THE USE OF AERIAL PHOTOGRAPHS IN A TROPICAL COUNTRY (SURINAM)

A SYMPOSIUM BY

Jan I. S. Zonneveld. D.Sc., Geologist, acting head of Central Bureau for Aerial Surveys, Paramaribo; Albert Cohen, M.Sc., Geologist of the C.B.A.S.; Dammes Heinsdijk, For. Eng., Forester of the C.B.A.S.; Jacob J. v. d. Eijk, Ped. Eng., Pedologist of the C.B.A.S.; Bernard J. Beltman, Topographer-photogrammetrist of the C.B.A.S.

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1. GENERAL

Jan I. S. Zonneveld

IN 1947 and 1948, the K.L.M. (Royal Dutch Airlines) carried out a complete aerial survey of the northern part of Surinam under the auspices of the Development Agency Surinam. A total area of 80,179.2 km^2 was covered by 10,469 vertical photographs on a scale of 1:40,000. Moreover 6,815 verticals on a scale of 1:20,000 of the coastal region were taken simultaneously. See Figure 1. Finally the K.L.M. composed controlled mosaics on a scale of 1:40,000 and 1:100,000.*

In this way this country obtained a valuable tool for topographic mapping and for assisting in inventorying its natural resources by means of photo-interpretation.

Due to the fact that only during the last few years have air photographs been available, photo-interpretation in Surinam has only recently passed beyond the initial stage. Nevertheless it may be of some value to describe briefly the methods and the principles, partly because the organization of research chosen in Surinam seems to be in some respects a new one, also because until now only a few published reports are available on the use of aerial photographs in the tropics, and finally because this paper may induce valuable comments being made by other investigators working with aerial photographs in tropical regions.

In most countries, where research is done for topographical, geological, forestry or pedological purposes, each photo-interpreter is a member of his specific department. In Surinam, however, the photo-interpreters working in the several branches of investigation are brought together in one organization, the Central Bureau for Aerial Surveys (Centraal Bureau Luchtkaartering).† The

* Besides this collection Surinam has at its disposal some twenty trimetrogon strips, made during World War II by the U. S. Air Force. The usefulness of these photographs, however, is reduced by the fact that there is often no coverage between the strips. Moreover the photos show much cloud and the available prints are mostly of poor quality (Reference 2).

† This Bureau was founded in 1948 because of the suggestion of Dr. A. L. Simons. Its staff consists of a head, a forester, a geologist, a pedologist and a topographer-photogrammetrist to which some junior topographers and draftsmen are attached.

task of this Bureau is to carry out a systematic interpretation of the photographs. This type of organization was selected because the geological, vegetal, pedological and topographic elements that may be studied in aerial photographs are not separate objects like the merchandises in a market stand, but assembled ones form a unity—the landscape—in which these elements are closely interrelated. The geologist in studying aerial photographs benefits from discussions with an expert in the investigation of vegetal types; the forester profits from coöperation with the pedologist, who obtains valuable aid in his work through

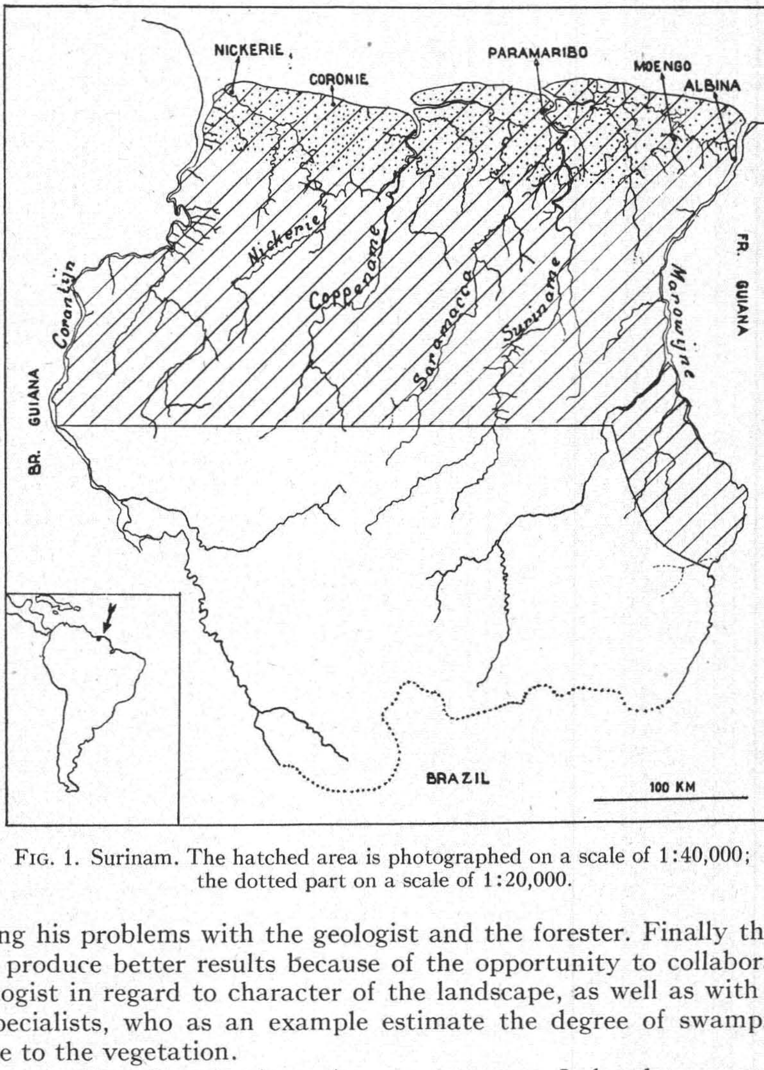

FIG. 1. Surinam. The hatched area is photographed on a scale of 1:40,000; the dotted part on a scale of 1:20,000.

discussing his problems with the geologist and the forester. Finally the topographers produce better results because of the opportunity to collaborate with the geologist in regard to character of the landscape, as well as with the two other specialists, who as an example estimate the degree of swampiness by reference to the vegetation.

These considerations in themselves are not new. It has been stated many times that the geologist who interprets the photographs should have some knowledge of vegetative types to do his job most effectively. The U. S. Geological Survey has even included some botanists in its organization. But in the Central Bureau for Aerial Surveys in Surinam, the botanical specialist (a forester) is included in the team to assist the geologist, and to apply the photographs for his own specific purpose. Because the forester and the geologist are working together in one organization, there is a constant exchange of data and experience that yields important mutual benefits. During the short time this team has been operating, it has been proved that the coöperation of representatives of the different sciences and the pooling of their knowledge assists in the solution of their specific problems and yields mutual inspiration for the work of the individual members.

It is obvious that for the interpretation of photographs, work cannot be fully achieved at the stereoscopic-table in the office. Studying aerial photographs without field control is similar to trying to diagnose a disease by looking at the patient from a distance and without other general observations on the human body. Occasionally it will be possible to come to the right conclusion, but in many cases the absence of contact with the reality will be a serious weakness and may lead to mistakes. For that reason the photo-specialists of the C.B.A.S. organize field parties, sometimes with their team colleagues and sometimes with the officers of the special Government Services with whom they work in close coöperation.

Generally speaking the task of tracing and exploring the natural resources of a country may be divided into (1) more or less preliminary general reconnaissance and (2) more detailed explorations. Photographs on a scale of 1:40,000 are especially suitable for the first mentioned type of work. Because the systematic study of the aerial photographs in Surinam has been delegated to the C.B.A.S., the activities of the members of this Bureau are especially aimed at the general reconnaissance.

These investigators do not enter into field details except where the study of the photographs make this possible or where necessary in solving special problems in the interpretation of the photographs. In this way they try to supply the officers of the other Services with general outline maps. The relation of the work of the C.B.A.S. team members to that of their colleagues of the specific Services is that of reconnaissance patrols to the advancing army.

As already mentioned, photo-interpretation in Surinam started only a short time ago. As most of the existing literature does not deal with problems encountered in the tropics, the C.B.A.S. members are forced to determine their own working methods. Many problems still must be solved. Therefore the following chapters deal only with the trends of some of the investigations and activities of the photo-interpreters and the difficulties they have met.

II. TOPOGRAPHIC MAPS

Jan I. S. Zonneveld and Bernard J. Beltman

The first requirement in any investigation of a country's resources is a topographical map. This nearly everywhere is the first reason for an aerial survey. This was the case in Surinam, where the following procedure has been followed:

The Phototechnical and Cartographical Department of the K.L.M. (Royal Dutch Airlines) photographed the northern part of the country* on a scale of 1:40,000; 26 points in the field were fixed by astronomical methods;† and

* For the surveying of the southern part a decision has not yet been made.

† The time required for the fixation of any of these points (astropoints, base and azimuth) varied with the position of these points in relation to the cultivated area of the coastal plain. In this region traveling is comparatively easy, if one sticks to the roads or the rivers. Accordingly the time required for the measurement is practically determined by the number of clear nights. The fixation of the astronomical points in the interior, however, where no roads are present and traveling is seriously hampered by waterfalls and rapids, required much more time. For instance, the expedition sent for the astronomical survey of the points O and L needed 4 months; the expedition included a staff of 5 members, about 20 trained laborers from Paramaribo and a fleet of corjals with approximately 80 natives as rowers.

controlled mosaics on a scale of 1:40,000 and 1:100,000 were prepared with the aid of combined aerial triangulation and slotted templet methods. Using these mosaics, topographers in the office of the C.B.A.S. and in the Bureau of Lands (Domeinkantoor), are engaged in drafting topographical maps on a scale of 1:40,000. The mosaics on the scale of 1:100,000 are used in drafting a preliminary map on 1:100,000; this shows only the chief topographical features and will serve as a synoptical map.

