PANEL DISCUSSION—THE USE OF AERIAL PHOTOGRAPHS FOR GEOLOGIC MAPPING

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USE OF AERIAL PHOTOGRAPHS IN MAPPING VEGETATION AND SURFICIAL GEOLOGY IN SUBARCTIC REGIONS*†

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THE Alaska Terrain and Permafrost Section of the U. S. Geological Survey is concerned with land forms, geologic processes, surface materials, and permafrost phenomena in Alaska. The geologists and botanists of the Section's field parties have been using aerial photographs not only as "location" maps in the many poorly mapped districts, but as sources of information that might otherwise be difficult to obtain or might even go unobserved from the ground or from airplane reconnaissance.

The uses of aerial photographs in this type of work can be roughly grouped into four categories. 1) The photographs are used for orientation and as guides to poorly mapped areas. For regions in which field parties must operate far from roads or trails, the value of aerial photographs is well known. 2) Aerial photographs are probably the most valuable of all maps in planning the ground sampling of areas, as they contain detail that is impossible to represent on drafted maps, which are commonly interpretive or generalized for special purposes (e.g., topography, drainage, etc.). However, the aerial photographs must be supplemented by reliable topographic maps for ground control and altitudes. 3) Because of the fineness of detail, sample localities can be plotted directly on the photographs, probably with greater accuracy than would be possible on drafted maps except by the laborious method of triangulation from established control points. 4) After representative areas have been sampled, the intervening areas may be mapped with accuracy commensurate with the understanding of the geology and vegetation developed from study of the sample areas and correlation with the photographs. When areas remote from sampled areas have to be mapped, criteria from the most nearly similar sampled areas are applied—a kind of extrapolation. This last technique is understood to be "airphoto interpretation."

By way of explanation, a few of the indicators that we have found useful in aerial photographs can be noted here. It is common knowledge now that the recent or present occurrence of permafrost (permanently frozen ground) is manifested by polygonal patterns in soils and vegetation and by sinkholes (thermokarst pits) in unconsolidated materials. More subtle permafrost indicators on aerial photographs are the trees of "drunken forests," tilted in all directions by growth of soil ice masses or entrapment of water between the seasonal frost and the underlying permafrost. Fallen trees and freshly cut vertical banks of lake shores indicate the progressive thawing of permanently frozen ground at the

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margins. In areas with permafrost, the vegetative cover, acting as an insulator, is as important as the soil type and drainage in determining the depth of the sesonally thawed layer above the permafrost. The peaty mats of tundra and muskeg are excellent insulators, seldom permitting seasonal thaw to reach deeper than about 18 inches. Under white spruce forest seasonal thaw ranges from 2 to 6 feet on the average. Under birch, aspen, and grass types of cover, seasonal thaw usually attains greater depths although drainage, soil materials, and exposure exert strong modifying influences. Destruction of insulating vegetation, as by fire or clearing, permits seasonal thaw to penetrate to much greater depths. But as the herbs, shrubs, birches or aspens, and finally spruce repopulate the surface, the permafrost body again grows surfaceward. Thus, it is of value to be able to read from photographs the successional status of plant communities, although plant succession in any area must first be determined by detailed surveys on the ground.

Land-form details too subtle for all but the most painstakingly devised drafted maps are inherently a part of aerial photographs. Notable among these details are turf-banked terraces, solifluction terracettes, stone stripes, and other "microrelief" forms common in regions of cold climates. Abandoned river channels, drained lake basins, and similar features that have been all but obscured topographically often do not appear on drafted maps. These are marked on aerial photographs by contrasting types of vegetation that reflect slight differences in drainage or soil types. Different types of country rock often have surface expressions readily distinguished on aerial photographs.

The extent of effective use of these photographic representations is equal only to the knowledge of the actual features as they have been studied on the ground either in the area in question or in areas of similar environment and geologic history. The understanding of an area determines the reliability of aerial-photograph interpretation within the net of sampled localities as well as the reliability of extrapolation into similar areas.

