the elevation control work. A third method is to obtain the elevation control by a combination of plane table and altimeter traverses in the field. In any event, the total cost in preparation of structural contour maps in low-dip areas, such as illustrated in Figure 7, is much less than by conventional surface mapping.

As mentioned above, necessary revisions and corrections are made subsequent to the field check or vertical control work, after which the final map is prepared and the report written. The final map and report are subject to a careful scrutiny in a seminar type discussion during which the photogeologist is called upon to demonstrate the basis for his interpretations, and to justify his final conclusions with respect to the structural possibilities of the area under consideration. This review is considered the final step in the photogeologic evaluation of any area.

In conclusion, it should be emphasized that photogeology today has gained an acceptance throughout the petroleum industry unequaled in its past history. Certainly the time and money saved in using photogeology as a rapid first-phase reconnaissance technique, or as a solution to many and varied special problems in surface mapping, have already more than justified its acceptance as a standard exploration practice.

AIRPHOTO INTERPRETATION OF ENGINEERING SITES AND MATERIALS*

Jean E. Hittle, Materials Engineer, Bureau of Reclamation, Denver, Colorado

INTRODUCTION

A REVIEW of the technical literature reveals that the practical applications of aerial photography in this country started during the first World War. During the 20-year period that followed, extensive photo coverage was obtained; great strides were made in the field of photogrammetry and thus permitted the production of precise maps from aerial photographs. The engineering demands for accurate maps cause this work to proceed on an enlarged scale. During and following World War II, additional emphasis was placed on the use of aerial photographs, not only as an approach to military intelligence, but as a facility for interpreting terrain conditions as they influence the design, construction, and subsequent performance of engineering projects. The technique of airphoto interpretation for engineering purposes has progressed to the stage where it is an important tool in all phases of engineering construction dealing with soil and rock as surface materials. The actual objectives to be obtained by the use of airphoto interpretation will depend upon the project in question. As a general statement, however, it may be said that airphotos can be used to identify soil and rock textures, to outline soil and rock areas having similar characteristics, to evaluate drainage conditions, and to identify geologic features that exhibit surface expressions. The application of these achievements to specific project developments makes it possible to appraise the suitability of site locations for dams, canals, highways, airports, and railroads; to conduct construction materials surveys; to develop sampling programs for detailed investigation of soil and rock materials; and to prepare land-use, drainage, and engineering-soil

* Presented at the Regional Meeting, American Society of Photogrammetry, Denver, Colorado, October 3–4, 1949.

maps. Admittedly, this same work can be accomplished by conventional field methods; however, the ease with which detailed information can be obtained from airphotos permits engineering planning to proceed with an enlarged perspective, and thus coordinates work that may otherwise consist of a series of random field investigations.

AIRPHOTO INTERPRETATION

Airphoto interpretation of engineering sites and materials is relatively simple and straightforward; basically, it is a progressive translation. The diagnostic features include: terrain position topography, drainage and erosion features, color tones, and vegetation-climatic effects. All of these items can be readily identified and studied from airphotos, and they all have significance when translated in terms of *land forms* and *pedologic concepts*. The relation of soil and rock materials to land forms and pedology permits the translation to be completed in terms of anticipated engineering problems.

LAND FORMS

The significance of land forms to the photo interpretation is easily understood when one considers that the surface features recorded on airphotos are

TABLE 1.—Some land form-materials relationships

Class	Soil or rock material	Land forms	Topography	Remarks
Glacial deposits	Sand, silt, and clay mixtures	Till plains	Flat to undulating	Grading variable
	Sand and gravel	Terraces	Benches between flood plain and upland	Usually well graded
		Outwash plains	Flat to undulating	Grading variable
Wind deposited	Sands	Dunes and ridges	Dunes and ridges	Uniform sizes
	Silts (loess)	Ridges	Ridges—usually parallel	Uniform sizes
Sedimentary rocks	Shales and clays	H—Lowlands	Rolling to undulating	Deep plastic soils
		A—Badlands	Highly dissected	Little or no soil mantle
	Limestones	H—Sinkhole plains	Rolling	Deep plastic soils
		A—High plateaus and escarpments	Variable, depending on attitude of strata	Thin soil mantle
	Sandstone	Hogbacks, mesas, bluffs, and escarpments	Variable, depending on attitude of strata—Strong relief in any case	Thin soil mantle

H—Humid climates.
A—Arid climates.

the result of natural processes acting on the earth's surface, thereby producing bare rock surfaces, residual materials, sedimentary, or transported materials, which are cut by streams and erosion features. Definite land forms are thus produced in which the regional topography and groundwater conditions are related to the characteristics of the soil and rock materials. Thus, the translation of surface features, recorded on airphotos, to the soil and rock materials represented, is facilitated by first establishing the land forms involved.