Maps of smaller scales are also being prepared in order to replace the existing out-of-date maps. Because the mosaics delivered by the K.L.M. are fully controlled, it is not necessary for the topographers to consider special photogrammetric problems. The picture they see in the mosaics, especially in the flat regions, is of the right scale and they only have to copy it on a sheet of kodatrace that has been fixed with tape over the mosaics. Stereoscopic images may be obtained by using the controlled mosaics in combination with the loose photographs forming stereoscopic couples with the photos that after rectifying were used in making the mosaics. After drafting this preliminary topographic interpretation map the topographer makes a field check. If possible in this difficult country he visits the spots where he experienced difficulties in the map preparation and he tests at random several other spots comparing the photographic image with the ground conditions. In addition he makes notes concerning such as is not shown in the photographs—names of villages and creeks, the location of milestones etc. In the office he prepares one final map that may serve as the basis for the printing.

The interpretation of roads, railways, canals, large rivers and buildings is discussed in practically all handbooks on phototopography. There is, however, an instructive and interesting example in the history of map making in Surinam that illustrates the necessity of field experience.

Long ago, around the border of the plantation region a "Cordon" was laid out to intercept the attacks of the escaped slaves. This cordon consisted of a series of lightly fortified points, connected by a path, the so-called "Cordonpad." These small fortifications have long since fallen into decay, but locally the path is still present; where situated in the savannahs, it is nearly in its original form, a straight sandy trail. In the forest areas, however, it has nearly disappeared. When drafting the U. S. World Aeronautical chart, with the aid of the trimetrogon photographs of the U. S. Air Force Survey, the interpreters oversea, missing the opportunity to check their conclusions in the field, interpreted the remnants of the trail as a traffic road, a secondary one. This mistake is understandable, but it stresses the importance of field observations.

On the same map another mistake was made in regard to the recognition of the character of the landscape. Some of the areas where dry *savannahs* occur have been indicated by the symbol for swamps and marshes. Actually these savannahs are dry sandy regions with shrubs and some hard grass where the white sandy soil is nearly always visible through the thin vegetation cover. Some of them have a clayey soil and a smoother grass cover. The distinction between some of these clay savannahs and *open grass swamps* in the older part of the coastal plain may create difficulties, but if the vegetation gives no opportunity to draw a conclusion the forms of the limitations may yield information. The savannahs forming the slightly higher parts of the area in consideration, have been entrenched by small valleys, grown over with trees. Due to this vegetation the boundaries of a savannah have a character as shown in Figure 2a. The swamps, however, are lower than their surroundings; often they have the character of inundated valleys. Due to this, their boundaries often show forms as given in Figure 2b.

The distinction between the forested swamps, the forested marshlands—dry only during the dry season—and the forested *dry parts* of the country must be based on the differences between vegetation types. Also this method needs ample experience based on reasoned observation in the field. It is hardly necessary to observe that the specialist in the study of vegetal types may play an important role in increasing the experience of the topographers.

The best way to utilize the contact between the topographers and the vegetal-type-specialist (the forester of the team) is to combine their field parties. While the forester measures the trees, the topographer checks the map that may serve as a base for the investigations of the forester (as well as those of the geologist and the pedologist) and in the meantime there is an opportunity to discuss the different problems that are met.

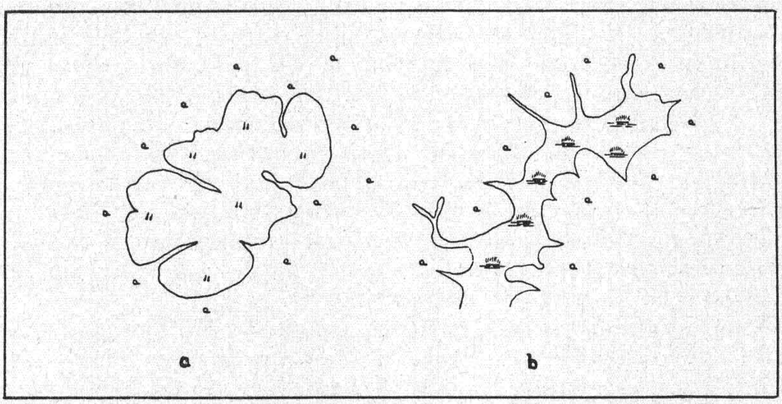

FIG. 2. The difference in forms between a dry savannah (a) and a swamp in the older coastal plain (b).

Another difficulty in the phototopographical mapping of the flat coastal region in Surinam is caused by the *smaller rivers* often being screened by the crowns of the trees. As no hill slopes mark the presence of a valley bottom, the investigator has to take the vegetation into consideration. Often—but not always—the rivers and creeks are accompanied by more or less broad zones of forest types that differ in some respects from the types present at some distance from the creeks. This shows that mapping a river may also require the proper evaluation of forest types. It is evident, however, that it is not possible to follow all the individual bends and meanders of these hidden creeks. In most cases we must be content with a dashed line indicating the approximate course of the river.

Trying to survey in the field all the hidden details such as creek bends would take nearly as much time and money as a complete ground survey without the help of aerial photos. The advantage of speed afforded by the aerial photos would be lost in order to secure some desirable, but not indispensable accuracy.

In hilly country the position of the creeks may be roughly indicated by the valley bottoms. But it is not always possible to rely upon this because sometimes the area is dissected between the hills so that a network of rather broad valleys has been formed without much difference in height. It is rather difficult to determine the direction of flow of the creeks below the forest in these valleys and to locate the watersheds. Often the geologist of the team has to apply his knowledge of stream patterns and practices in the search for the most likely solution.

With regard to the designation of *hills and mountains* it must be kept in mind that the contours on the image obtained from a stereopair are not the contours of the hill surface but of the forest surface. This may be 50 to 100 feet higher than the ground surface dependent on the character of the forest type. The drafting of contour maps therefore requires knowledge of tree heights. The most efficient way to obtain the necessary tree height would be by measuring it with the aid of a parallax meter. Unfortunately only very seldom is it possible to see the ground in the photographs. If the forest is interrupted by a large river we may measure the vertical distance between the water surface (sand bars or shadows may permit stereoscopic viewing) and the tops of the trees. But this distance is not necessarily the true tree height as the bank on which the trees are growing may be several meters high. Moreover, the vegetation type on the river bank may be different from that in the more inland regions.

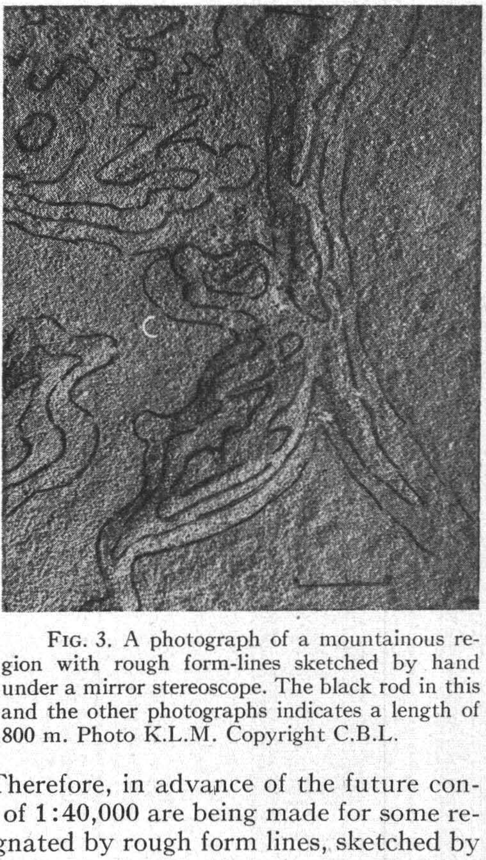

FIG. 3. A photograph of a mountainous region with rough form-lines sketched by hand under a mirror stereoscope. The black rod in this and the other photographs indicates a length of 800 m. Photo K.L.M. Copyright C.B.L.

Before using clearings in the forest for parallax tree height measurement, the investigator must be convinced that he really sees the ground and not the surface of secondary vegetation. This aid, moreover, is available only in limited areas along some rivers where villages occur and crop fields have been laid out. In most cases the data on tree heights must be obtained from evaluations by the forester.

In the interior of Surinam practically no data are available on the height of the terrain for use as control points. For obtaining a base for contouring it is therefore necessary to carry out a time-consuming aero-triangulation for all the photographs using special instruments.

The exploring services, however, need maps, delivered in a short time. Therefore, in advance of the future contour maps, preliminary maps on a scale of 1:40,000 are being made for some regions. The hills and mountains are designated by rough form lines, sketched by hand under the stereoscope (Figure 3). A comparison of such a map with a contour map, drafted in a Universal-stereoplotting-machine (Wild A 5) by the Phototechnical and Cartographical Department of the K.L.M. showed an encouraging resemblance.

