AN ASSOCIATIVE METHOD OF REGIONAL PHOTO INTERPRETATION*

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ABSTRACT

Present day military tactics require great dispersion. This puts more emphasis on the need for photo analysis of terrain by interpreters of low echelons. This analysis can be aided by keys, using associations to secure convergence of evidence. This technique has been used by the German Forschungsstaffel and by some U. S. Interpreters. Direct methods of interpretation have the advantage of simplicity, but they are not well suited to evaluating the probabilities of natural subjects. Associative methods combine terrain elements to confirm findings and to secure more information. Several examples and a military application are cited.

THE change of tactics which nuclear weapons have forced upon the armed forces has added new importance to photo interpretation as a tool for terrain studies. Methods of securing terrain information on a region-wide scale must now be used so that small, scattered units can make advantageous use of the terrain. Because of the danger of atomic counterattack it is doubtful if operations like Normandy or Iwo Jima will ever again be possible. In planning such operations a few highly skilled experts have studied every fold of the land surface for months in advance. The new tactics require that many intelligence specialists of the lower echelons, that may not be highly trained in the art of terrain analysis, must plan the movements of small units over immense areas. They must be prepared to do this not only for strategic planning of initial strikes but in conducting day to day tactical operations in the field. Then, too, they must be able to evaluate targets among widely dispersed enemy units, and to estimate their capabilities.

The complexities of strange topography, vegetation, and cultural features give these men an extremely difficult task. In addition, natural features have an inherent vulnerability to errors in interpretation which, by older methods, could be resolved only by ground examination. A systematic aid to photo interpretation, called the regional photo interpretation key, has been devised; this can help solve many of these problems. In this paper the term "key" is used both in the specific sense as applied to a particular set of interpretation guides and in the general sense referring to a series of such guides. Since there are many kinds of regional keys, those which seem to offer the best opportunity for making terrain analyses are examined in this paper.

To do the most good these keys should not only enable the interpreter to make identifications, but they should help him to combine information on many diverse factors into a well rounded appraisal. To do this effectively it is felt that a philosophy of associations can be applied to advantage. The associative method combines the techniques of many natural sciences, and, for want of a better name, has also been called the "combination," "wholistic," or the "integrated" method.

Investigators have found that, because of the trend toward over-specialization, workers in different fields have lost contact with each other. They have learned that when a problem in the natural sciences is to be attacked, they can profit by combining forces.

HISTORY OF THE ASSOCIATIVE METHOD AS APPLIED TO MILITARY GEOGRAPHY

The story of the associative method is in part the story of Dr. Otto Schulz-Kampfhenkel and the Forschungsstaffel, or research detachment, which he organized. He got his start as an explorer in Liberia and the Amazon. On the latter expedition he learned the explorer's standard-operating-procedure, the use of several specialists, each trained in a dif-

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ferent branch of science and combining their talents to solve the riddles of a new region.

According to Smith and Black (4), when war came, Schulz-Kampfhenkel went into the Luftwaffe and formed a special group to utilize his exploration theories. This group was composed of men most of whom were highly trained scientists who possessed outstanding ability and experience in photo interpretation and terrain evaluation. The major fields represented were geography, geology, ecology, botany, forestry and pedology. They worked closely together as a highly organized team. The geographical interpretation of air photos became their chief method. It was founded on the principle that nothing occurs alone in nature. This type of interpretation, employing plant ecology to a marked degree, was the most important part of their photo analyses.

During the same period photo interpreters in the U. S. Navy were using similar methods, as has been explained by Colwell (1), but on a more limited scale. Associative methods were used in the Navy's photo interpretation key to terrain in the Pacific (5), but they were kept in the background and subordinated to direct methods. In the vegetation key, land zones typical of Pacific islands were associated with vegetation types. These relationships provided an understanding of soil moisture and trafficability problems.

