SOME PROBLEMS CONCERNING AERIAL PHOTO-INTERPRETATION IN SOIL SURVEY [1])

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INTRODUCTION

In most countries the application of aerial photographs in soil survey is limited to use of the photographs as a kind of base map or working map in field surveys. The methods have been described in detail in the Soil Survey Manual (1951). The advantage of this kind of application over the use of ordinary maps is that the aerial photographs enable the field surveyors to work more accurately and more quickly.

Sometimes aerial photographs have been used for photo-interpretation purposes. Various articles dealing with aerial photo-interpretation can be found in scientific journals. They have been summarised by SMITH (1952, 1953). The interpretation of aerial photographs in soil survey and land classification has never been a success. On the contrary, many articles have brought the photo-interpretation of soils into discredit. Accordingly, in introducing some new methods for the application of aerial photographs in soil survey, one can readily understand the resistance to be expected.

In the summer of 1954 we had an opportunity of discussing the utilisation of aerial photographs at the Fifth International Congress of Soil Science, held at Leopoldville (Belgian Congo), and at the second meeting of the F.A.O. Subgroup for Soil Classification and Survey in Europe, which was held at Ghent (Belgium). The most important results of these discussions will be described in this article.

SOME ERRONEOUS WAYS OF USING AERIAL PHOTOGRAPHS

Three objections are made against aerial photo-interpretation in soil survey and mapping:

a Many people who are not soil scientists have tried to interpret aerial photographs of soils. They studied photographs, discovered important phenomena relating to soil conditions, and deduced their significance. In most of these cases no field-work or soil sample analysis was carried out. The results of this kind of work can easily be guessed. As an example I will mention a booklet written by VON FRIJTAG DRABBE (1951). The only good done by publications such as this, is in having drawn the attention of soil scientists to aerial photography.

b Some individuals and some aerial photographic companies have tried to carry out soil surveys, soil conservation surveys and land classification surveys, based mainly on aerial photo-interpretation. Very often, careful examination of soil profiles in the field and of soil samples in the laboratory has been neglected. Such surveys are announced as "modern surveys", using the newest techniques, which enable them to do the work in a very short time at relatively low cost. The results of most of this kind of work cannot be compared with those of the serious surveys of skilled soil scientists, who likewise use aerial photographs. It is also known that some people

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try to deduce from the photographs not only the present use of the land, but also the use to which it should be put in the future, a quite unfortunate procedure. In his general lecture at the Leopoldville Congress, KELLOG (1954) said :

"Short-cut surveys, and especially those which avoid careful study of the soils themselves, are bound to be untrustworthy and ephemeral. I grant readily that it is much easier to study aerial photographs and the aboveground parts of plants than it is to study soils. But dig we must".

c For the most part attempts are made to deduce detailed information on soil conditions from aerial photographs. This is wrong. (POMERENING & CLINE, 1953). Aerial photographs give detailed information on the physical conditions of the earth's surface. But they will never provide all the details regarding soil condition.

In the majority of photographs few if any details of soils will be shown. This means that it is impossible to deduce detailed soil maps from aerial photographs. Yet very often one finds that photo-interpretation of soils go into too great detail. A soil survey based on an intensive examination of aerial photographs in combination with field and laboratory research must be limited to a semi-detailed soil survey on a scale 1 : 50.000 (BURINGH, 1954a). If more detailed maps are needed it is better to apply the normal methods of field survey, using aerial photographs mainly as a basis or as a working map in the field.

THE LIMITATIONS AND THE APPLICABILITY OF AERIAL PHOTOGRAPHY IN SOIL SURVEYS

There is a great difference between photo-interpretation of soils and the interpretation of objects which are clearly visible on the photographs, e.g. vegetation. In case of the latter we can study the object (size, shape, texture, colour, etc.). Soils, however, are not visible on aerial photographs ; they are covered by vegetation (grasses, trees, crops, etc.). It is therefore impossible to identify soils and to deduce their significance by examining photographic images. Photographic interpretation according to the international definition [2]) cannot be applied in soil science.

A soil scientist examines soil profiles in the field and typical soil samples in the laboratory in order to study the physical, chemical and biological characteristics of the soils. The second step is their organisation into well-defined units according to a system of soil classification, and this is followed by the third step, the mapping of the units, thus distinguished, in the field. The last step is soil mapping proper in which points of observation, the unit symbols and the soil boundaries are indicated on a map. Finally, the soil surveyor will give interpretation of the results of his investigations as applied to his work.