In the coastal plain, large areas are occupied by plantations, the greater part of which were abandoned long ago. In these plantations many *dams and trenches* are present. It is not possible to map on a scale of 1:40,000 all these trenches and dams; these sometimes have or had a primary function or are only the result of another construction.* We indicate them only if they really

* If a dam had to be constructed a trench had to be dug beside it to obtain the clayey materials; on the other hand the digging of a trench practically always had as a result a dam of thrown-up ground.

have or had a primary function. This requires some knowledge concerning the laying out and the irrigation system of a plantation. In most cases the plantation boundaries are formed by dams that have the function of weirs, whereas the lines, visible within the plantation mostly represent trenches that have or had the function of drainage-channels and/or transport routes.

Rice fields in the coastal area may be recognized by the square or right-angular forms of the parcels; *regular crop gardens* (especially on the photographs on a scale of 1:20,000) by the occurrence of beds. On the other hand the *crop fields with shifting cultivation* of the Indians and Bushnegroes have rounded forms, giving the primeval forest a moth-eaten aspect. Because they are only used for a short time and, after some years abandoned and overgrown by second-

FIG. 4. A part of an old plantation region along the Saramacca. Most of the plantations have been abandoned and are occupied now by groups of small farmers. The construction of the road permitted occupation of the region with sand ridges in the southern half of the pictured area. Soil differences are visible by the change in vegetation and land use. Photo K.L.M. Copyright C.B.L.

ary forest, there is no justification for drafting these individual crop fields on the topographic map; only the boundaries of the regions in which this shifting cultivation has been put into practice are delineated.

SUMMARY

The exactness of the map drafted by means of phototopographical interpretation, especially in the regions outside the cultivated areas of the coastal plain, is obstructed by the presence of the tropical jungle. Firstly, because the forest cover screens nearly all details of creeks, etc. and secondly, because it hampers the carrying out of field control to an important extent. For this reason the maps in their present state in some respects may bear the character of preliminary maps. Nevertheless they have an important function in the exploration activities in Surinam because they give the explorers far more detail than the old maps on a scale of 1:200,000. These maps were the result of the tough jungle work of enterprising and persevering surveyors; but they have the drawback of being made before the existence of organized aerial surveys.

III. GEOLOGICAL RECONNAISSANCE

Jan I. S. Zonneveld and Albert Cohen

A geologist, accustomed to investigate aerial photographs of the kind that have been published in the handbooks dealing with photogeology, will be disappointed if he glances at some Surinam photos chosen haphazardly. Most of the Surinam photos show only more or less monotonous, lightly dissected areas covered with dense forest.

Sometimes it is possible to perceive some directions in the arrangement of hills and vegetation patterns, but only very seldom a real dipslope is to be found or a fault to be traced. There is indeed an important difference between the famous photographs of anticlines in oilfields in the U.S.A. or the barren rock bottoms of some parts of the Canadian shield and most of the photos of the Surinam jungle.

Yet it would be a wrong conclusion to assume that photogeology is impossible in Surinam, for it has been proven that in spite of the unfavorable conditions, geological interpretation of the photographs may be an important expedient for geological reconnaissance. It is only necessary to know the limitations specific to the method, especially those that are imposed by the investigation of photographs of densely forested areas in shield regions, and not to ask more detail than such photos afford.

The geologist using aerial photographs to obtain geological data concerning certain regions has sometimes been compared with a botanist using his magnifying glass or a petrographer using his microscope. But there are differences as to the possibility of composing and using determinative tables comparable with those used for determining plant species by counting stamen and petals, or recognizing minerals by means of the refractive index, birefringence and pleochroism. Each region and each climate has its own peculiarities in regard to the way in which the differences between rock types manifest themselves in aerial photos. Moreover geologic mapping nearly always has to deal with local lithologic characteristics which are typical for that special region; finally, the more morphological circumstances are of importance:

It is true that the occurrence of lithologic differences of out-cropping rocks may cause cuestas, hogbacks, "dipslopes" monadnocks and other morphological forms, but not all land forms bear such a close relation to lithologic differences. The earth surface shows also other forms such as marine and fluvial terraces, natural levees, drumlins, glacial troughs with or without shoulders, superimposed and antecedent valleys, pediments, piedmont benches and other features that certainly do not owe their existence to the presence of differences between hard and soft rocks.

The stage in the morphologic cycle, moreover, in many cases plays an important role in the measure in which lithological and many structural features are allowed to manifest themselves in the land forms. The same has been expressed in other words by Smith (Literature 3) who states that geomorphology requires more emphasis than has previously been given because there are many pitfalls in photogeology for the investigator who is unwary in regard to distinguishing between forms that are produced entirely by erosion and deposition and those which are controlled by structure. Smit Sibinga (Literature 4) even goes further and states that it is not the right way to start with the geologic interpretation and end with the geomorphic, or treat the geomorphologic interpretation only as something that is of secondary interest. He stresses that it is absolutely necessary to study the morphologic relations before reliable information can be obtained regarding structure and lithology.

Moreover it seems that some massive rocks, for instance granite, show up differently in the photographs according to their occurrence either in flat areas, hills or mountains. Finally it is generally known that one may recognize the rock types not only by the land forms but also by differences in the vegetation. This vegetation, also may change in character according to differences in topography, the height above the ground water level and the elevation of mountainous regions above sea-level.

When starting a systematic photogeological investigation of a certain region it would, therefore, be useful to compare the ways in which the rock types behave in different circumstances. The reader will take for granted that, during the time photogeology has been applied in Surinam, it has not yet been possible to acquire a complete insight in these correlations. We can do no more than briefly describe the working scheme and the methods by which we are trying to perform the task, and state where we think we have made some progress.

The outstanding work on the geology of Surinam is that of IJzerman (Literature 1) published in 1931. Since then no synoptical publication has appeared. Later, in 1943, the Geological Mining Service was established. Since that time detailed field work has been started. It was felt necessary, however, that besides this detailed mapping a more general geological reconnaissance map should be made. The first task with regard to the general reconnaissance was to put all the available data, collected during former expeditions and by the geologists of the Geological Mining Service, on a sample map with a scale of 1:100,000, for which the preliminary maps drawn with the aid of the controlled mosaics serve and—if these mosaics are not yet available—with the aid of the old topographical map on the scale of 1:200,000. This work, started by the Geological Mining Service has been continued by the geologist of the C.B.A.S. It must be stated that this sample map is rather unreliable in regard to the position of the samples because the older collectors and investigators had no good maps at their disposal. Furthermore most of the samples were taken along the great rivers and in only a small number of traverses in the interfluvial regions. Accordingly from tens or several hundreds of square kilometers no rock samples are available.

The general working scheme as far as it bears relation to the geology may be indicated as follows:

1. Drawing by the topographers of a preliminary topographical map on a scale of 1:40,000 (Cf. Chapter II of this symposium).
2. Geological interpretation of the photographs in the office with the aid of experience obtained during earlier field trips.
3. Field reconnaissance during which the photographs are used as maps, and checking of the maps resulting from 1 and 2 by the topographer and the geologist.

Owing to the fact that the *coastal plain* lies relatively close at hand and the controlled mosaics of this region were the first available, it was possible to start with the compilation of a geological outline map of this part of the country. The sand ridges occurring in this swampy territory—of great importance for agriculture, settlement, traffic and a host of other uses—could be surveyed with the aid of the photos and only relatively little field work. From the moment that, due to this interpretation of the photographs, the geographical distribution of the sand reefs, their different forms and their relation to the several rivers was known, certain ideas arose concerning their genesis. To check these ideas and to collect more data, symposia were convened where staff members of other Services were brought in to discuss data such as drilling profiles, sand analysis, leveling records and other observations. These meetings proved to be very fruitful and gave rise to interesting and enlightening discussions.

Other topics that could be studied with the aid of the aerial photos of the coastal region are the occurrence of erosional and accretional phenomena along the coast, changes of the coastline, old courses of several rivers, measurements of the ratio between river-width and the width of the meander belt (Literature 5).

In the same way, by using the available data of other Services as well as the photographs, it was possible to distinguish two different levels in the coastal plain which show certain morphological and stratigraphical differences. The general results of these investigations still have to be worked out in more detail, but the importance of the analysis of aerial photographs for geological reconnaissance mapping has already been proven by facts.

Behind the coastal plain a zone with "*continental alluvia*" ("Zanderij series") is present—sometimes called the "first savannah zone" or "-guirdle," although the savannahs cover only a relatively small percentage of the entire zone. On the basis of vegetation it is possible to distinguish the clay-savannahs from the sand-savannahs. In some of these savannahs structural features of the underlying rock may be detected, especially the savannahs situated along the southern border of the zone, where the sandy cover is rather thin.

The rest of Surinam is occupied by a crystalline basement of probably precambrian age and chiefly consisting of igneous rocks and metamorphic sediments.

The only exception to this rule is the occurrence of the *Roraima formation*—a flat lying complex of sandstones and conglomerates with intercalated volcanics—in Surinam represented by the 1,091 meters high Table Mountain and its nearest surroundings. It has already been stated by Simons (Literature 2) that this formation may be distinguished easily by its vegetation and topography from the surrounding granites. It must be stated, however, that also within this Roraima area the vegetation shows up differences. The vegetation present on the plateau of the Table Mountain itself is, in general, much poorer and more scrublike than that of the sandstones at its foot. Perhaps these differences are due to difference in height, climate and/or differences in thickness of the soil cover.

