marginal control points were not used because the number of lakes contained on each vertical was judged sufficient for control. Thus the geological data were projected on the base map in the same manner as the topographic data, using the same verticals and the same projection instrument.

The method used permitted a six-fold reduction (for final publication) for over 80 per cent of the data obtained and which was generally located accurately as individual outcrops.

AIR PHOTOGRAPHS IN GEOLOGICAL MAPPING OF CORDILLERAN REGION, WESTERN CANADA*

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I HAVE used air photographs a great deal in connection with geological mapping in the mountains and interior plateau country of B.C., and in the Foothills of Alberta where the mapping was done as an aid to oil prospecting. Most of this mapping has been done for publication on a scale of one inch to one mile, when I have been provided with a topographical base map on a scale of two inches to one mile with the principal point of each picture plotted. I consider the photographs almost indispensable.

The main uses are:

1. Preliminary office examination.
2. Use in the field.
   (a) Planning traverses.
   (b) Plotting boundaries of outcrops.
   (c) Obtaining a rough idea of rock types.
   (d) Plotting of geological boundaries.
   (e) Interpreting structure.
   (f) Extrapolating geological boundaries and structures between traverses.
   (g) Physiographic studies.
3. Use in office compilation.

The photographs supplied for mile to the inch mapping have a scale of about 1500 feet to an inch and cover an area of about two miles square. The flights overlap by about one-third and each photograph in a flight overlaps about two-thirds. When the photographs are viewed in a stereoscope each photo is used, but when they are used without a stereoscope it is only necessary to use each alternate photograph.

1. *Preliminary office examination.* Before leaving for the field it is useful to examine the photographs to get an idea of the amount of outcrop, kind of structure, and amount of dense forest, swamp, and burn. This helps in planning the party and equipment, and the geologist goes to the field with a mental picture of the area.

2. (a) *Planning traverses.* In camp, the photographs for the next few days' work are studied carefully with a large folding stereoscope. Outcrops and large areas of exposed rock (either cleanly-burnt areas or areas above timberline) are noted, and either transferred to the work sheet or the photograph itself may be carried on the traverse. Thus, instead of running a straight traverse and hoping to find rock, the traverse is planned in a zig-zag fashion that will be sure to encounter rock and to cross the structures in the most suitable manner. It is

* Base maps were available.

never safe to assume that, because rock is not seen on a part of a photo, no rock exists. There are always some small outcrops that do not show, but by using the photographs the number of "blind" traverses is kept to the minimum. Traverses can also be planned to avoid swamps and windfall.

2 (b) *Plotting outcrops.* On most of the maps I have made, outcrops less than 100′ in diameter are shown by a cross and the boundaries of larger outcrops and areas of fairly complete exposure are shown. These can be determined more accurately by inspection from the photographs than by pace-compass-barometer traverses, and as accurately and much more quickly than by plane-table. In accurate structural mapping, however, it may be necessary to use the plane-table to get accurate determinations of elevation.

Small outcrops are regarded as points, and marked by a cross or circle, using red or yellow pencil during traverse or ink in camp. Blue or black pencil or ink is better for the light grey parts of photographs. The point is also pricked through with a needle. Then on the back of the photograph the prick is encircled and given a station number. Short notes may also be written here. Larger outcrops may or may not be outlined on the photographs by coloured pencil or ink.

Sometimes a pocket stereoscope is used while traversing, but often it is unnecessary.

The method of transferring information from photograph to base map will be explained here. It also applies to Sections d.e.f.g. If the point is very close to a known point common to both photograph and map, it may be plotted by eye or by scaling, using the approximate scale stamped on the back of the photograph. Otherwise, tilt, etc., may cause distortion. Two fixed points, such as principal points of photographs, stream intersections, islands, intersections of cut lines, etc., are selected and joined to form a base line, both on the photograph and on the map. From the ends of the base line rays are drawn to the desired point on the photograph. The angles between these rays and the base line are transferred to the map by protractor or tracing paper and the position of the desired point is obtained by intersection.

In transferring outcrop boundaries, a few points are determined and the boundary drawn by eye.

(c) *Obtaining rough idea of rocks.* It is often possible to determine the general character of rock from the photographs. Massive limestone is generally separable from other types of sedimentary rock. Granitic rocks can often be distinguished. This never takes the place of study on the ground, but is useful in affording a preliminary idea of the geology.

(d) *Plotting geological boundaries.* Geological boundaries can often be seen crossing areas of bare rock. If such a boundary is exposed across a series of outcrops, or continuously across a large area of bare rock, it can be transferred from photograph to map just as accurately and much more quickly than it can be surveyed. Stations can be pricked through and recorded on the back.

(e) *Interpreting structure.* One of the most important uses of photographs lies in the fact that larger folds and faults are often excellently illustrated on the photographs. The photographs give a birds'-eye view that cannot be obtained in any other way, but sometimes can be approximated when standing on a high point. Sometimes the photographs afford structural information that would have been entirely missed if mapping had depended solely on traversing.

(f) *Extrapolating between traverses.* When geological boundaries and structures are exposed on photographs, traverses can be spaced farther apart and the intervening information extrapolated accurately, and still result in a better map than could be made by closely-spaced traverses without the aid of photographs.

(g) *Physiographic data.* The photographs are very useful in studying glaciers, plotting boundaries of glaciers, and in spotting and plotting moraines and terraces, etc.

3. *Use in office compilation.* The chief use in this connection is in checking doubtful points and in renewing one's mental picture of structures, during final preparation of map and report.

In four-mile and reconnaissance mapping the application is similar, but photographs are even more useful because this work is done with a minimum of traversing, so that wider extrapolation and inference from photographs is justifiable. As the number of photographs covering a four-mile map area is much greater it is generally desirable to go over the photographs carefully before going to the field, and to take only those that show geological features.

Much of the mapping done by oil geologists in Alberta is done without the aid of base maps. They use the photographs instead of a base map, plotting all their information on them or on the back by pricking. Small, selected areas are surveyed by plane-table. Later, in the office, they make a map on the scale of the photos by tracing. Such a map has a good deal of distortion but gives a good picture of the geology. If this work indicates a really favourable area they will return and make an instrumental survey and more detailed geological map before locating a well-site.

AERIAL PHOTOGRAPHS AS AIDS IN STRATIGRAPHIC STUDIES

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INTRODUCTION

AERIAL photographs represent an invaluable, if not indispensable tool for geological investigations of the nature and distribution of stratified rocks—studies which comprise the branch of geology known as stratigraphy. Because stratified rocks are extremely widespread at the earth's surface and because their composition, thickness, sequence, and structure have a bearing on most types of engineering and economic geology, the work of the stratigraphic geologist is fundamental for many of the practical applications of geologic science. Insofar as photos aid this one branch of the science, they are indirectly of service to other branches as well.

Nature of stratigraphic studies. In any area where stratified rocks crop out or are concealed only by unconsolidated materials such as soil, loess, dune sand, glacial drift, and the like, the first objective of stratigraphic study is to determine the composition and arrangement of strata with respect to one another. First, it is necessary to determine the order of succession of the rock layers, and then to ascertain the thickness of each significant division of the succession. Commonly the layers of like composition and texture that occur together are grouped together and defined as a map unit called "formation," provided the similar strata have sufficient aggregate thickness to suit classification for mapping purposes on a selected scale. A formation also may include dissimilar kinds of rock layers, provided they represent essentially uninterrupted sedimentation or accumulation and accordingly do not include strata of greatly differing age. It is a task of the stratigrapher to classify and define these divisions, and for purposes of description or other reference to apply a geographic name to each recognized formational unit. In case formations have been differentiated by