Aerial photographs can only be used in the third step, the actual systematic mapping of soil units. This is, for the most part, routine work. In all soil surveys much time has to be spent on this part of the survey.

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[2]) Photographic interpretation is the science of examining the photographic images of objects for the purpose of identifying those subjects and deducing their significance. (President of Commission VII (Photographic Interpretation) of the International Society of Photogrammetry, Phot. Eng., June 1952).

In soil surveying many problems arise. Most of them are concerned with the study of soil characteristics and their classification. The methods of soil mapping, especially detailed mapping, do not vary very much throughout the world. SIMONSON (1952) and PASTO (1953) have drawn attention to some important problems in soil mapping. The need for soil maps has increased to such an extent during recent years that it is impossible to cope with the demand. The number of soil experts is far too small. Often there are financial restrictions. It is therefore necessary to apply new methods in soil mapping (BURINGH, 1954a).

In Ghent we obtained a general view of what has been done in soil mapping in European countries. In the Netherlands, Belgium, Portugal, Germany and, during the last few years, also in Great Britain, systematic soil surveys are being carried out; however, it will take about 25 years or more before the first soil map of these countries is available. Some other countries, such as Austria, Italy, Spain, Norway, Turkey, Yugoslavia and Ireland, are just about to begin soil mapping. Some countries have only a very general soil map, and the systematic soil survey of these countries has yet to start, e.g., Denmark, France, Switzerland (F.A.O. Subgroup, 1954). In the Netherlands during the last ten years about 20 soil surveyors, with 30 assistants, have been mapping the soils of their country on detailed maps on a scale of 1 : 25.000. It will take about 25 years to finish this work, which is costing about *f* 800.000 a year. Nearly the same figures will be found to apply to Belgium.

Information on the soil survey in the U.S.A. has been published by SIMONSON (1952) and PASTO (1953), and summarized by BURINGH (1954a). Since this is the present situation in countries with a well-developed agriculture, one can easily guess what the situation is like in other parts of the world. Although in some countries great progress has been made during the last decades (e.g. Australia, New Zealand, Canada), in others soil surveys are only just beginning. In most parts of the world a great task has to be performed in the next 50 or 100 years.

Of recent years new methods in soil mapping have been developed (BURINGH, 1954 a, b). These methods are based on a combination of systematic analysis of aerial photographs and the study of soils in the field and in the laboratory. This combination fits in well with the methods of soil surveying which have been applied up to now. Examples are given by BURINGH (1954), BURINGH and VAN LIERE (1954), BURINGH and EDELMAN (1954), SCHERMERHORN (1953). The methods have been discussed with many colleagues (Proceedings, 1954) and at the Meeting of the F.A.O. Subgroup for Soil Classification and Survey in Europe, Ghent, 1954. In lectures at both congresses the present author discussed the advantages and limitations of the application of aerial photographs in soil survey (BURINGH, 1954d). At both conferences colleagues in soil science considered these new methods of applying aerial photographs in soil mapping very important. They constitute one of the greatest steps forward which has been made in soil survey during the last 20 years.

American soil scientists have made some important suggestions regarding this new procedure. A map prepared by the systematic analysis of aerial photographs has, until recently, been called a "tentative soil map"; such a map will now be called "a photo-analytical map for soil survey purposes". After completion of the relevant field and laboratory research, the map will be called a "semi-detailed soil map". Soil maps produced by the method of extrapolation (BURINGH, 1954a, 1954b) have, up till now, been called "general soil

maps". Following the American suggestion, we shall call such maps "schematic soil maps" or "exploratory soil maps". The units shown on the maps will not be called "soil associations", but "broad soil units" or "land units".

As has already been mentioned some soil scientists are not enamoured of aerial photo-interpretation, and therefore some of us have always had difficulties in introducing new methods in which aerial photographs are used. However, on being given an explanation of the systematic methods of aerial photo-analysis, all soil surveyors are enthusiastic, because:

a the analysis can be carried out in a short time, before field work commences. Thereafter, the surveyor already knows much about the physical conditions of the area; he can fix the itinerary, and he can start field work in the most favourable spots;
b mapping can be done more easily and more quickly and the accuracy of the soil boundaries is much greater than in a normal soil survey;
c considerable time is saved, because one surveyor can map an area which is four times as large or more as the area he could map before and because the cost of mapping per km^2 is considerably lower in comparison with that in normal surveys;
d for the soil scientist, however, the most important advantage is, that he has a new tool for routine mapping work. He now has much more time in which to study the soils. Previously he often had to spend nearly all his time on the mapping part of the soil survey, and basic research work was hardly possible.