A Comparison of Two Types of Regional Keys

Present day keys take two broad forms: subject and regional keys. Subject keys treat a single subject, such as an industry, or a type of military equipment, using primarily direct methods. Regional keys attempt to enable a photo interpreter to recognize and to understand unusual features found in a specific region, with which he is unfamiliar, giving emphasis mainly to features which differ from those found in other regions. Here the explorer's technique of the combination of several scientific disciplines is in keeping, because the interpreter is in reality exploring a strange region by means of the air photo.

There are two main types of regional key organization. As Russell, Foster, and McMurry (3) express it:

> "There are direct and associative keys. Direct keys are valuable for reading the nature of an object from tone, texture, shape or shadow of an image. . . . Associative keys make possible the deduction of the nature of an object from interpretation of its surroundings, and must be used when identification of an object alone is difficult."

The purpose here is to compare these two types of regional keys to determine which is most suitable for regional photo interpretation. It is assumed that the direct key remains at a non-technical level, and that the associative key has two levels, an initial non-technical level and a supplementary semi-technical level. In other words, it can be shifted into a higher gear when desired. It is also assumed that military specialists of both photo-reader and photo-interpreter caliber will use both keys to the extent they are able.

Direct Keys

Regional keys which are based on direct recognition features have the advantage of simplicity. Everything necessary to make the interpretations they suggest is directly visible on the photo, and few deductions need to be made. Such a key is in reality a series of subject keys. Everything is divided into neatly separated categories, and each subject key stands on its own, needing no help from other parts of the manual. This means that men with a very limited background can use the keys without difficulty.

In constructing direct keys each element of the landscape is isolated and studied as a separate subject. Relationships which exist between these elements are not denied, but it is felt that confusion is caused by the analysis of more than one element at a time. This process of isolation in itself helps to minimize any need which might be felt for close cooperation between disciplines in order to arrive at a sound evaluation. This viewpoint overlooks the fact that when investigators work independently not only does the opportunity to assist one another diminish, but coordination becomes difficult. For example, in the Navy's key to Pacific terrain (5), which is only partially associative, the landform and vegetation sections are completely independent of each other, and they differ so markedly in organization and format that it is difficult to compare the landforms and vegetation of an area and get a complete appraisal of the terrain.

The viewpoint one receives from a direct

regional key is somewhat like what a group of blind school children got when they were taken to visit a zoo. Since they could not see the animals the keeper allowed them to touch some of the more docile ones. When their teacher asked them what they thought the elephant looked like, the one who had felt of his trunk said that it was like a snake. The one who had touched his tail thought that the elephant was like a piece of rope. The one who had touched his leg said that it must be like a tree.

It sometimes seems that terrain specialists are similarly blind. The geologist seems to notice nothing but the rocks and gullies in an air photo. The forester sees nothing but the trees. Those who use keys made by these specialists get the same one-sided view, because they see the landscape through the specialist's eyes. They get fragmentary scraps of information which only the most able interpreter knows how to combine into usable intelligence.

In a simple situation a one-sided view may be all that is needed. A key to forest types sometimes involves only tree species, and no other factors need to be considered. In some parts of the world ecological relationships are very simple, and a certain vegetation type may always indicate a specific soil condition. Such a situation was apparently found in the vegetation section of the Navy's key to Pacific terrain (5). However, many other parts of the world have extremely complex relationships between vegetation, soil, moisture, and climate. One interpreter has described the boreal fringe in northern United States as a photo interpreter's nightmare. Direct keys to such an area would be of little value since they would reveal only the superficial aspects.

In the interpretation of natural terrain features positive interpretations are rather rare. The investigator who has personally examined the ground can frequently say with assurance, when he sees the air photos of the area, that here is a definitely known plant community which in this case definitely indicates a specific condition on the ground. The interpreter examining photos of terrain with which he is unfamiliar finds more "possibles" and "probables" than "certainties." No one knows this better than the man who makes field chekcks to verify his interpretations, only to discover how many times he is wrong. Such errors are, of course, highest for the inexperienced trainee.

