

THE USE OF BASIC PHYSIOGRAPHIC UNITS IN AIR PHOTO INTERPRETATION

by RICHARD WEBSTER

Soil Science Laboratory, Oxford University, England

Abstract A method is proposed by which air photographs annotated for soil reconnaissance survey purposes could be indexed according to the type of terrain which they depict. The landscape is divided at two levels of classification. At the lower level are *facets*, small physiographic units within which variations in soil conditions are either unimportant or else of a consistent nature. At the higher level are *regions*, each characterised by a regularly repeated pattern of facets.

Both *facets* and *patterns* are readily recognised on air photographs. Annotated air photographs would be catalogued in a library according to pattern. The pattern, however, is a reflection of its genesis and depends on rock type, climate and stage of development. These factors are usually known and might be used as additional index headings to aid selection of photographs of an analogous area.

Résumé Une méthode est proposée par laquelle les photographies aériennes annotées pour la reconnaissance de prospection pédologique peuvent être repertoriées dans un catalogue d'après le type de terrain décrit. Le paysage est divisé en deux étages de classification. A l'étage inférieur sont les "*facettes*", petites fractions de physiographie, dans lesquelles les variations de caractère du sol ne sont pas importantes ou toujours identiques. A l'étage supérieur sont les "*régions*", chacune caractérisées par un dessin des facettes régulier et répété.

Les *facettes* et les *dessins* sont tous deux facilement à identifier sur les photographies aériennes. Les photographies aériennes annotées pourraient être cataloguées dans une bibliothèque d'après le dessin. Cependant le dessin est une réflexion de sa genèse, et il dépend de la géologie, du climat et de la phase du développement. Pour la plupart, ces facteurs sont connus, et il est possible d'en faire usage pour les titres supplémentaires du répertoire afin de permettre la choix des photographies d'une région analogue.

Zusammenfassung Es wird eine Methode vorgeschlagen, nach welcher Luftbilder, die für eine globale Bodenanalyse ausgewertet wurden, auch hinsichtlich der Bodengestaltung, welche sie widerspiegeln, katalogisiert werden können. Die Landschaft wird in zwei Klassifikations-Stufen eingeteilt. In die untere Stufe fallen "*Facetten*", d.h. kleine physiographische Einheiten, innerhalb welcher Unterschiede in der Bodenbeschaffenheit entweder bedeutungslos sind, oder einen beständigen Charakter tragen. In der oberen Stufe liegen "*Regionen*", jede deren durch ein sich regelmässig wiederholendes "*Muster*" von Facetten gekennzeichnet ist.

Beides - *Facetten* und *Muster* - sind in Luftbildern deutlich zu erkennen. Bearbeitete Luftbilder würden in einer Bibliothek nach Mustern katalogisiert werden. Das Muster ist aber eine Widerspiegelung seiner Genesis und ist vom Typus des Muttergesteines, des Klimas und der Entwicklungsstufe abhängig. Diese Faktoren sind meist bekannt und könnten als zusätzliche Katalog-Aufschriften Verwendung finden, um die Auswahl von Luftbildern eines analogen Gebietes zu erleichtern.

It frequently happens in reconnaissance survey that, for reasons of remoteness, time or expense, prediction of soil conditions is desirable before field work is begun. It would be most helpful in such situations if preliminary air photo examination allowed reasonable interpretation of the nature of the soils and their relationships to one another. At present the extent to which this is possible largely depends on the experience of the individual interpreter, and there

is a need for some means by which others can draw on this experience. Thus in addition to the mental library of the individual we require a library of annotated air photographs, stereopairs and multiplets with a suitable classification and storage system. The following proposals are made in the belief that physiographic subdivisions of land are implicitly the basis on which experienced interpreters recognise soils, but that lack of specific classification makes it difficult for one interpreter to recognise that his area has its analogues in that of another and to transfer experience from one area to another.

The Facet

Probably most soil scientists when interpreting air photographs recognise the close relationship between soils and physiography, and that a change in at least one of the factors, relief, parent material or age, itself linked to physiography, is likely to produce a change in soil type.

It is now over thirty years since BOURNE [1931] at Oxford, faced with the problem of sampling in reconnaissance land survey, observed that areas of this sort were not usually unique but were encountered repeatedly and should be recognisable on air photographs. He used the term "*site*" for an area which throughout its extent had similar local environmental conditions: climate, physiography, geology and soil. From the examples given he clearly envisaged that a site defined physiographically could provide this.