A stereoscopic photo inspection of the area in question, taking particular note of the regional topography and drainage conditions, will usually suffice to

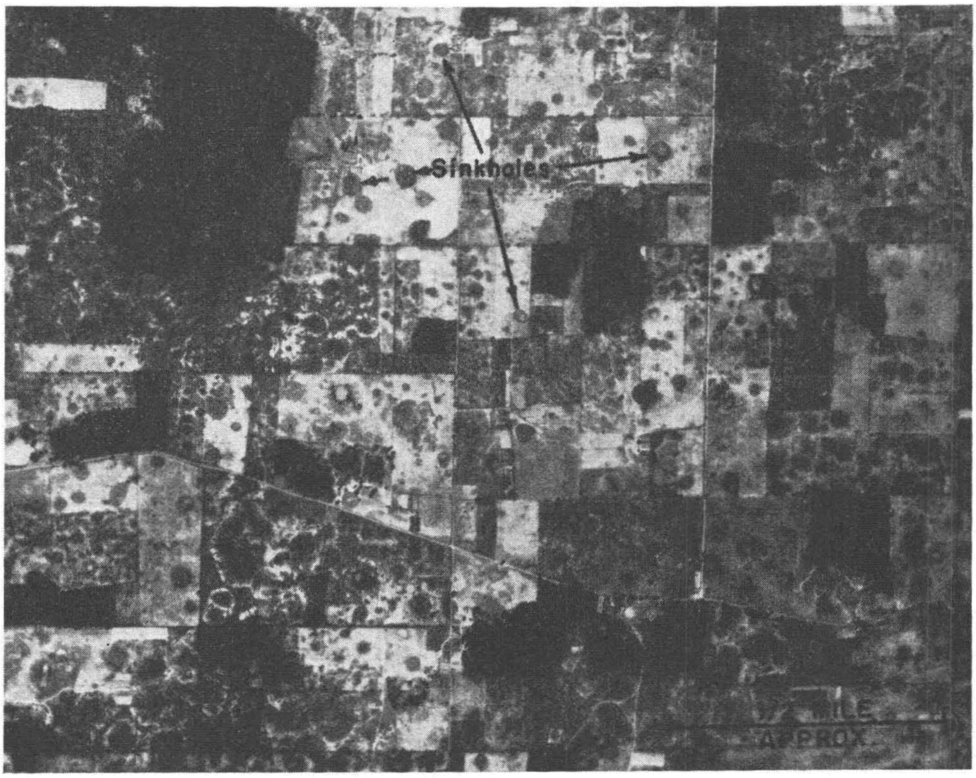

FIG. 1. The land form shown in this vertical airphoto is that of a "sinkhole plain" indicating deep plastic soils over cavernous limestone. The sinkhole development is characteristic of limestone in a humid climate. Compare with Figure 2.

identify the conventional land form divisions. This permits the possible range in soil and rock materials to be anticipated, and their characteristics to be defined within broad limits. An exhaustive treatment of the numerous correlations between land forms and surface materials is beyond the scope of this paper; however, the relations shown in Table 1 demonstrate how certain types of soil and rock material are indicated by specific land forms and topography under different climatic conditions. Figures 1 to 10 demonstrate a few of the land forms that have significance to engineering planning.

The study of land forms from airphotos also permits a wide variety of geologic features that are highly significant to the performance of engineering structures to be identified. In many instances, these geologic features can be more readily identified on the airphotos than on the ground. It must be recognized, however, that photo interpretation is only applicable to those features which develop surface expressions such as topography, drainage patterns, erosion patterns, etc. Such items as landslides, fault zones, folds, and other structural features can be readily identified; each of these items can be an extremely important consideration in the site location of dam, tunnel, or high-

FIG. 2. Local lowlands of shale and uplands of limestone with a thin covering of loess are shown in this vertical photo. An approximate section has been indicated. The gentle slopes identify the shale characteristics, while the plan and pattern of the erosion gullies is characteristic of limestone. The semi-arid climate of this region explains the absence of sinkholes in the limestone.

way structures. The general attitude, bedding, and jointing of exposed rock strata, as well as the presence of dikes and intrusions, can often be interpreted from airphotos. Such information is valuable in appraising the possibilities of landslides in open cuts, of seepage losses in reservoirs and unlined canals, and of grading problems during construction.

PEDOLOGIC CONCEPTS

Pedology (soil science) relates the formation of the weathered soil profile to the parent soil and rock materials, to local topography, and to the influence of vegetation and climate. Even though pedologic information, as such, does not have direct application to engineering soil analysis, the concepts and principles involved facilitate the interpretation of surface and near-surface soil materials encountered in engineering construction, thus permitting the translation of airphoto features to soil materials to be refined.

The significance of pedologic concepts and principles to the photo interpretation of soil materials is found in the relation of the soil profile to the local topography. This relation states that: For a specific parent material area and a given climate, similar soil profiles are developed on similar topographic positions and ground slopes. As a general statement, this means, therefore, that topographic position and ground slope can be used to give soil profiles a geographical expression. In terms of photo interpretation, this means that by a simple three-

FIG. 3. A glacial till plain. Flat to undulating topography and a lacework of contrasting light and dark tones on the airphoto is characteristic of this land form. An over-all silty clay soil texture prevails; however, the differences in color tone indicate differences in soil moisture, organic content, depth of profile development, and depth to groundwater.

dimensional study of airphotos, correlations of engineering soil properties to soil profile characteristics can be extended to other areas where similar topographic positions and ground slopes prevail. It further means—and this is important—that an airphoto study of a specific area, supplemented by a few "well-placed" test holes, will permit extensive areas to be evaluated in terms of engineering soil profile characteristics. This approach to engineering soil problems will substantially reduce the number of samples required for laboratory testing and at the same time extend the use of the soil profile information.

AIRPHOTO-MATERIALS INDICATORS

In addition to the use of land forms and topographic position to facilitate the airphoto translation, the drainage patterns, erosion features, color tones, and vegetation-soil-climate associations, interpreted in the light of pedologic concepts, can often be used as indicators of the textures and properties of the soil and rock materials. Collectively, these items can be used to confirm the soil or rock textures represented by the land forms in questions, and to further refine the translation of airphoto features; each individual item, however, may not offer conclusive evidence by itself—hence, the term "indicator."