Direct keys can deal only with the "certainties," since they have no means for evaluating the "probables" without confirmation from other sources. If the key maker rejects all the signposts which cannot be definitely proven, he loses an essential feature of military intelligence, the seemingly unrelated data which when collated provide a pattern of information. Thus the advocate of direct keys, who does not foresee the interrelation of the data he collects, may reject such valuable signposts to terrain conditions as spruce, pine and larch. These have definite but divergent environmental needs, which are usually, but not always, satisfied. For example, spruce, pine and larch might indicate in the boreal fringe, under some conditions, a moist clay soil, a well drained sandy ridge, or a wet swamp, especially when found in pure stands. Because they indicate a possible or a probable, but not a definite condition, they cannot qualify for a direct key. Thus the key maker is forced to group the species together under the broad term "conifers," which indicates very little in terms of ground conditions, leaving the key emasculated. He is not concerned with the possibility that other information from landform or cultural interpretation may point in the same direction as the vegetation indicators, giving other men just the help they might need to turn "possibles" into "probables" and "probables" into "certainties." Thus a valuable tool is lost.

Associative Keys

The first basic principle of associative interpretation is that *terrain is a complex of related factors.* It is possible to establish relationships and to deduce the unseen presence of one from the visible presence of the other. If any one factor, or group of factors, is omitted from consideration, then the environment becomes difficult to rationalize and errors in judgment might be made. Man's cultural changes are nearly always a violation of the environment, to one degree or another, but still related to it. The Imperial Valley is an example. The lush tropical vegetation found in that area is a violation of nature, when the vegetation and climatic factors alone are considered. It makes sense only when man's introduction of irrigation is considered as a third factor.

A second basic principle is that in making interpretations the *methods of one discipline should be used to help another reach its goal*, whenever possible. This requires a high degree of cooperation. For example, the forester might use the botanist's and ecologist's methods to interpret soil conditions for the geomorphologist, who in turn might confirm these findings by the methods of the glacial geologist. A second confirmation might come from the land-use analyst, who interprets man's use of the soil. Proof is thus secured through the convergence of evidence, because the findings of several branches of science suggest the same terrain condition. Confirmation from several sources is almost indispensable when ground checks cannot be made.

Colwell (1) has cited an interesting application of this technique from World War II. In the Ryukyus a plant called cycads can be used as an indicator of calcareous soils. In one large area this information was supported geologically by means of the drainage pattern. The area lacked streams which appeared elsewhere, and this indicated a porous substrata. Rice paddies were also lacking and dryland crops appeared in their place. Supporting all this were frequent coral borrow pits being used by the enemy. This evidence all combined to indicate a large area well suited to airfield construction. This was later proved to be accurate when the complex of air bases was built on Okinawa. He states: "Such 'convergence of evidence' . . . should be employed whenever possible in order to fortify estimates of terrain conditions made from aerial photographic interpretation of vegetation.'

Associative Key Organization

In organizing an associative key the author favors the use of *a basic key, to which related keys are added as supplements.* Landforms are well suited to the role of the basic key because they are the fundamental elements of terrain. Such a key may be organized as follows:

1. *Introductory description of the region.*
2. *Dichotomous key* to landform types.*
3. *Description of each type keyed out:*
   a. Direct recognition features.
   b. Associative recognition features.
   c. Terrain conditions—a description of typical associations commonly found with the landform.
      Topography
      Soils
      Vegetation
      Culture
   d. Military significance
      Movement
      Concealment
      Miscellaneous

Accompanying each item listed above are vertical stereograms, obliques and ground photos, annotated and captioned to point out each factor discussed. Cross references are made to the vegetation and cultural keys so that confirmation can be found which provides convergence of evidence. Also, more details on these related elements may be secured when desired.

For example, in keying out a glacial till plain, the *direct recognition features are listed first*, such as:

1. Topography gently rolling.
2. Drainage pattern aimless, with numerous rounded enclosed basins.

This is necessary to substantiate the findings of the dichotomous key. *Then, associative recognition features would be listed*, such as:

1. Bogs and lakes of certain types frequently found.
2. Eskers of certain types usually found, frequently containing gravel pits.
3. Forests of mixed conifers and northern hardwoods, with pines predominating on sandy soils and spruce-fir on finer grained soils.