As to the *granites* IJzerman mentioned (Literature 1) the occurrence of bare mountains and summits; later he supposed that these features might be important for recognition of granite areas on aerial photographs. Simons, after studying the trimetrogon strips of the U.S.A.F., however, had to report that the bare rock areas in the mountainous, as well as in the nonmountainous areas, are not so abundant as was suggested by IJzerman's descriptions. The new collection of vertical photographs confirms this statement. At any rate the occurrence of bare rocks can not serve as the only indicator of the presence of granite. Until now we have the impression, after comparing the photographs of some regions with the sample maps, that granitic areas may show the following features:

1e. The occurrence of numerous hillocks, arranged more or less honeycombwise, like the so-called "woolsack" topography. Simons considers this topography typical for most of the igneous complexes, where granites (and diorites) occur; indeed great stretches where granitic rocks have been sampled exhibit this topography.

2e. Other regions, from which it is known that granite is present, however, are characterized by a rather irregular forest vegetation in which the trees of the upper story do not form a serried cover. The vegetation gives the impression of growing on a rather poor soil. (Figure 5).

3e. Locally this vegetation may even be absent. In those cases apparently the soil has been washed away and the bare rock is visible. This phenomenon is especially observable on isolated mountains or peaks surrounded by flat country (Figure 5), and (although not to the extent that might be expected) on summits in mountain ridges, but also in flat areas which can hardly be called hilly.

It is not yet possible to explain these differences with the data now available. It will be necessary to obtain more data concerning the morphological character as well as the composition of the granites and the soils that have been derived

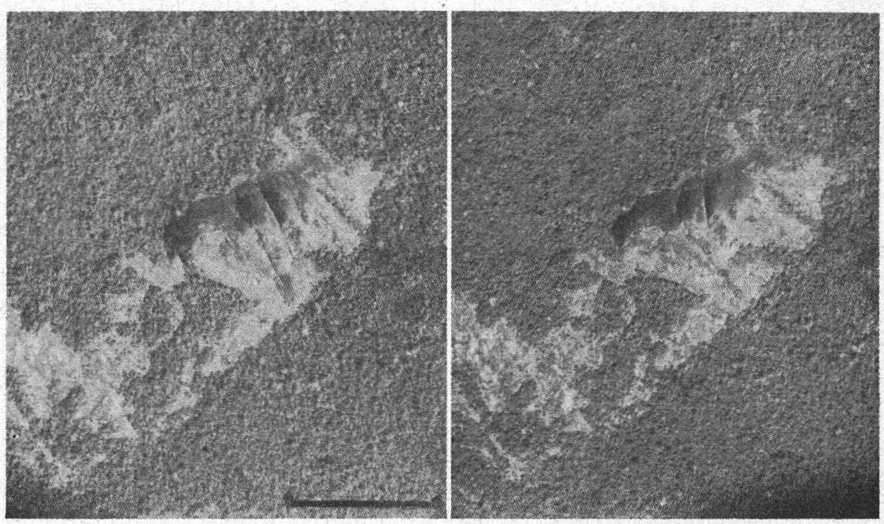

FIG. 5. The bare Van der Wijck-summit is a granitic mountain in a nearly flat granitic region. Note the irregular pattern of the forest. Photo K.L.M. Copyright C.B.L.

from them. It is significant that when photographs of a region with the irregular vegetation type mentioned in 2e, were investigated for the first time, the underlying rocks proved to be *diorites*. So close was the correlation that, without having seen the sample map, it could be predicted that in certain other areas diorites had to be present, a prediction that (in this case) could be affirmed by consulting IJzerman's data.

It is evident that several difficulties have to be surmounted and much experience has to be acquired, especially in the interpretation of photographs of the igneous complexes where granites may occur besides granodiorites, tonalites, and more basic rocks in nearly endless varieties and differentiations.

For the *younger basic igneous rocks* such as intrusive dolerites and gabbros, it has been possible to identify dolerite dikes if they form ridges in the topography; especially they are distinct in those granitic areas that show the "honeycomb" topography (Figure 6). They are practically always densely forested, even on the steepest crests and in consequence never exhibit bare summits. In the western part of Surinam, younger basic igneous rocks are present in the form of extensive sheets or lava flows, according to Simons probably running along old river beds. Simons (Literature 2) had the opportunity to map some of these flows from the U.S.A.F. photographs. They could be distinguished from the surrounding granites by their topography and the vegetation.

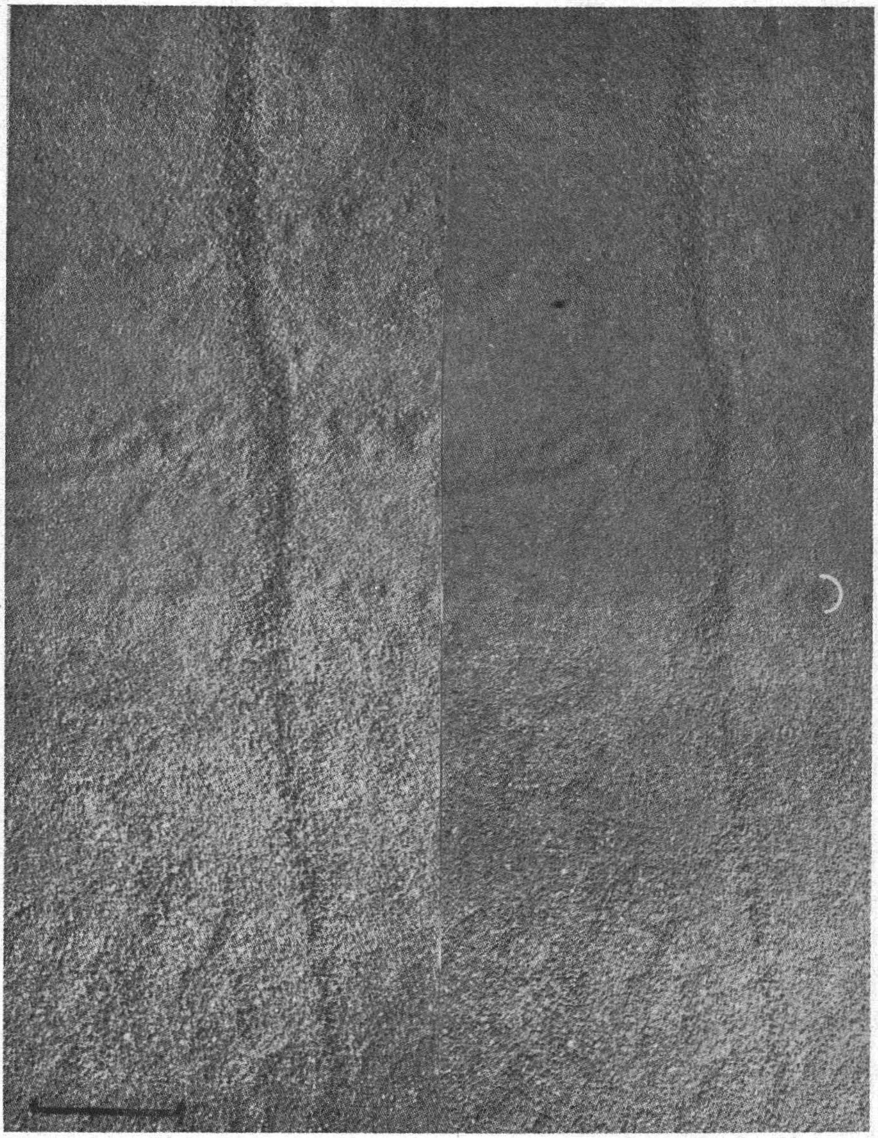

FIG. 6. Outcrops of apparently resistant layers and a dolerite dike. The southern part of the pictured area bears a different type of vegetation than the part where the resistant layers occur. Photo K.L.M. Copyright C.B.L.

The *paraschists* in Surinam are, generally speaking, to be distinguished from the granites and diorites by their morphological expression.

If they occur in hilly country, often the hillocks are sharper crested and steeper than those in granitic areas, and also in mountain ridges the forms are sharper. Moreover they sometimes show striking elongated ridges, due to more resistant outcropping layers and relatively beautiful structures. See Figure 6. It seems that some of the components yield soils that are favorable to the formation of savannahs (another type than those present on the continental alluvia). And finally it seems that sometimes dolerite dikes are not as well delineated in paraschist regions as they are in granitic areas, but we are aware that there are exceptions to this rule (Figure 6). Due to the detailed field work, and compilation of IJzerman's data, the geologists of the Geological Mining Service could divide up this series of paraschists into several groups. One of the first problems to be solved is to trace back these groups or some of them in the photographs. Considerably more field work will be required to reach this goal. As some parts of the paraschists appear to bear important minerals, it is thought advisable to direct our first efforts in this direction.