SOME BOTANICAL PROBLEMS IN THE INTERPRETATION OF AERIAL PHOTOGRAPHS OF TUNDRA AREAS*†

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INTERPRETATION of vegetation and surficial geology through use of aerial photographs depends upon the solution of two problems. The first concerns the significance of the geological-botanical landscape. What is the meaning of the surficial geology in terms of earth history and bedrock? What correlations exist between vegetation patterns and soil type, topography, bedrock, and recent history of the land surface? What patterns result from the interactions of plants and substratum, from the intervention of man, from the variations in climate, or from some other factor in the environment? All factors of the environment and the history of the development of vegetation must be investigated and understood before the meaning of plant communities can be determined. The second problem is the identification of patterns of aerial photographic representations of the land surface.

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Solution of the first problem requires field work. The geologist must dig holes, collect soil and rock samples, make sketches and maps, and take field notes before he can explain land forms. The botanist must collect and identify plants, describe plant communities, and study conclusions of geologists before he can explain the significance of the vegetation. The following four types of vegetation, which occur on the Seward Peninsula, Alaska, will illustrate some of the difficulties connected with the botanical study. A sedge sod is commonly found in stripes forming drainage lines and in fresh-water marshes surrounding ponds. Willow shrubs are found in numerous habitats: in poorly developed drainage lines on long slopes, in "dry" depressions extending downslope, on steep banks of rivers and lakes, on river flood plains, on slopes of some hills, and at the base of solifluction terraces. Alder shrubs occupy sites similar to and different from those of willow shrubs. They are found in and around poorly defined drainage lines and in large stands on the lower third of the steepest slopes of the mountains. Spruce, near their western limit, grow along streams parallel to slopes that are otherwise covered with low tundra or plant communities. They are also found at intermediate elevations at the base and the lower part of steep slopes and along banks of larger streams, but not on the higher stream terraces (Table 1). Two separate questions are raised by these facts: What is the significance of 1) apparently similar vegetation in different habitats and 2) different vegetation in analogous habitats? Considering different vegetation in analogous habitats (column A, table 1), does the presence of a sedge sod in drainage lines mean the same thing in terms of the substratum as the presence of willow, alder, or spruce? Does the vegetation develop in a sequence from sedge to willow, to alder, to spruce, or in some other order, or, does each vegetation type indicate different historical and environmental factors?

TABLE 1. GENERALIZED DISTRIBUTION OF FOUR TYPES OF VEGETATION ON SEWARD PENINSULA

A Drainage Lines	B Marsh	C Dry Depression	D Steep Banks	E River Flood Plains	F Solifluction Terraces	G Steep Slopes
Sedge	Sedge					
Willow	Willow	Willow	Willow	Willow	Willow	
Alder						Alder
Spruce				Spruce		Spruce

The second problem in the use of aerial photographs in the interpretation of vegetation and surficial geology concerns the identification of patterns on the photographs. It is necessary to set up criteria describing configuration, texture, shade, and meaning of the patterns before one can expect a worker unfamiliar with the country to study aerial photographs and to interpret them correctly. Each photograph with a different scale requires its own set of criteria. Many patterns on the ground appear similar when reproduced by black and white photography, yet they are often correlated with different types of substratum. For example, isolated willow shrubs and large lava boulders on the Seward Peninsula show a striking resemblance on aerial photographs, and exact criteria must be set up to distinguish them. Also, it is difficult to differentiate smooth limestone slopes, snow banks, and certain types of vegetation characterized by the predominance of matted willows.

However important these problems are, they should not preclude the use of aerial photographs in geological, botanical, and engineering studies of the land surface. The field worker and the interpreter should assist in the solution of them.

Aerial photographs are invaluable aids in the study of field problems and should be used wherever possible. Patterns present on the ground may go unnoticed if a study of aerial photographs is not made or cannot be made. Polygonal patterns, as well as other patterns in the vegetation, the areal extent and complexity of the vegetation resulting from its development subsequent to the draining of lakes because of thawing of their banks, and the detection of bedding planes and joint systems in rock covered with rubble are only a few of the features delineated by aerial photographs.