FIG. 4. The land form developed by loess (wind-deposited silt) is remarkably consistent. Smooth silt ridges that are usually parallel and form a rolling topography, right-angle drainage patterns, and steep-sided, flat-bottomed gullies and streams are identifying features. Being a wind-deposited material, the soil texture is usually uniform. Loess has a characteristic porous structure and is therefore well drained.

Drainage patterns—particularly the type and density, provide an indication of the relative permeability of the soil materials. A dense, finely divided drainage pattern indicates an impervious soil area with high runoff and low infiltration. In contrast, the absence of a surface drainage pattern indicates a well-drained soil area with low runoff and high infiltration. The drainage pattern in high watertable areas has but limited significance. Definite alinements in the pattern usually indicate control by the local geologic structure.

Erosion-features—have significance in that they often reflect the textural characteristics of the exposed materials. Short, steep, V-shaped erosion gullies with uniform gradients are associated with granular and slightly plastic, glacial drift materials; however, long, flat gullies with uniform gradients and rounded cross-sectional slopes are associated with fine-grained plastic soils. Silts and sand-clay materials usually exhibit erosion gullies having U-shaped cross sections and compound gradients. The significance of erosion gullies as an indicator of soil texture is modified by extreme climatic influences, such as in arid regions where "box" gullies seem to prevail irrespective of soil texture. Regardless of the climatic influence, however, changes in the gradient or cross section of erosion gullies, or changes in the surface slope of eroded surfaces indicate a change in the exposed soil or rock texture.

Color—tones (relative photographic gray values) have a general significance in that they reflect the soil-moisture conditions, and often reveal the relative

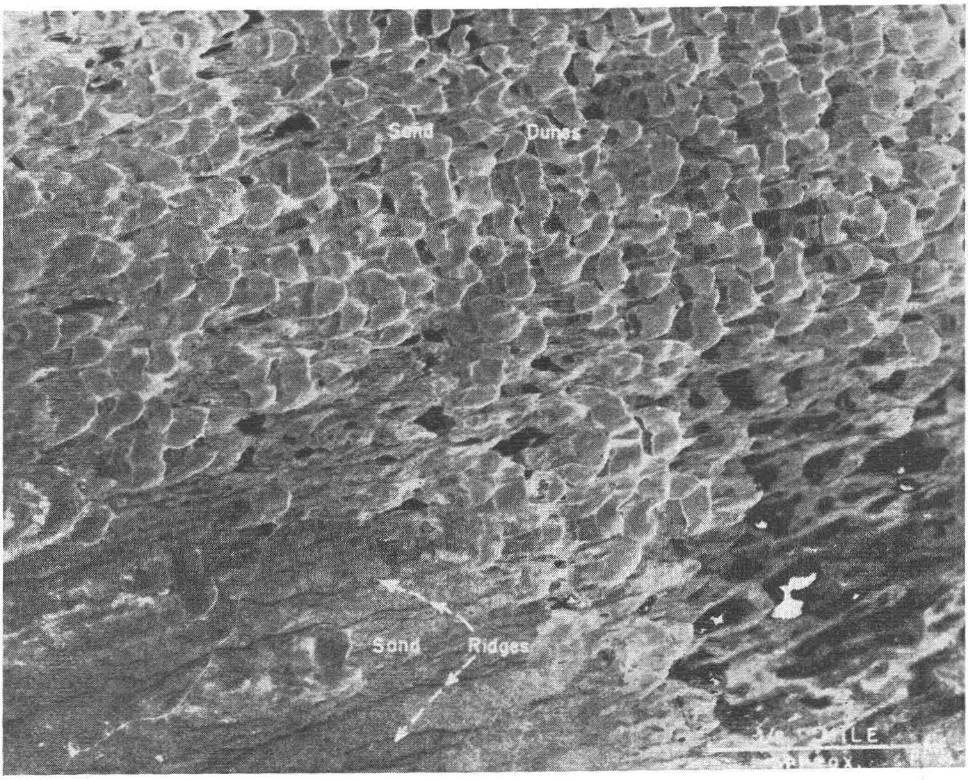

FIG. 5. The characteristic shapes and light color tones of wind-blown sand make the land form identification extremely simple. In this photo, both dunes and ridges are shown. The dark areas indicate that the groundwater level is near the surface.

position of the groundwater table. Light color tones are usually associated with well-drained soils, such as gravels, sands, and silts with groundwater levels well below the ground surface. Dark color tones usually indicate poorly drained organic clays and silty clays with a groundwater level near the ground surface. Intermediate gray values are usually associated with inorganic clays and silty clays. The significance of soil color in airphotos must be appraised from the over-all color pattern, since some variation may be expected in the photographic tone quality of individual airphotos; it is also necessary to visually "screen out" the color tones produced by vegetative cover.