In regard to the joints and faults, it was possible to detect the directions of *diaclase systems* due to the fact that many of the smaller rivers follow angular

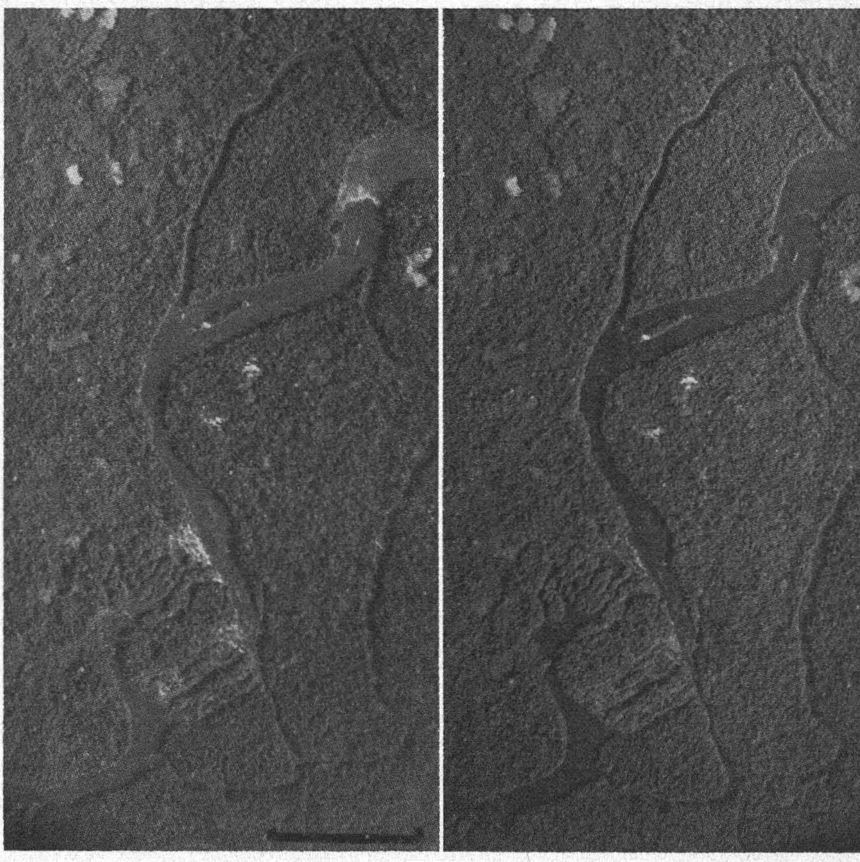

FIG. 7. Rapids in the Surinam river. The course of the river seems to be influenced here by the presence of a fractured zone. The two white spots in the center of the photographs are villages of natives, the other open spots are crop fields. Photo K.L.M. Copyright C.B.L.

courses that seem to be dependent on the presence of diaclases. Simons (Literature 2) already pointed to this possibility after studying photographs of the "honeycomb landscape" with granite basement. (See also Literature 6.) We found that also in the paraschist area diaclases (together with the strike directions) influence the river courses.

There is another matter in regard to the joint-and-fault-structure of Surinam that can be studied very easily by means of the aerial photographs, namely, the *directions of the various dolerite dikes*. This direction in the western part of the country is practically always SW–NE, whereas the dykes in the middle and eastern part all strike S–N.

Some photographs show features that must be interpreted as *faults*. Sometimes it is a channel-like straight course of a river, apparently following a fault zone (Literature 2 and 6) that attracts the attention; in other cases it is the straightness of a boundary between two areas with different topography and/or vegetation, the form of rapids in the rivers (Literature 3) or the fact that a dolerite dike has partly been moved aside, apparently by a faulting movement with a horizontal component. But not all faults are easily traceable; sometimes they can only be traced by the occurrence of "lines" with a certain direction in the vegetation, due to the fact that some trees seem to form rows. But we are aware that not all these barely visible lines are connected with faults, and that on the other hand many faults do not manifest themselves in the photographs.

The *geomorphology* of Surinam is very poorly known. With aid of the airphotos and future contour maps, however, it will be possible to study the morphological character of the regions. This study must, as expressed above, go hand in hand with the geological interpretation.

Until now it has been possible to recognize several plateaus with different altitudes and in different stages of dissection, from very "young" or apparently recently rejuvenated up to old. Some of them form remnants of peneplains, or piedmont benches or the like, situated around mountain massifs; others have the character of river terraces. The isolated granitic domes surrounded by nearly flat country represent interesting morphologic problems (See Figure 5) as do the rapids and falls with their various forms in the rivers (See Figure 7). The occurrence of ridges and other forms resulting from the way in which the several rocks and strata respond to erosion have already been mentioned.

It goes without saying that the use of airphotos is not restricted to reconnaissance mapping. The geologists in charge of the detailed work constantly consult them. First, because an airphoto has the properties of a map, though not always accurate as to the scale, but it is far more accurate in the representation of most topographical details than any maps drafted from them can be. And second, because the geologists have the opportunity to try to recognize in the photographs the geologic situation found in the field, and meanwhile to check in detail the reconnaissance map, drafted by the photogeologists of the C.B.A.S. with the aid of the photographs and relatively rough field work. This combination of efforts, whenever possible, has to go hand in hand with discussions between the two differently charged geologists in the area that is studied in detail. It affords a maximum of profit from the photographs under the existing circumstances, both for the detailed exploration and the reconnaissance work.

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IV. FOREST PHOTO-INTERPRETATION IN SURINAM

Dammes Heinsdijk

The northern part of Surinam is almost wholly covered by natural vegetation. The exceptions are some open swamps, bare spots on mountain summits, savannahs and certain cultivated areas. Nearly seventy five per cent is virgin forest.

At first the interpretation of photographs of tropical forests looks like a hopeless task. As a start one must know what is real (timber-wood) forest and what is "non-forest." There are in this part of Surinam several vegetation types with a thick cover of scrub and some small trees, very dense low forests with thin small trees, and palm forests. For valuation purposes the Forest-Service of Surinam measures only trees with a DBH (diameter breast height) of 10 inches or more. The vegetation type is called "forest," only when it has a majority of these bigger trees and a certain density.

Until now we have not had much time and opportunity to study the interpretation of the "non-forest" vegetation types; but it has been proven possible to recognize the following non-forest-types in the aerial photographs.

A. 1. Swamp and savannah scrub vegetation and especially brantimaka (*Machaerium (-Drepanocarpus) lunatum*) scrub vegetation in swamps, and Bisihoedoe (*Curatella americana*) on grass savannahs.
2. Low tree vegetation along savannah-borders, low tree vegetation of koffiemama (*Erythrina glauca*), Mirahoedoe (*Triplaris surinamensis*) and mostly also Bébé (*Pterocarpus officinalis*).
3. Low tree vegetation of Dakama (*Dimorphandra conjugata*) on savannahs.
4. Palm vegetation of Morisi (*Mauritia flexuosa*), Maripa (*Maximiliana Maripa*) and, mostly also Pina (*Euterpe oleracea*), kiskismaka (*Bactris minax*) and small bamboo scrub vegetation (some of these only on 1:20,000 scale photographs).
5. Moko-moko (*Montrichardia aborescens*) and brantimaka vegetation along river borders.
6. Grass vegetation in general.

The real difficulties present themselves with the interpretation of single trees and real forest types. After more than two years of intensive photo-study—about half of this time was spent outdoors—it can be said that under certain circumstances it is possible to identify a number of tree species of the Surinam forest. Recognizing a tree or a group of trees from an aerial photograph will never be the same as recognizing a cross or a circle drawn on a piece of paper. For example, it is easy to recognize on the photograph a group of Possum-trees (*Hura crepitans*, Rakunda tree) growing along the sandreefs in the coastal area of Surinam. However we sometimes see in the hills, a group of trees looking exactly the same as Possumtree, but we know that this group cannot consist of Possumtrees because this species does not grow on hills. As we have to deal with some hundreds of tree species, it will be evident that some of the bigger and many of the smaller ones look nearly or exactly the same on an aerial photograph. For the photo-interpretation of trees and forest-types it is therefore a first essential to know the topographic characteristics of the area under examination. During the first year extensive traveling through the whole northern part of Surinam below the falls in the rivers was necessary, to obtain experience in topographic photo-interpretation together with the ability to indicate the most outstanding vegetation types. As a result of this preliminary work we can now recognize the following *forest-types:*

B. 7. Mangrove-forest with Mangro (*Rhizophora mangle*) and Parwa (*Avicennia nitida*).

8. Swamp-forest in general, mostly being a dense forest containing trees with a small crown (3–8m diameter) and with little difference in tree height of the upper story, except in some easily recognizable types. In this group we can indicate.
   a. Matakki (*Symphonia globulifera*), Panta (*Tabebonia*) Bébé, (*pterocarpus officinalis*), Baboen (*Virola spec.*), Swampforest; the most commonly widespread type.
   b. Mirahoedoe (*Triplaris surinamensis*), nearly pure stands.
   c. Dakama (*Dimorphandra conjugata*) nearly pure stands on sandy soil; with many flat crowns (diameter 8–15m).
   d. Possumtree (*Hura crepitans*) nearly pure stands, full big crowns (15–25 m. diameter) mostly in the swamps along sandreefs and partly growing on these reefs.

