2. *Kent's* Paper

A question was raised about the tones in the color illustrations used. Kent explained that these were much better in the original photos and were very satisfactory.

Another question concerned the use of photos near the edges of prints. Kent pointed out that the usual overlap in aerial photography does not necessitate using the edges of photos.

Mr. Goodale's company has conducted studies in Venezuela involving panchromatic, infrared and color aerial photos. He suggested that the photos and information for this study be exchanged with that for Kent's study. Kent agreed that such an exchange would be beneficial to both parties.

The discussion made evident the need for a controlled study comparing black and white against color photos. Kent stated that such studies were under consideration.

3. *Pope's* Paper

A question was raised about using more precise instruments in measuring tree heights. Pope stated that the errors in measuring height are not instrumental in the main, but are particularly due to photography. Photos are needed that permit seeing the ground and tops of trees. Large-scale photos have parallax factors sufficient to measure heights precisely, but large errors occur which are not instrumental. Simple stereoscopes with height finders like a parallax wedge are adequate for the present.

A suggestion was made that enlargements of smaller scales with a shorter length lens be used. This method has not been studied to date.

Moessner reported that Pope's work seems to agree with results obtained on a TVA study made several years ago. Here large-scale photos did not improve the accuracy of height measurements on stands.

The Concept of Analogous Area Photo Interpretation Keys

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ABSTRACT: *All photo interpretation efforts are based upon the concept of analogy. Photo interpretation keys are good examples of the employment of this concept. Analogous area keys, prepared in an accessible area for interpretation of inaccessible areas, are founded upon the assumption that every geographic region in the world has at least one analogous counterpart elsewhere. Geographers, whose specialty is the description of regions, have often used a comparative technique to study similar landscapes in different areas. A simple case is cited to illustrate the preparation of an analogous area key, emphasizing the need for the determination of the significant geographical factors of a region and the precise mapping of these factors on a world-wide scale.*

THE concept of analogy is at the heart of photo interpretation. When the interpreter is working from memory, the analogy is drawn between the image that he sees on the photograph and one which he recalls having seen before, either on other photographs or from field observation. When the interpreter's memory is supplemented by a set of photo interpretation keys or similar devices, the analogy is simply between two images, one on the photo being analyzed, the other in the key or handbook.

If the interpreter is trying to determine the characteristics of a shipyard crane at the Kronstadt Naval Base, he can consult a key made up of photographs taken over British or German or French shipyards where cranes of similar or perhaps even exact makes are in use. The interpreta-

tion of cultural or military features of this type can be relatively easy as well as accurate. Here, the concept of analogy is rather strongly founded.

When the interpreter's task is shifted to natural, rather than man-made, features, a greater element of fallability is introduced. In this case, it often becomes more difficult for the observer to recognize immediately the images before him even with the assistance of a pictorial or written guide. Nature, unfortunately for the interpreter, has the perverse habit of refusing to be nicely pigeonholed or categorized.

Photo interpretation keys for specific environmental features again draw their strength from analogies, and if they are used within the geographical areas from which they were compiled, their accuracy or utility may not be seriously impaired. For example, a key to glacial features, compiled in Wisconsin, might be successfully employed in New York State but might be less reliable in the glaciated Baltic region of Europe.

Regional keys, i.e., those that treat *all* the landscape features in a particular region tend to decrease in value, particularly if the area in which they are being used is distant from the area of compilation. A regional key to the Middle East (which is predominantly arid and Moslem) would not contain all the images to be found in Mauretania or in West Pakistan, even though both of these areas are desert in nature and Moslem in cultural background.

An increasing amount of attention, particularly by the military, is being paid to another type of regional key, prepared from photographs of Area A for use in Area B.* Such keys are called "analogous area keys," a relatively new idea in photo interpretation.[1] They are, in several ways, perhaps the most difficult keys to prepare, and their use is fraught with the greatest number and variety of pitfalls.

It is evident from the general discussion of keys above that the concept of analogy should therefore be applied most cautiously when: 1) the area under interpretation is not the one in which the regional key was prepared, and 2) the whole complex of geographic features are under analysis rather than a single feature.

There is a very close relationship between the concept of regions as employed by geographers and the concept of analogous areas as used by photo interpreters. It would perhaps be valuable to examine briefly the philosophy that underlies the historical development of regional geography, especially as it pertains to the problems incurred in the compilation of an analogous area key.