These last features require experience, reasoning, and some familiarity with geomorphology and plant ecology, rather than direct reading from the photo, in order to prevent incorrect application of these somewhat complex principles. These are needed to recognize some of the more subtle variations in the type, and to provide an understanding of some of the finer

* A dichotomous key is a system for identifying objects by following an outline, in which the graphic or word descriptions are placed in a series of pairs of contrasting characteristics which permit progressive elimination of all but one object or condition from the group under consideration.

points of terrain evaluation. A separation is made between these two kinds of recognition features, because at this point the user of "photo reader" caliber should stop and leave the associative features to those who have a better understanding of the processes which created the landform, as will be discussed in more detail later.

Two additional methods of organization should also be considered. A different type of key is needed in regions which are so remote and unusual, such as the upper Amazon, that little is known, even by specialists, about the origin and composition of their landforms, the ecology of their plant communities, or the functions and relationships of the cultural features. Many indicator types may be present, but their significance may not yet be known. Research may eventually solve most of these problems, but in the meantime keys are needed to provide at least some of the answers. In such cases direct keys can be supplemented by discussions of the associations which are known. This promotes a better understanding of the environment and permits some interpretations to be made. More complete keys will have to wait for the future.

A second type might be called a "multiple basic key" manual. It is possible that an associative key could be organized with not one, but three basic keys. The landform, vegetation, and culture keys would each act as a alternative starting point. The interpreter would choose the one that is most pertinent to his particular problem, and the associations found would lead to the other keys for converging evidence and more details. Such a key might be the most satisfactory format to fulfill many diverse requirements.

Examples

The following is an example of how a basic key and two supporting subject keys, which are parts of a larger regional key, can be integrated to get the maximum amount of information by means of the convergence of evidence. The requirement here is to identify targets of either a military or civil nature, in this case a small industrial plant. The accompanying stereopairs, Figures 1 and 2 were taken in the Wisconsin Lake Region in Sept. 1951, with infra-red film. (Also see Figures 3–5)

The first action is to note what information a direct key would reveal. This would presumably key out broad, general types and avoid technical problems. The landform key reveals that since this is rolling terrain, with groups of low, rounded hills and rounded depressions, in a glaciated region, it falls into the Moraine Type. These hills and depressions have measurable heights, depths and slopes; these indicate the degree to which they would become obstacles. The vegetation key reveals that the hills are covered with a pole-sized hardwood stand of measurable height and density, with scattered conifers, which would be an obstacle, but would provide concealment. The user of either photo-reader or photo-interpreter caliber will presumably have difficulty in deciding whether to apply an agricultural or industrial subject key at this point. He will doubtless select the most obvious subject, one which would key out farm buildings. The rural culture key reveals that farmhouses are located between a highway and a railroad, and that hay is being cut in an adjoining field. A well used road indicates that materials, either sand, gravel or clay, have been hauled out of a pit behind one of the farmhouses. The information gathered is useful, but obviously it falls short of the full story.

Now let us see what an associative key would reveal. The basic landform key is entered first. The same landform recognition features used in the direct key are checked. Below these are listed the associative recognition features. These suggest that we have a variation in the Moraine Type here, and that it is on the edge of an outwash plain. The round depressions and the rounded moraines are probably kettle holes and kames. This does not provide a positive identification, because kames are usually more conical in shape. Possibly the influence of the glacial outwash has rounded them off. The key then describes associative features commonly found with this landform. Among these the interpreter notes that gravel pits are commonly found with kames. Since he lacks a positive identification he needs verification from other sources.