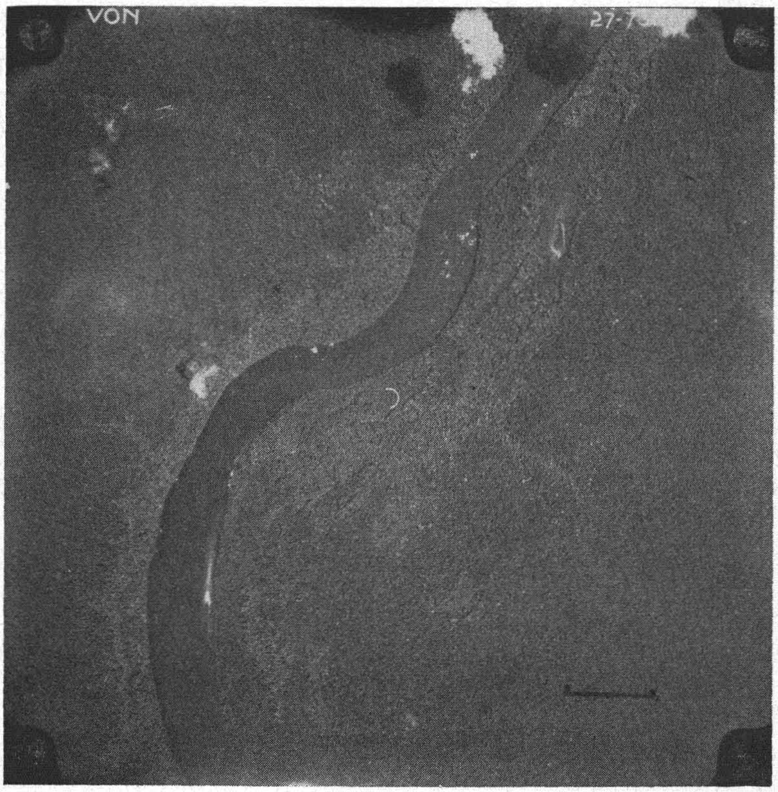

FIG. 8. Forest along the Corantijn with *Mora exelsca* complexes (the lighter parts). Photo K.L.M. Copyright C.B.L.

   e. Koffiemama (*Erythrina glauca*), irregular shaped crowns (8–15 m. diameter).
   These distinctions are already of great importance for our topographical work, because it is now possible to map the swamps under forest-cover in the coastal area with great accuracy.
9. Marshland-forest in general, mostly along riverbanks and higher spots in the swamps. This type is recognizable by a particular mixture of a few trees with broad crowns, and many trees with a small crown with relatively important differences in tree height. Under the stereoscope it looks like a very irregular broken forest. An analogous forest pattern may also be found on hills, but with the help of a stereoscope mistakes can be avoided.

Of course there are exceptions: The easily recognizable *Mora excelsca-forests*, for instance, growing along the marshy river borders in the Western part of Surinam, are homogeneous forests (Figure 8). Also the Foengoe (Licania spec.)

forests, which are found in the neighborhood of swampy areas. With some experience these are recognizable by the widespread flattened crowns of the Foengoe trees.

10. Forest on dry land. The majority of the forests of Northern Surinam are dry land forests with a large variety of tree species and several palms. In this group it is only possible to recognize a few outstanding and easily recognizable types, for instance, Walaba (*Eperua falcata*) forest on flat sandy soils and in hilly sandy areas; in comparison with the surrounding forest this type is very pure; Moraboekia (*Mora Gonggrijpii*) forest in hilly country in the western part of Surinam (also in nearly pure stands) and small areas with a majority of Kopi (*Goupia glabra*) trees. With regard to the other mixed forests it is, without further field work, only possible to give some indications about trees of the upper story.

In the beginning of our fieldwork we were not especially trying to find any relationship between the crown diameter and the volume of the trees. We merely tried to learn to recognize on the photographs the several tree species we found in the forest. At the same time, however, we had the opportunity to obtain data concerning the D.B.H. (if the tree had root swellings, measuring took place just above this swelling), the length of the merchantable bole and the diameter of the crown. In this way the volume of 2,900 upper story trees from the most different parts of N. Surinam were registered in the same way as practiced by the Forest Service of Surinam.

After working out these data it became evident that some very interesting indications could be found. The average length of the merchantable bole from all the tree-groups with the same crown diameter, for instance, was nearly the same, and there was a nearly linear relationship between the crown diameter and the volume of the merchantable bole of these trees. At the same time it was found that we have to deal with a large middle group of trees with a total height of between 20 and 30 meters, and with two smaller groups of lower and bigger and higher trees. Then we got the feeling that somehow it might be possible to give a rough volume estimate of the upper-story of this kind of forest.

After the first year it was concluded that with the aid of the photographs, maps could be made of the above mentioned forest types with relatively pure stands. With more experience and much more detailed fieldwork, it is deemed possible to map several other more mixed types. In accordance with the Forest Service of Surinam, a program was drafted and early in 1950 the mapping of forest types was started; at the end of that year, the mapping of an area of about 100,000 hectares (ca. 250,000 acres) has been completed. During this mapping, some fundamental information was gathered about the way in which this kind of work has to be performed. First a preliminary map was drawn with the help of a stereoscope and all forest types recognizable on the pictures were outlined. In the field this map was checked, and it became evident that it was possible to map many more types from the aerial photographs than were represented on the preliminary map. As a matter of fact, we concentrated our photo-interpretation work on a relatively small area wherein the different swamp-, marsh- and dry-land forests were closely related to each other, and no differences due to geographic distribution in a broad sense could be expected. In this way we had to deal with relatively few tree species, and especially with only a few outstanding trees in the upper-story of the types. To give a good description of the types it was necessary to make some strip surveys in typical forest of the type, the location of which in the field was exactly known. If the locality of a tree or a certain group of trees, well defined in the photographs, could not be retraced in the field, then it would be *impossible:*

a. To correlate the photographic image of outstanding tree species with the reality. Recognizing the tree itself without any means of orientation is very difficult because the photographs yield only the vertical pictures of the crown; the forester, traveling in the dense jungle sees only the underside, and sometimes the side of the crown.

As to retracing by means of other orientation points it must be said that open spaces in these types of jungle are rare. "Open spots" on the photographs are mostly areas with a 2–3 m. high "scrub" vegetation and what at the time of the photo survey really was an open area. For instance, a crop field of the inhabitants is often 3 years later grown over by a 5–6 m. high vegetation of young trees. When learning how to recognize trees in the photographs, one cannot rely on the view of trees that exceptionally may be obtained along river borders, the borders of open savannahs and alongside of other open spaces. We must measure tree crowns out of the upper story also, in the middle of the forest; therefore it is necessary to be able to locate them, even when natural orientation points do not exist.

b. To give an approximate percentage of the different species in the type to be mapped. There are too many tree-species to make possible a reliable ocular identification.

During the forest type mapping we continued the measuring of trees during which we not only gave attention to the length of the merchantable bole but also to the total tree height, in order to indicate more exactly the different tree height groups and also to obtain experience in the measurement of tree heights from the pictures especially in the forest types to be mapped. It is practically impossible to measure a tree height under the stereoscope because these forests have hardly any open spaces (see chapter II). Out of all the data that could be collected (about 5,200 trees), we composed some preliminary volume tables classified by crown diameter, volume of merchantable bole and tree height-classes: below 20 m. tree height (practically 15–20 m. tree height), 21–30 m., and more than 30 m. tree height.

In this way we got a preliminary table for all species in general, and special tables for tree species that we could indicate on the pictures in this relatively small area. We checked this table with the volume data of the strip surveys and found the following differences.

For swamp forest (14 strips, total 10,385 hectares), average difference 5.7% per hectare.

For marsh land forest (5 strips total 5,909 hectares), average difference 11.6% per hectare.

For dryland forest (17 strips total 18,244 hectares), average difference 5.4% per hectare.

As a result of this work we know that it must be possible to make a rough volume estimate of the upper story of the forests in Surinam through using only the crown diameter of the tree and an easily applied height classification. We found that it is possible to measure and count the tree crowns on 1:40,000 scale pictures from about 8 m. diameter and up.

In the strongly mixed dryland forests, the majority of the tree crowns of the upper story have a diameter of 8–15 m.; some smaller crowns of younger trees fill the open spots caused by fallen dead ones; and the bigger trees have large crowns of 18–25 m. (with exceptions up to 40 m.). This last group consists of the *remarkable* predominant trees on which we concentrate our photo-study to learn how to indicate some tree species, and with their help the forest types. In swamp forest it is only possible to measure tree crowns on 1:20,000 scale pictures as the crowns of our most common swamp trees are too small (3–8 m.) to be distinguishable individually in photos on scale 1:40,000.*

With the help of the aerial photographs we are now making forest type maps. As these maps have not been checked by the Forest Service of Surinam, we call them preliminary forest type-maps. As, during this work, we have to make strip- or plot surveys in the forest, we are able to do some research in the field of volume estimation from aerial photographs. We trust that in the future in one way or another we will be able to facilitate and accelerate the inventory of tropical forests by using aerial photographs.

SUMMARY

We know something about cruising in tropical forests without the help of aerial photographs and good topographic maps, and about the results obtained from this method of cruising. Compared with the costs, these results were few, whereas the forest maps were mostly not reliable. One was practically never certain that the wanted tree species or the best located forest area had been cruised, because there was no over-all picture available. The aerial photograph can give this over-all picture when we have time and money to learn to interpret these pictures properly. In the author's opinion it cannot be expected that all or most of the individual trees of a tropical forest can be identified from the photographs. He who tries to do this will be quite disappointed, and perhaps through his disappointment, he will acquire the opinion that aerial photographs have no value at all for forestry purposes in the tropics; especially if he should have the opinion that by using aerial photographs the tiresome traveling in the tropical forest may be replaced by "armchair forestry," the disappointment will be very great.

The value of the aerial photographs of the tropical forests is because the photos guide and extend our cruising; it is now possible to locate and delimit in an efficient way the forest types that must be studied. Largely before the aerial survey, we did not even know their exact location.

The photographs with the necessary field experience, properly interpreted, provide the opportunity to acquire rapidly a rough forest valuation for general purposes.