Vegetation-soil-climate associations—are significant in that the vegetation patterns produced in the airphoto often reflect the nature of soil and moisture conditions. The use of vegetation patterns as an indicator of soil conditions has thus far proven most successful in extreme climates, such as in arctic, tropical, and arid regions, where the combination of soil and climate becomes "selective" of the prevailing vegetative growth. In forested, arctic regions, for instance, the predominance of deciduous trees can be used to distinguish between unfrozen soil areas and permanently frozen soil areas containing ice formations. Tropical rain forests, although completely obscuring the ground surface, have vegetation patterns that reflect differences in soil textures and local drainage conditions. In arid desert regions, the pattern of vegetation can be used to distinguish be-

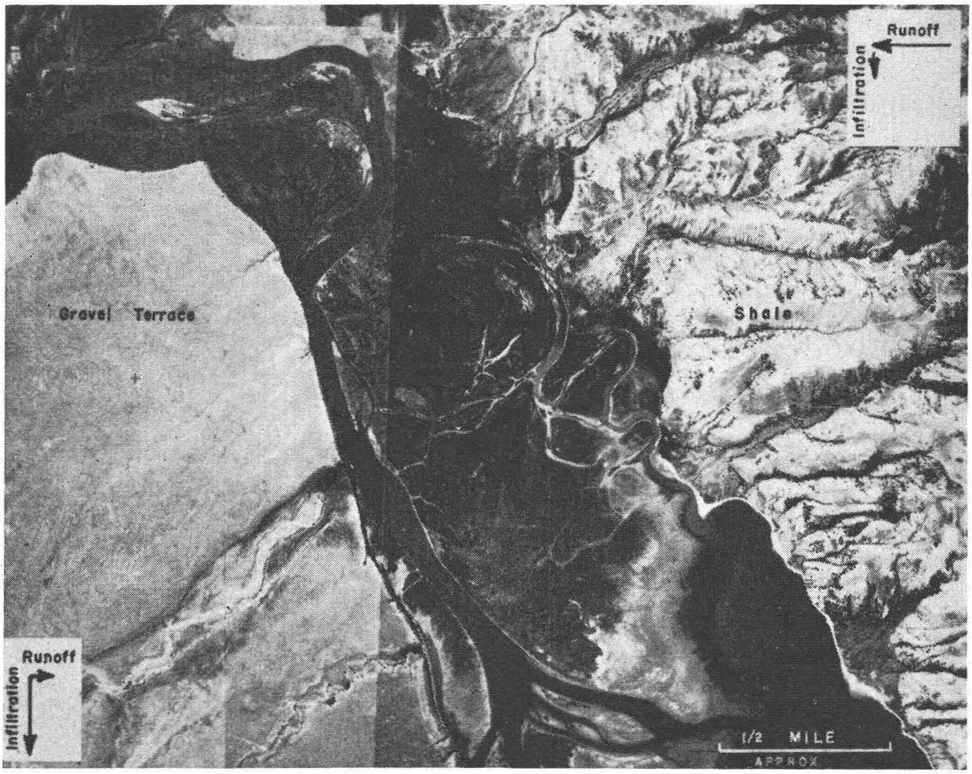

FIG. 6. A gravel terrace, an alluvial flood plain, and a "badland" shale formation is shown in this airphoto. The relative ratio of runoff to infiltration (as indicated), plus an arid climate, explains in part the strong contrast in the land forms produced. The relative merits as engineering site locations are obvious.

tween high- and low-alkali soils, and between high and low groundwater levels. Since all of these situations apply to either dense or sparse vegetative cover, the effective use of vegetation as an airphoto-materials indicator requires a limited amount of field correlation to obviate local biotic variations.

ENGINEERING SITE SELECTION

Once the soil and rock materials, groundwater conditions, and geologic features have been identified on the airphoto, it only remains to complete the airphoto translation in terms of engineering problems. While photo interpretation is applicable to some degree in practically all phases of engineering planning, the greatest benefits can be realized if photo interpretation is employed at the outset when the site for the project is being selected. The bearing of the site location to the ultimate success of the project, plus the ease with which favorable site locations can be distinguished from the less desirable locations on airphotos, permits this approach to site location to fulfill the requirements of modern engineering planning at a lower cost.

Experience has shown in many instances the original site selection to be a deciding factor in the ultimate success of the project development. Site locations having favorable foundation conditions and a natural supply of suitable construction materials lead to economical designs, lowered construction costs, and