One of the other associations catches his eye. It states that pines are indicators of coarse granular soils. He then turns to the vegetation key to see if such indicators are present. This key goes into more detail than the direct vegetation subject key, in

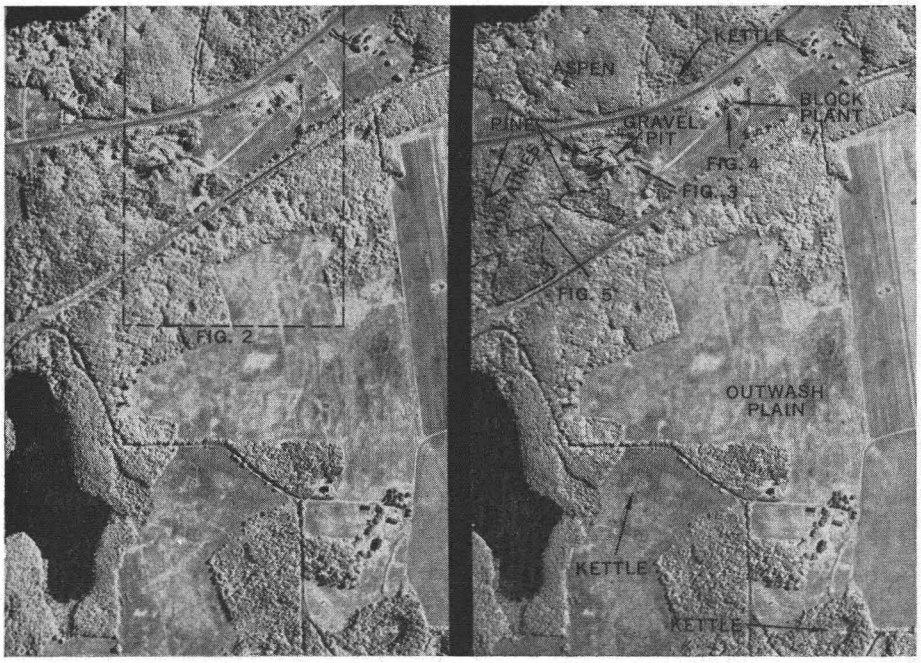

FIG. 1. An example of associative interpretation. A belt of wooded moraines at the left, with an outwash plain at the right, suggest the occurrence of gravel deposits. This is confirmed by vegetation and cultural evidence. A cement block plant is using gravel from a pit at the left. The rectangular pattern at the lower right is caused by haying operations. Infra-red film. Hazelhurst, Wis. Sept. 1951. Scale 1:15,840. (Park Aerial Surveys.)

order to key out indicator species needed in other parts of the manual. It shows that there is a scattered stand of pines, which partially substantiates the gravel hypothesis. A further uncertainty is introduced because pines are difficult to identify accurately at scales smaller than 1:10,000. Therefore we can call this only a "possible." The rest of the trees are keyed out as young aspens, which in this region come in following the removal of pine. This may indicate that formerly a more extensive stand of pine grew there; this would have been a better indicator. A pure stand of pine is a good indicator, but a scattered stand of pine and aspen is not conclusive. Again a positive indication is lacking. Then turning to the rural culture key he gets two bits of information which strengthen previous findings. The alinement of the farm road, at the lower left, indicates by its regular curves that it is an old logging railroad spur, suggesting the possibility that pine, the major timber species in this region, was removed from these hills. The proximity of the highway and the railroad also suggests probable logging in this accessible area. Now that he is more confident that there is a gravel pit here, he examines the "farmhouse" more closely, because it is unusual for a gravel pit road to lead into a farmyard. He discovers that it has the inconspicuous recognition features of a small processing plant. The central building, which had been mistaken for a barn, has a rectangular tower instead of the typical silo, making it resemble a small industry. The well beaten yard entirely around the main building, the rectangular rather than circular stacks of materials, and the lack of the large barn and sheds of a typical farm, also suggest this. This fact was missed by the direct key because small subsistence farmsteads are common in this region. An enlargement of the photos at low contrast to bring out faint details, frequently missed by infrared, discloses that it is a cement building block plant. A ground check indicated that this was the case, and that an entire moraine of gravel had been removed leaving only a deep pit.