As an aid in the study of perennially frozen ground in tundra regions, photographs are of value only so far as the vegetation and microrelief features indicate the nature of the frozen substratum and to the extent that the photographic representations of these features can be identified. It cannot be stressed too strongly that, in the interpretation of patterns on aerial photographs, a thorough appreciation and understanding of the topography, physiography, and vegetation on the ground are of first importance.

NAVAL INTEREST IN PHOTOGEOLOGY*

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THE United States Navy became vitally interested in the various phases of aerial photographic interpretation and photogrammetry prior to the entry of the United States into World War II. That part of aerial photographic interpretation now referred to as photogeology is one of several phases in which the Photographic Interpretation Center has taken an active interest, and this paper is presented mainly to indicate that interest. It may be interesting to note that during World War II more than 800 officers completed the basic course in photographic interpretation at the Naval Photographic Interpretation Center, Anacostia, Washington, D. C.

Throughout the war many of these photographic interpreters were called upon to prepare terrain intelligence reports, mainly from aerial photography, as too often there was little or no ground data available. As these officers came from diverse fields of civilian activity, many of them did not have the necessary geologic or pedologic education or background to exploit fully the immense amount of geologic information available on the aerial photographs. As a result, the overworked geologists were continually being called upon to do geologic and soil interpretation. In order to ease their work and to increase the accuracy and rapidity of the interpretation of the geologists as well as to allow other professional men to aid in terrain reports, handbooks and guides were prepared by the Photographic Interpretation Center, other military units, and government agencies in the United States. Many of these guides are the forerunner of our present day research in aerial photogeology and aerial photobotany.

Since the end of the hostilities, one of the functions of the Photographic Interpretation Center has been to conduct research and develop techniques and additional applications of interpretation. One of these is research and development in the field of aerial photogeology and aerial photobotany, especially as applied to coastal areas. It is not, however, the intent of this Center to produce detailed geologic, pedologic, or vegetation maps or reports. The intent is rather to apply established or newly formed principles as tools for more accurate and rapid interpretation of aerial photographs for naval use.

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In the interpretation of coastal terrain and beach trafficability from aerial photography, the interpreter must have either a well-rounded background in the earth sciences or else the use of reliable guides or keys, which will aid him in visualizing actual ground conditions. The value of these guides in the final accurate evaluation of terrain intelligence as obtained from aerial photography depends on the interpretation of the story told by geomorphology, vegetation, and their allied fields. The Photographic Interpretation Center through ONR and in conjunction with several universities, is conducting research in aerial photogeology and aerial photobotany as a means of using to the fullest extent the wealth of information available on aerial photographs.

It is pretty well conceded that for a photographic interpreter to obtain the most value from an aerial photograph, he should have as much knowledge of the area concerned as possible. If he is a geologist he should be familiar with the geology and terrain features either through published material or personal investigations. It is very seldom that at least some published data are not available relative to a given area. Occasionally the section of primary interest at the time of the interpretation may not be covered by any detailed report so that the interpreter is called upon to rely on the data of nearby or similar areas, on the terrain features prominent on the aerial photographs, and on his background of experience in order to obtain a correct interpretation of the area. Under such a condition the interpreter is working under a severe handicap which may be relieved to a certain extent by the use of prepared guides. It is entirely possible that the interpreter will jump to conclusions which eventually may be found to be in error. Nevertheless, under such conditions, certain assumptions must be formed even to start the preparation of a report. The reliability of such assumptions can be increased by the use of better photography, wider experience of the interpreter, and accurate guides and keys. The first two factors often are not possible under all conditions, and the burden of correct interpretation may fall on the reliability of photographic interpretation keys.