One of the basic tenets of geography holds that the earth's surface is divided into a multitude of landscapes that differ in substance and appearance from one another. Some of these landscapes persist over many thousands of square miles and have received local names such as Les Landes or the Black Hills or the Upper Karroo. Other landscapes are more limited in size as the Carolina Bays or the Ivigtut cryolite quarry or the Kharga oasis.

It has been the task of the geographer to describe such places in terms of the local environment, cultural development, and relationships to other areas. Consciously or unconsciously, the geographer compares each landscape with others and notes basic similarities or differences. One of the most frequently used methods of regional description is the employment of known standards (Cbf climate) or accepted generic terminology (folded mountains). Much of the development of the systematic branches of geography is founded upon recognized similarities between landscapes in different parts of the world.

It was not until the nineteenth century that geographers became truly aware of the recurrence of patterns from one place to another. The exploratory period, typified by von Humboldt, Darwin, and Richthofen, was followed by an era in which the data that they and others gathered were systematically reduced.

Schimper's work on vegetation[2] and Köppen's on climate[3] led the way in subdividing the earth's surface into meaningful divisions. Herbertson[4] and others, pursuing a more composite approach to "natural regions," reached somewhat the same goal.

The significance of these large-scale regional subdivisions of the earth lay in the

* Area B is, in most cases, a "denied" or otherwise inaccessible area for which photographs are not available to prepare a regional key in the routine manner. It is assumed that photographs of Area B may, however, become available at some future time and interpretation tasks required.

fact that one "type" might appear on several of the continents. Areas of *Cbf* climate, for example, could be found on every continental landmass. The presumption, based upon the climatic record, was that the climate of one of these areas resembled closely that of the other areas so designated. Although they were not described as such, the regions with *Cbf*-type climate were analogous to one another. Similar regional breakdowns were made for the vegetational aspect of the landscape. It is no surprise, then, to find the majority of the generic names of our broader regional landscapes bearing climatic or vegetational terms—rainforest, savanna, steppe, tundra, etc.

This "comparative" period in geography held forth in Europe and the United States during much of the first third of the twentieth century. As more detailed studies were carried out by workers in the systematic sciences, it was seen that there were often many minor differences between regions that appeared superficially alike, and moreover, that many supposedly uniform regions could be even further subdivided.

There followed a period in which detailed studies of very small areas—microgeography—were made in some numbers. One of the justifications for these was the proposed use of such studies as regional samples. The analogy here was being drawn between the sample and the population. One regional text book[5] was written based almost solely upon such sampling. Regional geography became more and more concerned with the further delimitation of regions and areal differentiation in general, rather than noting the similarities between one area and another.

Is it possible, under such circumstances, to prepare analogous area keys, based upon geographic regions? The nature of the area under study, both with respect to natural and cultural feature, is, of course, the governing factor, and the size of the area under consideration is critical. In other words, the less complex the geography of an area, and the smaller its size, the more likely one will be able to find counterparts elsewhere in the world.

There is little doubt that it would be impossible to find two separate areas in the world that are *totally* analogous. This is true if only natural features are considered, much less both natural and cultural features. Since *totality* of analogy appears difficult to attain, one begins to search for the highest possible *degree* of analogy.

In the preparation of an analogous area photo interpretation key, the factors to be considered are precisely those which would be taken into account in any systematic regional study. Certain geographic factors must be weighted more heavily than others, particularly those that are visible on aerial photographs.

The following is a simplified checklist of features basic to any such study:

Physical Features
- Topography
- Geology
  - Bedrock
  - Surficial
- Soils
- Natural Vegetation
- Climate

Cultural Features
- Population
  - Size
  - Distribution
  - Ethnic background
- Settlement patterns
- Economy
- Methods of Transportation

Thus, one can see that we are dealing with a minimum of a dozen variables, each one of which can be subdivided into numerous subtopics. Important factors such as the occurrence of Pleistocene glaciation, the presence of permanently frozen ground, the size and shape of the dwelling unit, principal crops, etc., are concealed under these more inclusive headings.

Heath,[6,7] Black,[8] and Churchill and Stitt[9] have considered the several aspects of preparing regional keys, particularly the concept of associative interpretation. Such keys are prerequisites to any analogous area study. In many cases the analogous area key for a denied or inaccessible area will simply be a regional key of a similar but accessible area. Consider, for example, the problem of preparing an analogous area key of Nepal.

The first step, in any case, will be the preparation of a general geographic analysis of the area with an emphasis upon possible regional divisions. In Nepal, it appears that there are three geographic regions:[10]

1. a northern region of rugged mountains with deep valleys, containing

glaciers and permanent ice fields at higher elevations,
2. a foothills region of more moderate relief, with snow only at highest elevations, valley walls and floors forested, some agricultural occupance on the valley floor,
3. an area of plains and low hills, densely wooded, with a sizable amount of land under cultivation, particularly in paddy rice.