In general, the new methods save time, money and manpower. Soil survey work can be done more efficiently, with better and more accurate results.

There is always a danger of overestimating the possibilities of utilising aerial photographs in soil survey. I draw attention to this fact in nearly all my articles. There are some basic conditions which cannot be neglected:

a Aerial photographs have to be used by experts in soil science, soil conservation and land classification, not by beginners or laymen.
b These soil specialists have to be trained in the utilization of aerial photographs. It is surprising what results an expert in the systematic analysis of aerial photographs can achieve. Nearly every soil scientist can learn to apply these methods of systematic analysis, just as he had to learn how to examine and describe a soil profile or make a soil sample analysis.
c Soils have to be studied in the field and in the laboratory; it is not possible to save time or money on this part of the work. Aerial photographs are only used as an aid in soil mapping.

Failure to observe any one of these conditions will cause great mistakes to be made.

Recent developments in photo-analysis as an aid in soil surveying and land classification

For systematic analysis of aerial photographs for soil survey purposes, we can now use about a hundred elements, approximately 50 which always indicate differences or similarities in soil conditions (Buringh, 1954). In many land types 5 to 10 elements have to be analysed. Here it must be pointed out that vegetation is not a trustworthy element in our analysis, because there is, as a rule, no direct relationship between soil conditions and vegetation. Primary

natural vegetation is very scarce. Human activity has had a great influence on present vegetation, even if it seems to be "natural" vegetation. Analysis according to different vegetation types, structure, density, pattern, height, colour, etc., will often yield unreliable results. However, most of the many other elements in the photographs may be analysed in areas with "natural" vegetation. Analysis of some characteristic vegetation types, indicating wet or dry, fresh or brackish or salt-water conditions, deep or shallow soils or differences in parent rock, constitutes the most important application of vegetation as an element in photo-analysis. In fire savanna areas with annual burnings, vegetation cannot be used as an element in photo-analysis.

Sometimes diffuse soil boundaries have to be mapped. Aerial photographs can help to determine the most suitable points of observation and enable the field work to be done more efficiently.

The use of geomorphological features as elements in photo-analysis is very important. A soil scientist engaged in doing this, not only has to know geomorphology, but also has to know that there is not always a clear-cut relationship between geomorphology and soil condition.

In combination with an intensive study of soils in the field, systematic photo-analysis will always give good results. The mapping of soil units which cannot be analysed on aerial photographs can only be done by additional field work. The soil scientist applying these methods must never be content with a lower standard of accuracy in soil surveying. By using the photographs in the right way, he will enrich basic research in soil genesis and soil morphology.

The co-operation of Prof. W. SCHERMERHORN, Director of the International Training Centre for Aerial Survey, one of the world's leading photo-grammetrists, and Prof. C. H. EDELMAN, Professor of Soil Science and Director of the Soil Survey Institute, has enabled me to study during the last three years, the possibilities of utilising aerial photographs in soil survey and land classification. I believe I am the first soil scientist to have had a full-time job in this field. Thanks to the help of this Training Centre's experts in photogrammetry, aerial photography, photogeology, photogeomorphology, and the interpretation of vegetation, I have had the opportunity of acquiring many important "tricks of the trade".

A number of soil scientists of different countries have been trained in the use of aerial photographs. From my own experience, and from the three months' training courses which the Training Centre organizes, I have learned that it is no simple matter to start applying aerial photographs in soil surveying. It takes many years before a soil scientist can make complete and efficient use of aerial photographs, especially when he has had to learn the methods of application by himself. The training course of three months enables experts in soil survey to learn these methods. The main part of the course is concerned with practical excercises.

It goes without saying that the student has to start by grasping the simple principles of photogrammetry and stereoscopy. It is also necessary to learn the principles of aerial photography, photogeology, photogeomorphology, and methods of recognizing the different types of vegetation.

The Dutch Government has established an International Training Centre for Aerial Survey at Delft. The Agricultural Section there deals with the applications of aerial photography in soil survey, soil conservation and land classi-

fication. Its aim is to offer to foreign students and experts the experience and knowledge available in this special field of science. Besides providing this training, we are also willing to give advice, or to help in planning soil surveys for many purposes. It has also been found possible to carry out soil surveys in foreign countries, as has already been done in New Guinea (BURINGH, 1954). This is an example of the assistance which a small country, such as the Netherlands can offer to the world.

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