Several points in this deductive process need special emphasis. In this example,

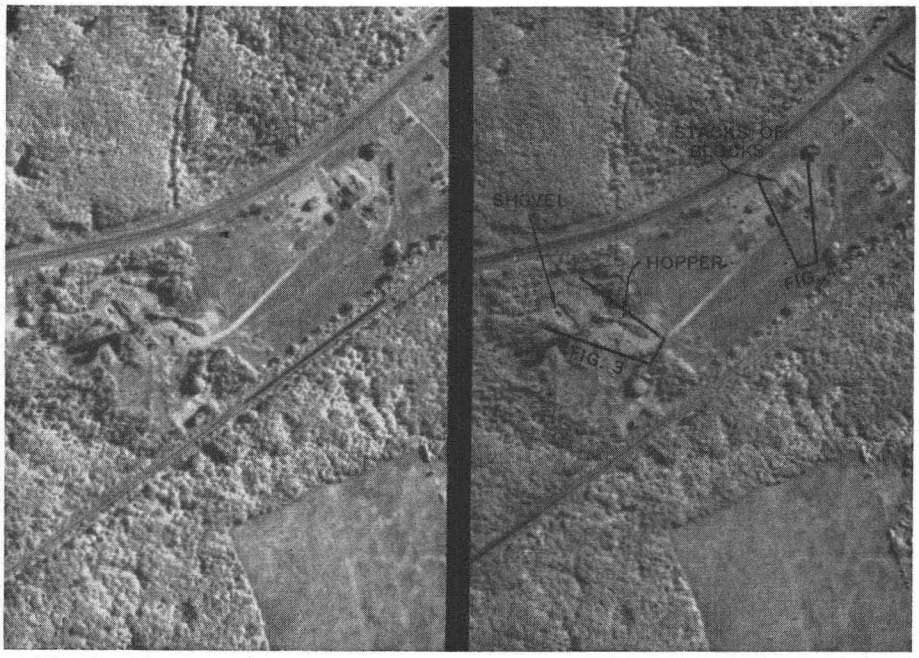

FIG. 2. A 2× enlargement at low contrast of the above. The group of buildings comprising the block plant could easily be mistaken for a farmstead. Here the square tower of the plant and the rectangular stacks of finished blocks are visible. Dec. 1954. (Park Aerial Surveys.)

identification and interpretation by means of associations take place concurrently, with each new identification strengthening the previous one and the interpretation of its significance. This systematic procedure also brought out information that would have been passed over by the more cursory methods of direct keys, in which individual images, rather than groups of related images, are identified. To achieve convergence, evidence which conflicted with other information was given close scrutiny and found to be in error. The chain of deductions was triggered by a discussion of associations in the landform key, which indicates features commonly found on the landform. None of these indicators of terrain condition was conclusive, which is a normal situation. However, all the suggestions they gave pointed toward one conclusion.

Perhaps it seems repetitious to go through three keys when one alone suggests the answer. It must be remembered that when ground inspections of natural subjects are not possible, grave errors can be made by reaching a decision based on one piece of evidence. The problem must be viewed from as many angles as possible. When these confirm the first indications then a decision may be more safely made.

A Military Application

How can the military use an associative key? Let us join the Photo Interpretation Section of a Reconnaissance Technical Squadron. The mythical mission over Wisconsin has just been flown. An airman takes the first prints fresh from the photo lab, and immediately makes a mission review report. This consists of a listing of the areas covered and the targets included in them. When he has difficulty with an identification, he used the direct keys in his regional key, and makes the identifications of the highway, railroad and farms given previously. This man can identify almost any object on earth with the aid of regional keys. But is he in a position to make reliable deductions from what he identifies? With his limited education and background this is open to question. He turns his report over to his superior, 2d Lt. Blow, a year out of engineering school where he got a degree in geology. He checks