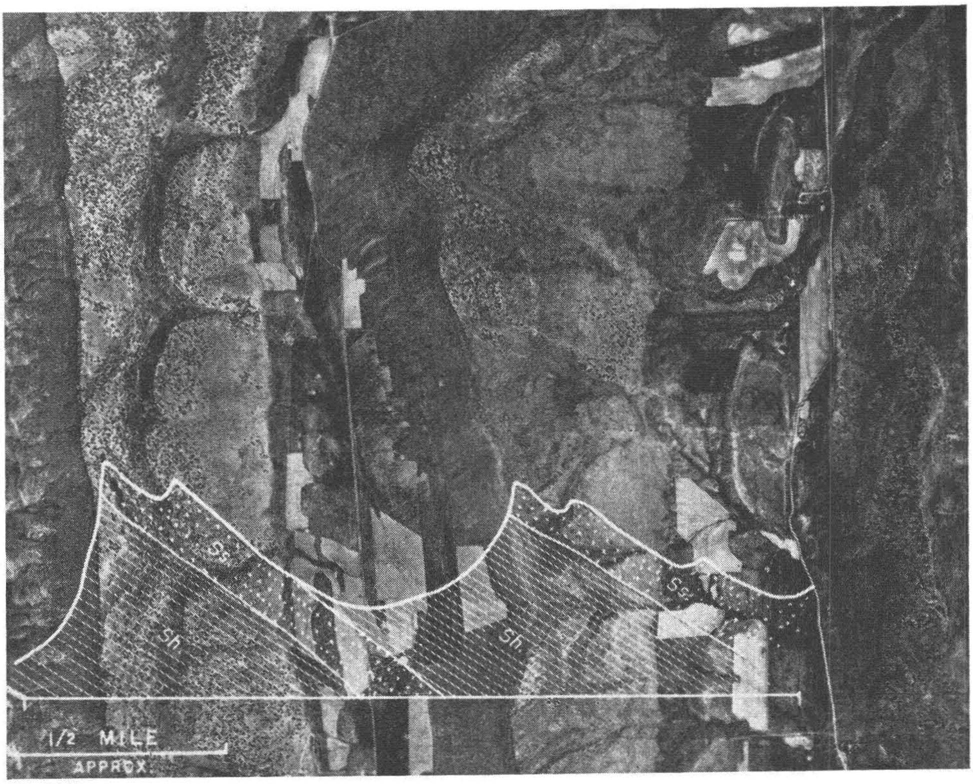

FIG. 7. A formation of tilted sandstone and shale is shown in this airphoto with an approximate section indicated. The attitude and bedding of rock strata is often a consideration in the selection of engineering sites.

assured performance; on the other hand, site locations having poor foundation conditions and a scarcity of suitable construction materials results in excessive designs, higher costs, and increased maintenance. The problem of engineering site selection, therefore, becomes one of seeking out those areas that will prove favorable from the standpoint of foundation conditions and available construction materials and, at the same time, permit the objectives and concepts of the project to be fulfilled in an economical manner. The problem ultimately becomes one of anticipating foundation, materials, and construction problems in specific areas. The ability to evaluate these problems by photo interpretation, assisted in some instances by a limited amount of field work, obviates a number of difficulties that are often encountered when conventional field methods alone are employed in making site selections; moreover, the airphoto information gathered in the early stages served as a guide to later detailed studies on the ground.

Photo interpretation is especially suited to the site selection of projects having extreme urgency, such as wartime construction, or where insufficient time has been allotted for this phase of engineering planning; the latter is often the case even for peacetime construction. Site selection is also greatly simplified where several varied areas are being considered or where inaccessible areas are involved; in either case, random reconnaissance surveys that often prove futile are eliminated. For the normal site selection, free of all extenuating conditions,

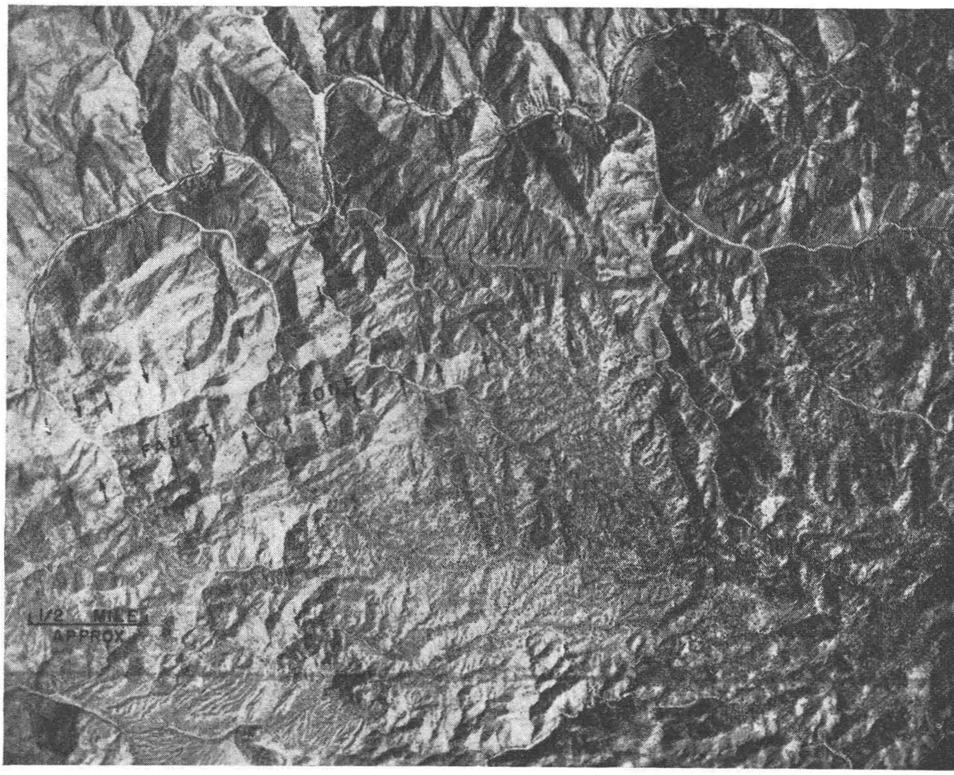

FIG. 8. The topography and drainage pattern shown here indicates highly jointed granite crossed by a pronounced fault zone. The control and alinement of the drainage pattern indicates the presence of the fault zone. Faults are a major consideration for tunnel locations and, in this case, the airphoto has application to an underground structure.

the use of photo interpretation permits a substantial reduction in field work by eliminating nonproductive work in undesirable areas; in this way, the detailed field investigations required for final designs can be concentrated in those areas best suited for the project in question.

The technique of making the translation from the airphoto features to the soil and rock materials, etc., has been discussed previously and some of the common land forms as shown in airphotos have been illustrated. For the purposes of demonstrating a completed airphoto translation, Figure 10 has been prepared. In this illustration, a detailed description has been made of the "Diagnostic Features on the Airphoto" and of each succeeding step in the translation. While the land form which is illustrated is quite common (a gravel terrace), it serves to emphasize that this land form is a highly desirable site location for many types of surface construction and a good source of construction materials for any type of engineering development.