V. SOIL MAPPING FROM AERIAL PHOTOGRAPHS

Jacob J. v. d. Eijk

On the aerial photographs, the pedologist, like the geologist, seldom sees the image of his study-object, the soil itself; practically always he sees the vegetation covering this soil. Therefore the pedologist has to draw his conclusions about the soil from the image of this vegetation. Other sources of inquiries, visible on the aerial photographs are topography, geographic situation and, in agricultural districts, the manner of land utilization.

Although these last three factors may give important information concerning the soil-association (soil-province, soil-family) to which the area concerned belongs, the vegetation is by far the most important source of information for a more detailed graduation, as into soil-series.

* Harrison, J. D. B., 1950, "Planning a National Forest Inventory, F. A. O. Forest Products Studies no. 1. On page 39 it is stated that the scale of 1:40,000 is unfavorable and too small for forestry photo studies. We found, however, that in our (tropical) regions the 1:40,000 photos, made by the K. L. M. are really very useable, due to the fact that in the tropical forest the full grown trees are bigger on the whole than in the temperate forest.

It is a well known fact, that there is a definite relation between the natural vegetation of a terrain and the soil-profile underneath. In other words, every well-balanced natural vegetation has its special soil-profile, or in turn every virgin soil-profile bears its special vegetation. The geology of the terrain, the climate, soil-profile and vegetation have influenced one another, until the balanced position which we now meet in virgin areas, was reached.

Therefore the above mentioned relation is most evident in uncultivated areas; these areas in Surinam form by far the greatest part of the country.

The consequence of these circumstances is that the photo pedologist has to work indirectly; his survey has to advance in two steps, namely:

1. To investigate the connection of the soil-profile of a special terrain with the topography, geographic situation and vegetation.
2. To compare the photo-image of the terrain with this topography and vegetation, so that conclusions may be drawn about the soil-profile of this terrain and a soil map may be drafted.

PRELIMINARY INVESTIGATION

At this time, the soil survey with the help of aerial photographs has been under way for two years. In order to obtain some experience and to get an idea concerning the usefulness of aerial photographs for pedological purposes, several terrains were visited during the first period of these two years. With the help of the aerial photographs an exact orientation was carried out, during which the topography and the vegetation were observed. At the same time the soil profiles were studied by means of a great number of borings to a depth of seven feet. This survey was carried out in agricultural districts as well as in virgin woods; the most important result was that for ground with a natural vegetation, many more conclusions about the soil could be drawn from the photographs than in cultivated areas. This is clear when we remember what is said above concerning the relation between the natural vegetation and the soil profile of a terrain. For this reason, the survey was temporarily limited to the non-cultivated areas.

With the aid of the experience obtained in the second period, a number of vegetation maps was drafted from the photographs, and in close coordination with the forester of the C.B.A.S. On these maps as many recognizable vegetation-types as possible were distinguished. Afterwards the mapped area was cruised, so that the aerial photographs could be compared with the ground condition on the spot and the vegetation map could be corrected.

Of course, while controlling these maps in the field, many borings were made and the soil-profiles were described. The important result of these preliminary investigations was, *that many of the vegetation-types, recognizable on the aerial photographs appeared to correspond with special soil-types or soil-series, so that many of the vegetation-limits, drafted on these maps also represent soil-limits.*

Thus it appeared possible to draft soil maps by using the differences in the vegetation visible in the aerial photographs.

DRAFTING OF SOIL MAPS

This visibility was utilized for several areas, covered by a natural vegetation. The procedure was as follows:

a. *Preparation.* At first the photographs of the area were studied intensively. This examination included the topographic forms of the area and the vegetation-types which could be distinguished on the photograph. For each of these vegetation-types some typical terrains were selected which could be considered as a "sample," and which would be visited later. After that, the route of the trip was scheduled. In a month an area of 300 to 600 square km. can be cruised. Operating in this way, the field work is directed very well; in this jungle country, this is a great advantage as compared with the way of operating in former times when aerial photographs were not available and important spots were missed because the situation of the tracks only could be chosen more or less haphazardly.

b. *Fieldwork.* On the mosaic the starting point and the direction of the trails which must be cut through the forest (the so called "lines") are fixed.

In order to be sure of the position of the borings along these lines the starting point should be a well-recognizable spot on the photographs (such as a little open space in the forest, a very big tree at the river side). From this starting point the lines are cut towards other recognizable points. The lines are measured, and stakes are placed every 40 meters (corresponding with 1 mm. on the mosaic). In this way direction and length of the lines are roughly known and it is possible to locate a number of points, recognizable on the photographs, along those lines.

So the measuring of such a line, which in itself is not very accurate because only a compass and a measuring chain are used—is only an expedient for an exact orientation on the photo and the mosaic. The essential is the finding of recognizable points, along which the line afterwards is drafted on the mosaic. In the dense tropical jungle this requires, however, much experience in photo-reading.

Along these tracks the topography, vegetation, geology and soil are studied.

It is clear that also in this period the teamwork of the pedologist with the forester and the geologist is very useful, as, in studying all these properties of an area, the continuous mutual connection between geological properties, soil and vegetation becomes visible. Indeed the landscape is determined from top to bottom.

For studying the soil along the lines it is necessary to carry out a number of borings. As a rule, the depth of the borings is $3\frac{1}{2}$ feet. In some cases, when knowledge of the subsoil below this depth is required, the borings are carried out up to a depth of 7 feet. From every boring, the position in the line, known by means of the placed stakes, is noted. The interval of the borings is made smaller where the configuration of the vegetation and the topography makes it likely that locally there are more differences in soil-configuration. Sometimes the distance between successive borings may become so small that mapping on a scale of 1:40,000 is not readily possible. Yet in these cases, this type of linear "detailed soil-mapping" is carried out, in order to gain the necessary insight in the upbuilding of the ground and in the relative age of the different sediments. In consequence of the well directed manner of working, as described under "Preparation," the number of lines through a certain area can be reduced to a minimum; the *total* number of borings, necessary for a reliable outline soil-map drafted by means of aerial photo-interpretation may be relatively small.

Our experience is, that in order to draft a soil-map on the scale of 1:40,000, the required number of borings, when reckoned over the whole area, is about one to the square kilometer. As a rule, for a great number of borings the soil-profiles are described.

Already during the trip the position of the borings is indicated on a piece of kodatrace used as an overlay-sheet with the aerial photograph.

At the same time a provisional soil classification is framed, whereby soil-types and soil-series are distinguished.

Soils of which the profiles are equal within very narrow limits are considered to belong to one type. Soil-types, not wholly equal, but showing conformity with their respective profiles, and having the same origin and situation in the landscape, are united into one soil-series or soil-complex.

From every soil-type a typical profile is sampled (2 to 4 samples per profile) dependent on the number of discernible horizons, in order to be analyzed physically and chemically.

Besides this, the relation between the natural vegetation and topography on one side and the soil configuration on the other hand is continuously examined. Comparison of the photographs with this vegetal reality reveals the connection between the photo-image and the soil configuration, and so the possibility of drafting a soil map from the aerial photographs is realized.

c. *Working out the data gathered in the field.* First the trails ("lines") and the position of the borings on these lines are transferred stereoscopically from the overlap sheets to a master sheet laid over the mosaic.[1]

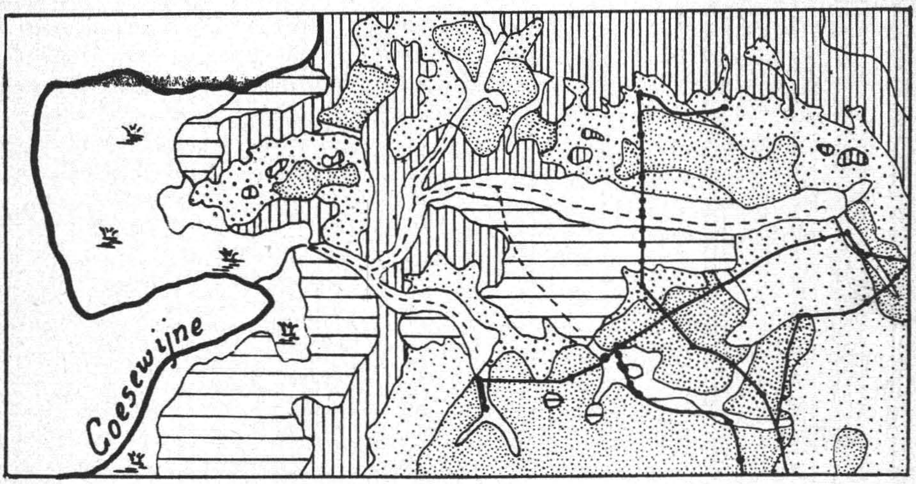

FIG. 9. A part of a soil map drafted by the photo-pedologist. Field control took place along the thick lines; the dots along these lines indicate the spots where small borings were carried out. Photo K.L.M. Copyright C.B.L.

The second step is to frame a *definitive* soil-classification of the area by correcting and completing the provisional grouping of the soils into soil-types, and uniting of the soil-types into soil-series or complexes. In their turn the soil-series are united into soil-associations or soil-families. Every soil-association corresponds with a landscape which has its own origin and topography.

Although the profile of the various soil-series, united in one association, may be very different, these series belong together unbreakably as they are the composing elements of the landscape, corresponding with soil-association.

