning mineral exploration, land acquisition, or other operations. The type of ground checking varies with circumstances. In many cases, routine geologic examination may be sufficient. In other cases, the inadequacy of surface exposures may require that trenching, drilling, or geophysical testing be carried out.

Another type of checking is by direct observation from the air, preferably with a light, low-speed plane flying at low altitudes. In this way much significant detail that is lost on photos of small or intermediate scale is readily observed, and may be recorded, if necessary, with a small hand camera. For this type of observation, the helicopter would be ideal, but has not yet come into general use.

The advantages arising from photo interpretation all lie in the direction of increased efficiency. The degree of increase varies widely with the type of terrain investigated. Where surface expression of geologic features is poor, owing to various types of surface cover, the main advantage may be in providing for more effective planning of field work. Localities favorable for ground study may be ascertained in advance, and routes selected, so as to avoid the lost time occasioned by blind traversing. Interpolation between localities studied on the ground, furthermore, may be facilitated. Where the terrain is more favorable, as in many arid regions, it frequently is possible to go much further, and outline all or nearly all of the essential geologic features directly from photos. The time required for mapping is accordingly reduced, and costs are lowered, sometimes to a small fraction of that required for the conventional methods of former years. Still another advantage is the increased accuracy and completeness of mapping made possible where surface expression of geologic features is favorable. Features obscure or invisible on the ground may be clearly revealed on photos, with the result that important structures or other phenomena unnoticed in ordinary field mapping are found, and problems encountered in field mapping are solved. It has even been commented by Raasveldt that no geologic study of an area can be truly complete and thorough unless air photos are used. Certainly when office interpretation is combined with adequate field checking, the best possible geologic map is obtained with maximum economy.

As a result of the advantages noted above, virtually all geologic mapping in North America now utilizes photo interpretation to a greater or lesser extent, if carried on in areas for which suitable photos are available. This applies alike to mapping carried on under governmental, academic, and commercial auspices. In the petroleum industry, photogeologic interpretation has been found particularly valuable, and, although specific data have not been released, it is probable that this method has been at least partly responsible for the discovery of many new oil fields. In the mining industry, the use of air photos is perhaps less extensive, but experimentation is in progress, and one major new discovery of iron ore, Cerro Bolivar in Venezuela, was made directly on the basis of photo interpretation (Lake, 1950). In highway engineering, photo interpretation has been found to make for increased economy and efficiency of operation in many ways. In other fields of engineering, less specific information is available, but it can be said that photo interpretation is assuming a role of increasing importance. This is particularly true of arctic regions, where the peculiar problems imposed by the occurrence of "permafrost," or perennially frozen ground, require very specialized methods of procedure, and very careful selection of sites for engineering operations.

Another benefit which arises from photo interpretation, aside from expediting routine mapping and various practical applications, is the discovery of research problems. Unusual or anomalous features found on photos sometimes raise questions which cannot be answered from current knowledge, and thus lead to investigations which enlarge our understanding of earth phenomena.

In view of the importance of photo interpretation, it is pertinent to consider briefly the existing training facilities in this field. At the present time, these facilities are by no means adequate. Elementary courses in the use of photos are given in some of the more progressive colleges and universities, but it is probable that only a minority of the geologists and engineers now graduating receive such training. Many oil companies and other organizations find it necessary to provide their own training for new employees. A viewpoint frequently expressed is that well-rounded training in the fundamentals of a professional field is more important than specialized training in photo interpretation proper, and it probably is true that the best field geologist or engineer will make the best photo interpreter. As in many other fields, experience is, within certain limitations, the best teacher, and the more advanced phases of photo interpretation are best learned by practice, with opportunity to check results. A proper formal introduction to elementary photogrammetry and to interpretation, however, does make it possible to profit more rapidly and more fully from experience, and to be alert to opportunities for acquiring beneficial types of experience. Expansion in training facilities is overdue.

From the over-all viewpoint, present trends are toward more extensive and intensive application of photo interpretation in the various fields of earth science, toward better evaluation of its capabilities and limitations, and toward results of greater reliability. In certain quarters, there is perhaps a tendency to expect too much from photo interpretation, to regard it as a panacea for all manner of problems. Although this can be expected to lead only to disappointments and temporary setbacks, fortunately it is not a widespread attitude, and it may, indeed, be regarded as a part of the usual growth cycle of a new field, leading ultimately to a better appraisal of its proper functions.

In order to utilize photo interpretation with maximum effectiveness, and provide an adequate foundation for it, much remains to be done. Further research and experimentation is greatly needed in many phases of the subject. The compilation of reference works or manuals showing the typical surface expression on photos of a wide range of natural phenomena, well known from the ground view, would be most helpful. And there is a pressing need for more and better dissemination of information on photo interpretation at all levels. Potential users need to learn of the advantages which it offers, and interpreters have much to learn by pooling their experiences and studying one another's accomplishments and errors. The publication of case histories of individual interpretation projects, in which predictions made from photos have been thoroughly tested on the ground, is urgently needed. The inclusion of carefully annotated air photos, showing typical expression of rock formations and soil types, in every published report by geological surveys and soil surveys would render a noteworthy service. The more knowledge the interpreter brings to his photos, the more information he can extract from them, the more definitive and trustworthy his interpretation.

In conclusion, photo interpretation has proved its worth, and has gained for itself a secure place among the basic techniques of the earth sciences. It is not a science in itself, but has become an invaluable adjunct to the sciences in which it has its roots. It is a dynamic, continuously evolving field. Significant advances in human knowledge already have been made possible by photo interpretation, and the practical work of the world has been substantially expedited. The future holds promise of still greater progress.

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