Although favorable foundation conditions and available construction materials should be major considerations in making a site selection, the location must of necessity be made to conform to the concepts and requirements of the project at hand. In this connection, the local topography is usually a deciding factor. Here again, the three-dimensional study of match pairs of airphotos will permit the topography to be evaluated with sufficient accuracy for planning purposes. Grade and alinement are major considerations for highway, railroad,

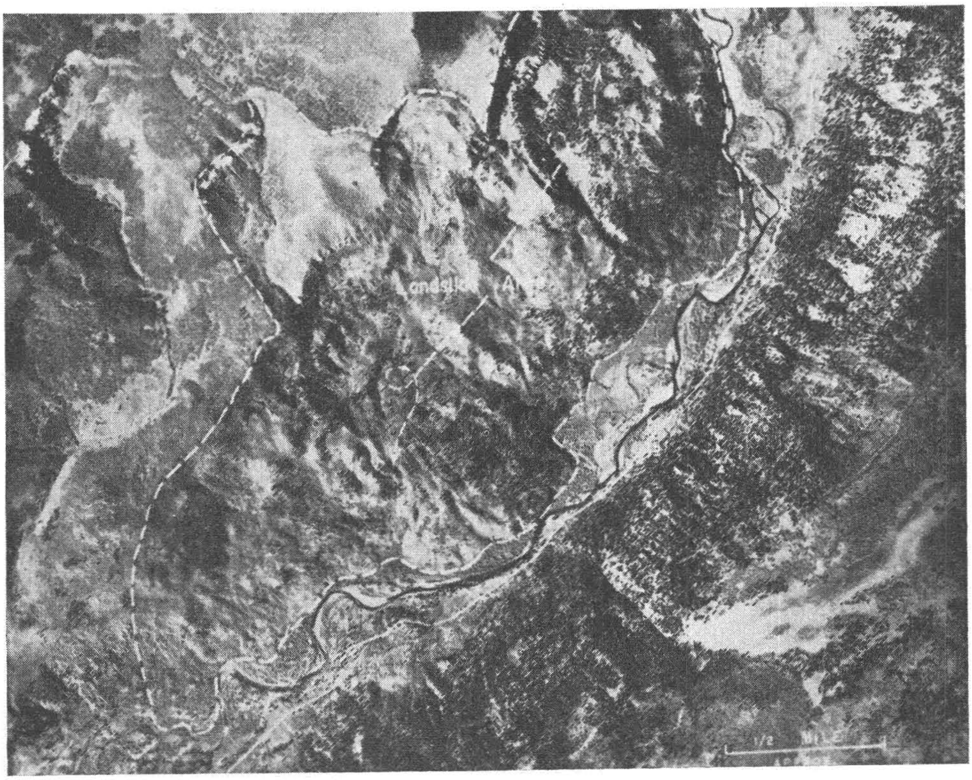

FIG. 9. The "unstable" topography of landslide areas is easily identified in airphotos. The landslide shown here is unusually large; however, small landslides can be identified with the same ease and accuracy. The threat of continued sliding makes such areas to be avoided as locations for engineering structures.

and canal locations; while for airport locations, grade and unobstructed approaches are the major considerations. Thus, site locations for these engineering structures become a question of selecting locations that will permit the grade requirements to be accomplished at a minimum cost, and at the same time located on materials favorable to the performance of the structure.

The study of topography is also highly significant to the location of damsites. Here, not only the dam length and volume must be considered but also the reservoir capacity; drainage areas must be compiled; seepage problems must be considered; the relocation of existing highways and railroads, and clearing estimates in the proposed reservoir areas must be studied. The ability to study these factors in relation to anticipated foundation conditions and available construction materials gives additional emphasis to the advantages afforded by the use of airphotos in engineering planning.

Airphotos can be further used to evaluate other planning items that, though not deciding factors in site selection, often influence the cost of the project. For instance, the question of accessibility often arises in connection with dams, air bases, and certain types of industrial developments which are frequently of necessity located off the established routes of travel. For such situations, the accessibility of proposed site locations in relation to existing roads and trans-