Soil-association A	soil-series	(-complex)	a—soil-type 1
	soil-series	(-complex)	b—soil-type 2
	soil-series	(-complex)	c—soil-type 3

By completing the soil-classification, an outline is obtained of the pedological configuration of the area. As a last step the limits of the distinguished soil-classes

[1] As mentioned in chapter II it is possible to obtain bit by bit a stereoscopical image of this mosaic by using it together with loose photographs. Mapping in this way has the double advantage of geodetical exactness and photo-interpretation from a stereoscopical image.

are to be drafted from the mosaic upon the kodatrace master sheet. To this end we used the following method:

From the field data is known to which soil-type and soil-series each boring point belongs. Thus it is possible to mark the points where the soil-limits cross the several lines. By interpreting the photos, with the help of the field experience in evaluating the difference in the vegetation cover, these soil limits are followed also in the regions that have not been visited in the field; sometimes up to a large distance from the "line" (Figure 9). Sometimes it is possible to follow the limits of soil-types; in other cases only the boundaries of soil-series may be drafted, because the vegetation does not show enough difference.

The scale of our mosaics (1:40,000), however, also plays an important part in the possibility of drafting soil limits. The scale is rather small for pedological purposes. The first consequence is that in many instances there are different soil-types, which, by lack of photographed details of the vegetation, do not find expression on the photo-picture of this vegetation clearly enough to be distinguished and outlined with certainty. Another consequence of the small scale is that frequently the limits of different soil-types, although visible on the mosaic, cannot be drafted on the kodatrace, as the distance between the limiting-lines would be too small (e.g. smaller than 1–2 mm). Our experience is, that, from the 1:40,000 mosaics with regard to the photo-interpretation, as well as to the distance of the limiting-lines, it is usually possible to map the occurring soil-series. Drafting the limits of the largest units, the soil-associations, offers no difficulties, as the limits of these landscapes are visible already without a stereoscope.

SUMMARY

Our soil maps, drafted from the photomosaics, have the character of outline maps, on which the soil-association and the soil-series or complexes are pictured; only locally, where this is possible, they give more details showing the soil-types within some series too. It is clear that the knowledge of the soil, gathered from the borings, can only support the photo interpretation sufficiently, if *all* distinguishable soil-types and soil-series are traversed once, or better several times, by the "lines." Therefore planning the lines carefully is necessary.

VI. CONCLUSION

Jan I. S. Zonneveld

Although in Surinam the systematical interpretation of aerial photographs concerns only the subjects mentioned in the preceding chapters, there are still other kinds of investigation that may profit from airphoto study. We mention the possibility of investigating the currents in tidal river mouths, especially by comparing photographs made during several phases of the tide. A specimen of a photograph is reproduced. It shows (Figure 10) the Nickerie river pouring its relatively clear water (dark in the photograph) into the broad estuary of the Corantijn (with more muddy water). It can be seen that during the moment that the photo was made the water of the Nickerie river flowed for some distance along the eastern bank of the estuary, and then turned to the west, possibly under the influence of the making flood tide.

Photographs made during the dry season reveal sand banks in the middle courses of the rivers. It must be possible by comparing photos taken at intervals of some years to ascertain the displacement of these sandbanks (Figure 11).

And finally the photographs show the activities of man himself as far as these activities changed the original landscape by cultivation, settlement of villages

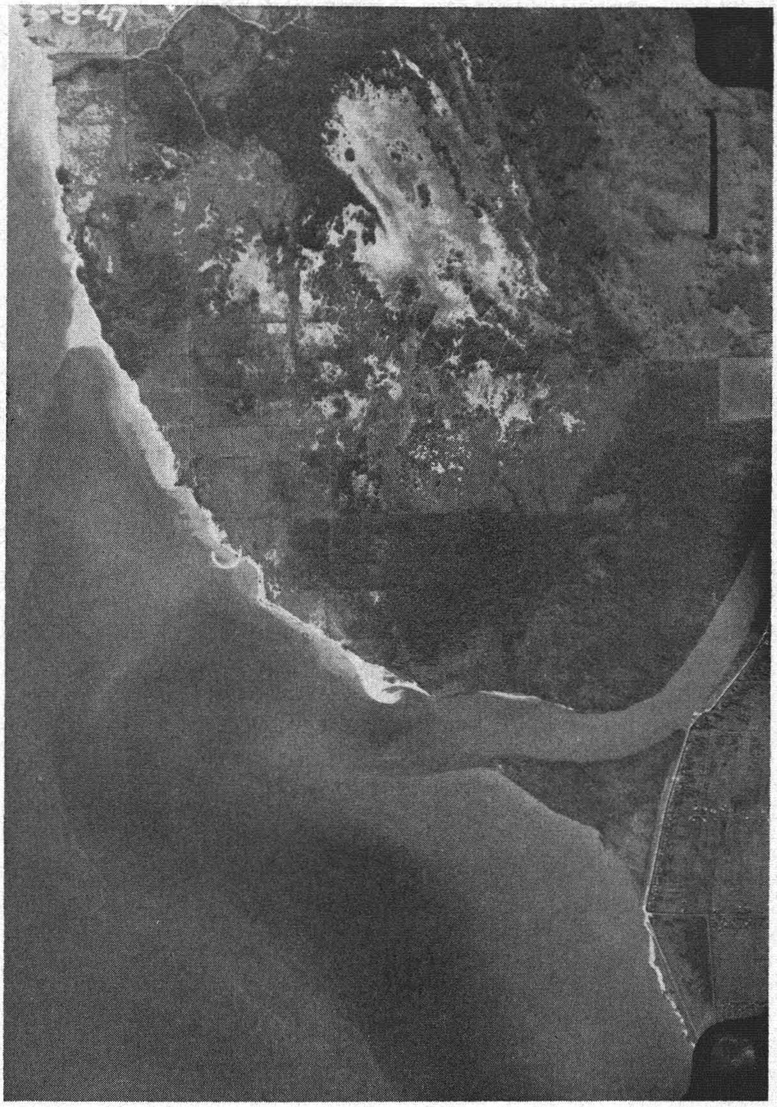

FIG. 10. The Nickerie River pours its water in the estuary of the Corantijn, apparently during the making flood tide. North of the mouth of the Nickerie River, a spit-like beach. Behind the abrasion coast in the middle of the photograph: abandoned plantations, swamps and a swamp-lake. Photo K.L.M. Copyright C.B.L.

and towns and construction of roads and canals. In this respect Surinam shows an interesting variety, due to the fact that there are settlements of autochthonic Indians, Bushnegros, colonists from Europe and immigrants from India and Java. It proved to be very interesting to study the influence of different factors regulating the form and structure of villages, towns and cultivated regions, factors like physiographic conditions, tradition, the technical level and the different ways of living of the several population groups.

This kind of study has not only a pure scientific value but may form the base for a rational rural planning, especially when it is combined with pedological investigations as mentioned in chapter V.

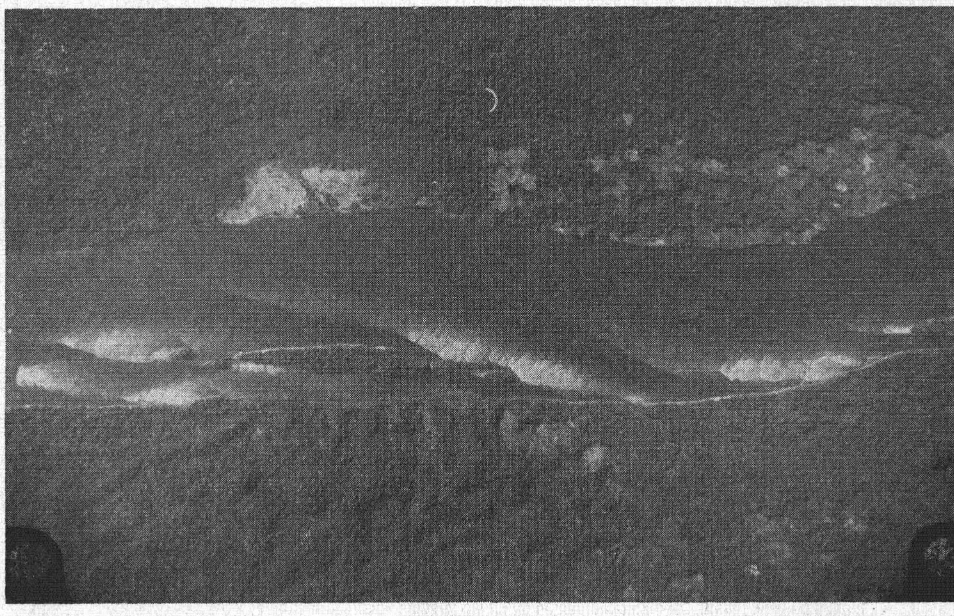

FIG. 11. Sandbanks in the Marowijne River. Photo K.L.M. Copyright C.B.L.

This symposium will be concluded with the statement that it has proven possible to use the aerial photographs fruitfully for several investigation purposes in Surinam, notwithstanding the special difficulties caused by its tropical nature.

Photo-interpretation especially benefits the reconnaissance activities in this difficultly passable and for the greater part unknown country. Of course it does not make field work superfluous (no more than it does in other regions) but it guides the work in the field and it gives the opportunity to increase the efficiency of the outdoor work to an important degree.

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See also "Literature" at the end of chapter III.