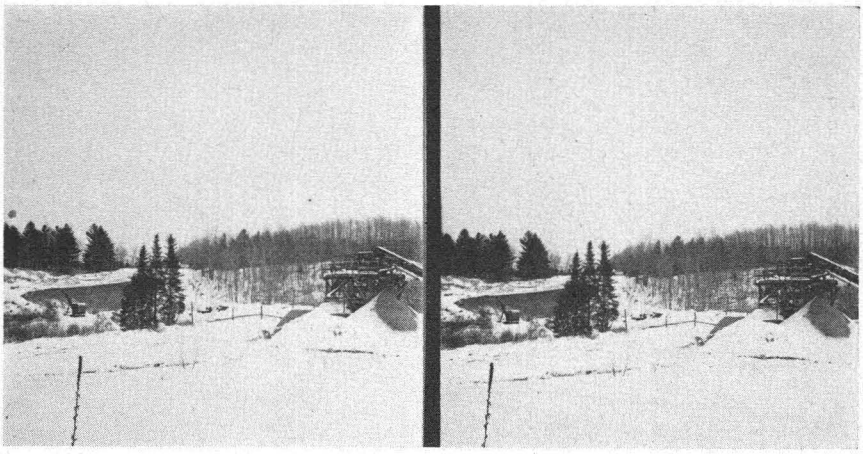

FIG. 3. Ground view of the gravel pit. In the background pines appear at the left and aspens at the right. In the right foreground is a washing and loading hopper. Note the location of the ground views in Fig. 1 and 2. Dec. 1954. (Ed Steigerwaldt.)

the report briefly for completeness and accuracy and turns it over to the Intelligence Section. A short time later a request comes back from Intelligence asking for more information on activities at a list of locations. One of them is our "farmhouse." Lt. Blow takes this assignment himself. He understands terrain, but what he specialized in was oil geology, and he was not paying much attention when they studied glacial geology three years ago. So the landform key is very useful to him. He follows the chain of evidence through and discovers the block plant. His report is not a detailed terrain study but a summary of information on which operational plans can be made. It can, however, contribute to detailed studies by higher commands.

This was not, of course, a military target, but merely an example of an analytical method. Under different circumstances a small processing plant such as this could very well have considerable military significance, especially in parts of the world where "cottage industries" form an important part of the culture.

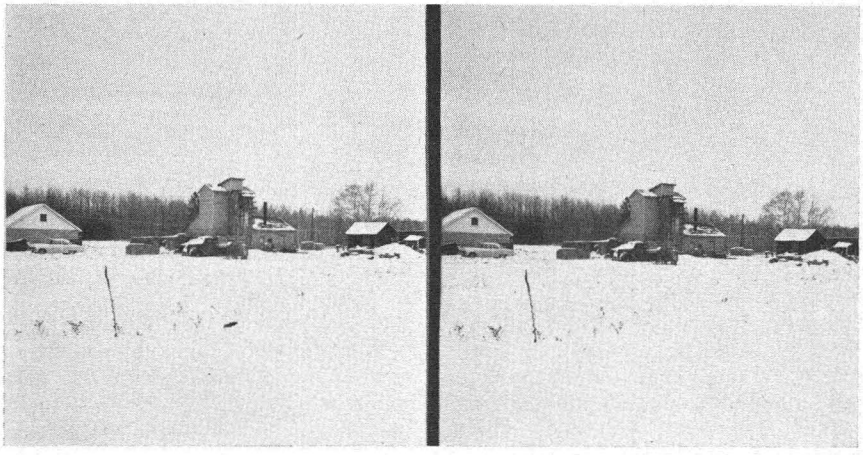

FIG. 4. The cement block plant. Washed sand and gravel are loaded into the tower and progress to the mixer and molds by gravity. Stacks of blocks appear on the other side of the plant. Aspen appears in the background. Dec. 1954. (Ed Steigerwaldt.)

FIG. 5. The aspen stand and the top of a low, rounded moraine. Dec., 1954. (Ed Steigerwaldt.)

CONCLUSIONS

In discussing the various types of keys Roscoe[2] has said:

"Associative keys are the most important keys and at the same time the most difficult keys to master."

They require more exacting knowledge of their subject matter by the men constructing them, than the simpler direct keys. This results in more time and expense to do the necessary research. Specialists in various fields must also work in very close cooperation in order to integrate their material. This coordination raises many technical and administrative problems, not found in making independent direct keys, where no integration is needed.