The next step will be a detailed organization of the geographic factors peculiar to each landscape region: topography, climate, natural vegetation, and culture (according to the checklist described above).

On the basis of the criteria for each specific region, the key compiler is now ready to search elsewhere in the world for other areas where similar conditions prevail and for which aerial photographs are obtainable, or could be obtained.*

(Continuing the Nepal example:

Region 1: Three possible analogous areas present themselves: the Alaska Range, the St. Elias Range, and parts of the Peruvian Andes. These are listed in descending order in likelihood of securing adequate photo coverage. The Caucasus, a fourth possibility, is, of course, in a denied area.

Region 2: This area presents a more difficult problem in that the climate here is quite unlike that of comparable foothill regions in Alaska or Canada. Factors of latitude, elevation, as well as climate would have to be taken into account. It is likely that only along the eastern flank of the Andes would analogous areas occur for which photography might be available. World War II photographs, taken along the route of the Burma Road or the Assam-China route, might also be checked.

Region 3: The widespread occurrence of paddy rice in this area limits the search to south and east Asia. Close examination of the Philippine Islands should reveal analogous areas for Region 3. Photographs should be more readily available here than from Burma or other southeast Asian countries where other analogous areas probably exist.

The example of Nepal has been drawn from a very cursory examination of the geography of that country and the suggested analogous regions from general geographic information. An analogous area key, to be useful as well as reliable, must be based upon careful, detailed research in delineating the geographic regions of the area under study, and in precisely describing the important geographic factors of each region.

Once these critical factors are known maps showing the world-wide areal distribution of each factor must be prepared. If, for example, there are five significant factors for Region 1 above, maps showing the distribution of these five factors must be drawn. These maps, in turn, are superimposed to show precisely those areas in the world where all five of these factors occur in combination. Such an area or areas should possess a high degree of analogy.

The availability of aerial photographs† of such an area is another matter. Photographs may already be available through civilian or military sources. The key compiler, on the other hand, may suggest that missions be flown in an area to obtain analogous photographs, with perhaps accompanying ground surveys. This was, in part, the concept behind the German *Forschungstaffel.*

The successful preparation of an analogous area key, therefore, depends upon sound geographic analysis and mapping, combined with the acquisition of photographs and ground information of the accessible areas.

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* It is well to stress the elusive factor of availability in obtaining reasonably good aerial photographic coverage. The sample region *must* be available to the key compiler.

† This does not mean that ground photographs should not be sought out, for such photographs would be of considerable value in the preparation of an analogous area key.

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Photogrammetry Is Looking Up

The Use of Stellar Photographs in an Aerial Photogrammetric Application

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A RESEARCH program currently being pursued at the Mapping and Charting Research Laboratory is outlined in this paper. This work is sponsored by the Flight and All Weather Test Directorate of the Wright Air Development Center, contract number AF 33(616)–3448.

The Air Force has flight instruments and navigational and guidance equipment under continuous development. Many of these systems produce information about the heading and attitude of an aircraft in flight, to a reasonably good order of accuracy; of course, the objective of continuing programs is even more accurate systems.

In the case of navigational and guidance systems of the inertial type, the program includes serious efforts to reduce size and weight in the operational units without affecting the accuracy of the continuous flow of information. It is all very well to say that an item has a certain average or maximum error in operation, and such figures are usually offered by the manufacturer, having been extrapolated from quasi-operational bench testing situations. However, it is obviously very desirable to have test data taken under the actual operating condition, that is, from an aircraft in flight.

There has been required an independent source of attitude and heading information of a higher order of accuracy than that produced by the inertial systems. At least one organization has successfully used daylight photography of ground targets on a carefully controlled range to obtain this information. From this photogrammetric data roll, pitch and heading of the aircraft can be derived from the instant of taking the photograph, but continuous data cannot be obtained. It is possible, however, to take photographs at intervals of a few seconds, so that a fairly complete record of aircraft attitude and heading throughout a maneuver can be compiled. The necessary increase in accuracy over the inertial data is purchased with time: in place of a continuous and essentially instantaneous display of roll, pitch and heading, the photogrammetric system produces these results several days later. This general approach is satisfactory, because post-flight comparison of the photographically recorded readings of the inertial system output and the photogrammetric data can be made for any predetermined in-flight situation.

There is, however, a serious practical difficulty in this scheme. Flight testing situations involving long distances or com-