Certain land forms recognizable on aerial photography, such as landslides, undrained areas, beach ridges, sand dunes, and certain glacial and permafrost features, are used at the present time as indicators of terrain conditions and trafficability. It is expected that, by the recognition and judicial use of the significance of drainage features, erosion characteristics, relief, vegetation, and perhaps cultural features in terms of bedrock geology and geomorphic history, additional land form patterns will provide a wider application of land form usage as well as a more accurate interpretation of coastal areas.

In the same manner, certain types of vegetation, such as the mangrove and casuarina trees, are excellent indicators and when used either separately or in conjunction with land forms, will give accurate interpretation of terrain and coastal conditions. Additional research is needed in both vegetation and geology in order to interpret accurately the characteristic land form or vegetational pattern indicative of trafficability.

We are interested in such problems as to what extent aerial photographs provide an adequate picture of the natural features, and to what extent these features alone provide an adequate basis for interpretation of land form patterns? We are also faced with the problem to what extent the data on a known locality can be applied to that of an unknown area.

The trafficability of beaches has always been a major problem, and while interpretation of them from aerial photography has advanced tremendously in the last several years, there is still a decided need for improvement. Several recognizable shoreline features, such as the gradient, whether it is a retrograde or a prograde shore, and the presence of inland swamps or sand dunes, aid in the interpretation of the type of beach, but they do not always give us the true trafficability story. It is hoped that by the study of enough different types of beaches we can present a much more accurate picture of the actual conditions.

Experiments in recent technical developments such as radar and the airborne magnetometer may help in beach and coastal interpretation. For instance, to what extent will the radar image detect the difference between a granite hill and a similar hill composed of shale or limestone? If there is a difference in the image, is it only relative and therefore only reliable for nearby areas, or could it also be used for widely separated points of interest?

As the Navy is interested in coastal conditions extending from the Arctic to the Antarctic, climatic conditions and their effects on weathering must be taken into account in the interpretation of land forms and vegetation.

In obtaining answers to these and many other questions, as well as in keeping up to date with the advancement of photogeology and photobotany, the Photographic Interpretation Center maintains contact with other branches of the Navy, other government agencies, universities, and private industries. Thus it is hoped that we can do our share in preparing photographic interpreters to fulfill their missions more rapidly and accurately.

PRESENT STATE OF THE APPLICATION OF PHOTOGRAMMETRY TO CARTOGRAPHY IN SPAIN

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TRANSLATED BY BERNARD J. COLNER

1. Since Laussedat announced the principles of what he termed *Metrographia* in 1859, the Spaniards have been interested in this new procedure of surveying. This topic was the theme for a meeting of the *Real Academia de Ciencias de Madrid* in 1861. Gen. D. Antonio Terrero published a notable work in 1862 in which he solved the problem of determining the location of an object by means of its images on two photographs. This was twenty years before Hauck, a German, presented a solution of the same problem in his "Theorem."

Since that date, many studies have been undertaken by various technicians and practical experiments were completed by several governmental agencies. The works of Lt. Col. D. Alejandro Mas y Zaldua are deserving of mention. In 1901, he completed a topographic survey using photogrammetric methods in the Pyrenees which extended more than 10,000 hectares (38.6 sq. miles). At the same time, Maj. D. Jose Galbis, a highway and cartographic engineer, completed some tests of the new methods on the municipal boundary survey of Otero de Herreros, which included an area comprising some 4,300 hectares (16.6 sq. miles) at 1:25,900, the same scale as the *Mapa Nacional*. The *Brigada Topografica de Ingenieros* tested in Calaluna y Baleares the idea of photogrammetric tachymetry derived by *Coronel de Ingenieros* D. Rafael Peralta, Chief of the *Servicio de Aerostacion*.

2. The encouragement that photogrammetry received in 1900 on substituting stereo-photogrammetric methods for conventional practices, resulted in a rapid development of its cartographic applications by utilizing the stereocomparator (Pulfrich—Zeiss, 1902); and especially the Stereoautograph (Orel—