Associative keys also are limited to men with the proper background. This background can be supplied only partially by the information in the key. When working with cultural subjects, the interpreter needs only to know why these patterns appear as they do; this can be explained in the key. To interpret the meaning of vegetation and landform patterns, he must have an understanding of ecology and geomorphology, which cannot be wholly imparted to him in the limited space of a key.

The limitation placed on associative keys by interpreter qualifications is also one of its outstanding advantages. The associative type of format allows the interpreter who is not trained in the natural sciences to follow the dichotomous landform key down to an identification of the landform type and through the direct recognition features.

The dichotomous key is ideally suited to lead the non-specialist to a correct answer. This allows him to annotate photos, or make a mission review report, but does not allow him to make a detailed interpretation. From there on the interpreter trained in the natural sciences should proceed. He enters the associative recognition features, makes his correlations, and comes out with a detailed analysis of the terrain. In this way the key becomes a dual-purpose key, for use by photo reader and trained interpreter, as well. It also provides the specialist in one natural science with the answers which he would expect from specialists in other fields, if they were members of his interpretation team. In other words, the isolated specialist, such as the interpreter at squadron or regimental level, is provided with a Forschungsstaffel in book form.

The author feels that for purposes of terrain analysis it is unwise to train the novice to make quick decisions, without verification from other sources, on problems which frequently stump the experts. He feels that although students of photo interpretation can be taught by direct keys to recognize many features, they should not be taught to evalute intricate terrain complexes with such keys in regions completely foreign to their past experience. The magic connoted by the word "key" cannot alone produce estimates, without corroboration, of sufficient reliability that they may become the foundation for operations risking the lives of men.

These considerations lead inevitably to the conclusion that direct keys are limited in their value for natural subjects, and that at times they can mislead rather than guide the photo interpreter, by giving him only part of the story. They also point up the interpreter's need for all the aids possible in solving the mysteries of a strange region. Such aid can come from the ecological viewpoint and the associative approach, by combining the talents of the best qualified men to reach a solution.

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ASSOCIATION ANALYSIS APPLIED TO THE INTERPRETATION OF AERIAL PHOTOGRAPHS*

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ASSOCIATION is a term which, when referring to aerial photographic interpretation or to aerial photographic interpretation keys, has different meanings to different individuals. As a result there is considerable lack of agreement with respect to the application and utility of association analysis and of the association type of aerial photographic interpretation key. It is thought that much of the lack of agreement is due to an inadequate understanding that an association is an organization of related elements and that the constituent elements are not of equal importance. An association is a logical unit for aerial photographic interpretation. In this paper a definition of association will be given, and the nature of an association and the utility of association analysis will be discussed.

An association is defined as a group of objects, features or elements which characteristically occur together, have specific relationships to each other and to their environment, and have a definite organization. Selected definitions of association from the Webster's New International Dictionary are:

1. An associating, or state of being associated; union; confederation.
5. The bringing of a person or thing into joint action with another.
7. Ecology a. A major unit in community organization characterized by essential uniformity and composition in structure, with usually two or more dominant species of a particular life form or habit. This unit is often taken as the fundamental entity in community organization.
   c. Any group of organisms, usually of similar life form, associated in a given environment and distinguishable as a group from neighboring groups of like nature.

Selected definitions of associations from the Shorter Oxford dictionary are:

1. The act of associating, or the being associated; confederation.
2. A body of persons associated for a common purpose; the organization formed to effect their purpose.
5. Conjoining one person or thing with another.
7. The mental connexion between an object and ideas (e.g. of similarity, contrariety, contiguity, causation).

These definitions do imply similarity to that first given. Most of them are not sufficiently specific for association analysis because they do not emphasize the specific relationships between the elements. Of these definitions the ecological definitions are closest to the desired definition.

It is understood that some use the term association to mean a group of objects which commonly occur together, that is without specifying that there are definite relationships between the objects and that there is a definite organization of them. There would be no point in coining a new term with a specific meaning as first defined because the term association is used in several disciplines essentially in agreement with the definition first given. The definition of association as used in this paper does not violate the association concepts of the several disciplines concerned.

In a qualitative sense each association

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