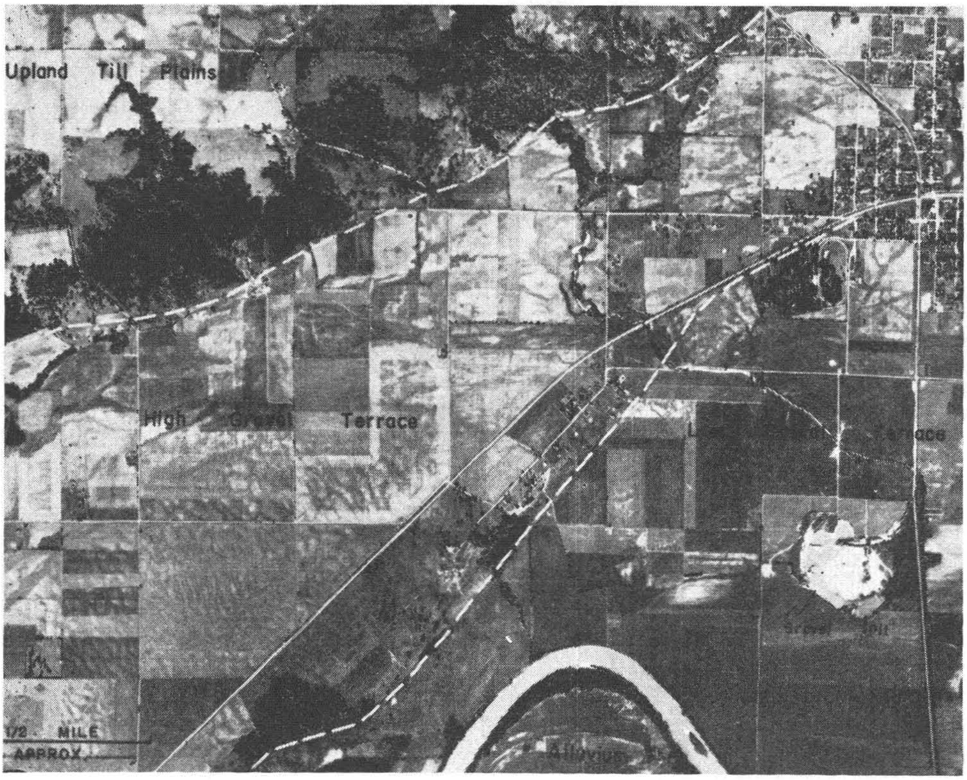

FIG. 10. An upland till plain (glacial), a high gravel terrace, a low gravel terrace, and an alluvial flood plain (in a humid climate) is covered by this airphoto. Differences in the groundwater level in the high and low terrace positions are indicated by the over-all light and dark tones, respectively. The notations at the right demonstrate in detail the technique of engineering site appraisal from airphotos. The analysis applies only to the high gravel terrace. All of the diagnostic features, either directly or indirectly, show the land form to be a gravel terrace, while the color and drainage features indicate the general characteristics of the weathered soil profile.

portation facilities can readily be determined; further, the terrain difficulties can be evaluated and the most feasible access routes for efficient field work can be selected from the airphotos. Clearing estimates sufficiently accurate for planning purposes can be made from airphotos; and if special large-scale photography is available, highly accurate estimates of timber stands can be obtained. Also, the problem of land acquisition for right-of-way is greatly simplified since property lines, fence lines, etc., are usually accurately recorded on the airphoto.

LIMITS OF APPLICATION

Photo interpretation, like all other engineering techniques and equipment, has its limits of application. Failure to recognize these limits often gives the uninitiated the false conception that photo interpretation has universal application. Thus, those approaching the use of photo interpretation with over-optimism are likely to end up with a prejudiced attitude toward the method and the advantages that if affords, simply because they were ignorant of the limits of application.

At the outset, it must be recognized that photo interpretation deals primarily with surface and near-surface conditions. Although there are certain situations where the airphoto features reflect the nature of deep underground conditions and permit reliable predictions to be developed by logic and inference, these

DIAGNOSTIC FEATURES ON AIRPHOTO	*Terrain Position*—"Bench" position forming transition between upland and flood plain *Topograply*—Flat *Erosion Features*—Minor evidence of surface erosion on steep slope at boundary of flat "bench" and flood plain *Color*—An over-all light color tone with darker speckle markings of random shape and distribution *Drainage Features*—Little or no evidence of local surface drainage
LAND FORM	High gravel terrace (with a low groundwater level)
SOIL OR ROCK MATERIALS	Sand and gravel (thickness in high terrace estimated 40 to 50 feet)
PEDOLOGIC	A shallow weathered soil profile (18 to 36 inches), consisting of a slightly plastic silty clay, is characteristic of terrace deposits of sand and gravel in a humid climate. The darker speckle markings indicate slight depressions on the terrace surface where a deeper profile development may normally be expected—soils slightly more plastic and organic
ENGINEERING SITE APPRAISAL	*GENERAL* 1. The granular texture of the materials reduce subdrainage and excavation-handling problems to a minimum 2. The flat topography eliminates the necessity for extensive grading operations 3. Unlimited quantities of sand and gravel for fabrication of concrete. Existing gravel pit close at hand 4. Existing highways and railroad close at hand to serve construction and future access needs 5. Field and crop pattern indicates a high level of agricultural activity. Land and right-of-way costs will therefore probably be high *INDUSTRIAL:* Excellent location for industrial development. Good bearing capacity may be expected throughout area. Foundation and settlement problems will be minor. Industrial water supply readily available from river or shallow wells in low terrace (note groundwater level in gravel pit). River close at hand to facilitate disposal of wastes. Possibilities for future expansion appear good *HIGHWAYS AND AIRPORTS:* Subgrade conditions are excellent—good drainage and bearing capacity; however, the surface horizon of silty clay should be removed in order to utilize the improved drainage qualities of sand and gravel. Grade and alinement problems for highway construction will be minor. Grading and drainage problems for airport construction will be minor *HYDRAULIC STRUCTURES:* The pervious nature of the gravel terrace will make seepage problems a consideration. The flat topography is favorable for canal locations; however, seepage losses will make unlined canals inadvisable. Also, the problem of seepage losses for earth dam abutments founded on the terrace face makes this location questionable as a dam site

situations are special cases without general application. Likewise, engineering interpretation is limited to some extent where a dense forest cover obscures the ground features; however, this can be obviated in part by the correlation of soil and drainage conditions with vegetation patterns.

In most cases, the scale of the photograph is a limiting factor since small-scale photos immediately limit the amount of information that can be obtained. A scale of approximately 1:20,000 has been found to be satisfactory for engineering interpretation of surface materials, since most land forms can be identified by either single or stereopairs of photographs. While large-scale photographs often have application to highly detailed work, such as for grade and alinement control for highway or canal locations and for clearing estimates, they often present the disadvantage of requiring a large number of prints for land form identification; this, of course, depends on the extent of the land form in question.

The method of photo interpretation, in itself, is logical and straightforward. The skill is easily attained, requiring only the ability to observe fine detail and a few basic fundamentals on land forms and soil formation. A further requirement for engineering application, however, is a thorough knowledge of soil and rock materials as they influence engineering construction and performance.

Beyond these minor limitations and requirements, it must be recognized that the benefits to be derived from photo interpretation depends, in part, on the nature of the project at hand. Where engineering design depends on highly detailed subsurface information, photo interpretation will distinguish between favorable and undesirable locations and thus eliminate random field investigations. In contrast, however, where engineering design depends primarily on surface conditions, considerable design information can be obtained directly from the airphoto, requiring only a sufficient amount of field work for confirmation. Thus, the maximum benefits of photo interpretation can be obtained by first recognizing the limits of application, and then adapting the method to the particular project under consideration.

CONCLUSION

The scope of photo interpretation, as related to engineering sites and materials, is so broad and comprehensive that the treatment presented here is of necessity restricted. A brief description of the method and technique has been presented, the limits of application have been cited, and some significant applications and advantages afforded by airphoto interpretation have been discussed.

Airphoto interpretation is a relatively new field in engineering and many of the potential applications have yet to be developed. The method offers a new approach to training the student engineer in the concepts of engineering materials, not only from the standpoint of their physical properties, but also from the standpoint of their natural occurrence and the attendant problems of design, thus reducing the inherent abstractness of classroom instruction on this subject.

In practice, there are numerous other ways, not discussed here, in which airphoto interpretation can be used to simplify and coordinate engineering planning. The extensive photo coverage available in this country makes the possibility of using the airphoto technique within the grasp of all engineering organizations engaged in surface construction; it only remains to extend its use and thus permit engineering planning to proceed with a broadened perspective, effecting economy not only in the planning proper, but in the ultimate construction of the project.

REFERENCES

1. Smith, H. T. U., *Aerial Photographs and Their Applications*, D. Appleton-Century Company, New York, 1943.
2. Belcher, D. J., Gregg, L. E., and Woods, K. B., The Formation, Distribution, and Engineering Characteristics of Soils, *Research Series No. 87, Engineering Experiment Station*, Purdue University, 1943.
3. Levings, William S., "Aerogeology in Mineral Exploration," *Quarterly of the Colorado School of Mines*, Vol. 39, No. 4, 1944.
4. Jenkins, D. S., Belcher, D. J., Gregg, L. E., and Woods, K. B., The Origin, Distribution, and Airphoto Identification of United States Soils, *Technical Development Report No. 52*, Civil Aeronautics Administration, Washington, D. C., 1946.
5. Belcher, D. J., "The Determination of Soil Conditions by Aerial Photographic Analysis," *Proceedings, Second International Conference, Soil Mechanics and Foundation Engineering*, Rotterdam, Vol. I, pp. 313–321, 1948.
6. Woods, K. B., Hittle, Jean E., and Frost, R. E., "Use of Aerial Photographs in the Correlation Between Permafrost and Soils," *Military Engineer*, Vol. XL, No. 277, pp. 497–499, November 1948.
7. Frost, R. E., and Woods, K. B., "Aerial Photographs Used for an Engineering Evaluation of Soil Materials," *Proceedings, Second International Conference, Soil Mechanics and Foundation Engineering*, Rotterdam, Vol. I, pp. 324–330, 1948.

UNIVERSITY INSTRUCTION IN PHOTOGEOLOGY*

Benjamin A. Tator
Louisiana State University

MODERN search for mineral resources, particularly petroleum, demands more rapid exploration techniques than those employed in the past, as well as greater accuracy in the location and mapping of potential areas of production. Various methods of speeding up surface and sub-surface analysis are in vogue as evidenced by the number and variety of service companies which remain operative. A most economical type of reconnaissance, Photogeology, revitalized by the need for cheaper and more rapid surface mapping, is gaining its proper perspective in this scene.

A fundamental requirement for mineral search and production is the existence of adequate topographic and geologic maps. This is true whether the method of exploration is of surface or sub-surface type. As a matter of fact, these two lines of approach to the location of mineral deposits are supplementary, the need for adequate base maps, in planning and accomplishing geophysical surveys, for example, being well recognized. Unfortunately, however, except for the more recent maps produced from photographic coverage by photogrammetric techniques, most areas requiring exploration have been mapped inadequately or not at all. In some regions, where terrain is such that field reconnaissance may be accomplished with relative rapidity, normal surface mapping has proved adequate for most types of exploration activity. However, the location of potential petroleum and mineral bearing structures, by ordinary field methods more often than not requires months of intense effort, and is a relatively slow process.

In the search for accelerated methods, mining and oil companies are rapidly recognizing that efficient field reconnaissance can be accomplished by analysis of aerial photographs. As Brundall stated in the *Oil Weekly* of December, 1946 (1): "Photogeology . . . an improved and speedy method of reconnaissance surface mapping. . . has already been successfully used in many areas in the United States and foreign countries."

* Paper presented at Regional Meeting, Denver, Colo., Oct. 3, 1949.