BOURNE's sites then corresponded with the type of landscape unit which interpreters commonly recognise and map, and is precisely what is required as the fundamental unit in terms of which to subdivide the landscape when interpreting air photographs for soils. The term *facet* is now proposed; the term was used by WOOLRIDGE [1932] with the same meaning, that is a small face of land surface. A *facet* is a subdivision of terrain which for most practical purposes may be considered uniform, or, if variable, showing definable variations which are of the same kind wherever the facet occurs and in the same sense as the variation in the larger landscape of which the facet is apart. A facet is

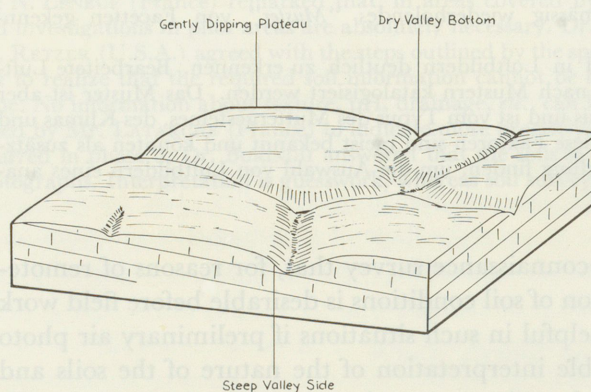


FIG. 1. Block diagram showing three facets as they occur in the English Cotswolds

defined in terms of its morphology, its position in the landscape as a whole, and the nature and variation of the material of which it is composed. FIG. 1 suggests the way in which several facets occurring in the English Cotswolds might be defined in terms of the first two criteria.

Others concerned with land survey have used similar units and the facet may be compared, for example, to the Australian *land unit* [CHRISTIAN and STEWART 1952], to VON ENGLER's [1942] *third order relief form*, or, also in air photo interpretation, to LUEDER's [1959] *unit land form*.

The Pattern

Thus facets are basic subdivisions possessing similar soil conditions wherever they occur. They are definable and where their recognition has been checked in the field air photographs can be annotated to show their appearance. However, since there are likely to be several thousand facets in the world correct identification could prove very difficult. What is required is some larger unit of classification in to which facets can be organised to assist both interpretation and the collation of air photographs when they have been annotated.

Returning to BOURNE we find that he observed on his sampling strips that certain sites were repeated again and again in association with one or several other sites but that sooner or later a point was reached beyond which the site was no longer encountered. More important, however, most or all of the associated sites ceased to recur from the same point, and their place was taken by a different assemblage of sites. This point marked the boundary between two distinct regions each with its own peculiar association of sites.

BOURNE's region then is characterised by a regularly repeated pattern of a few, and only a few, sites or facets. Furthermore on analyses of a landscape it will usually be found that, except for a few outliers from adjacent landscapes, the facets are related to one another in the same way. All occurrences of the pattern may not have the same proportions of constituent facets and occasionally facets may be missing from an occurrence. Nevertheless provided that the facets present are inter-related in the same way the pattern retains its distinctive character.

Parallel to BOURNE's region is the catena concept introduced by MILNE [1935] in order to map the soil patterns he observed in East Africa. More recently the soils of the whole of Uganda have been mapped using such units [CHENERY 1960] whilst several large parts of Northern Australia have been similarly treated using roughly equivalent *land systems* [CHRISTIAN et al., 1960].

When viewing air photographs stereoscopically one sees the land pattern rather than the region as a whole. It is the author's belief that interpreters recognise analogues between areas largely because they exhibit similar land patterns which are reflected in the air photo image. Such recognition is something more than that of drainage patterns or pattern of tone, vegetation or land use. LUEDER (*loc. cit.*) has illustrated the air photo appearance of some depositional landscape patterns but the above examples taken from Australia

and Africa emphasise that land patterns are not confined to such terrain.

A typical temperate maritime scarpland pattern of which the three facets illustrated in FIG. 1 are part is shown in FIG. 2. A desert scarpland (FIG. 3) appears at first sight to be similar, but the constituent facets in the two cases are not comparable. They differ both in the nature of their soil cover and in their internal variation, the third criterion used in defining the facets.

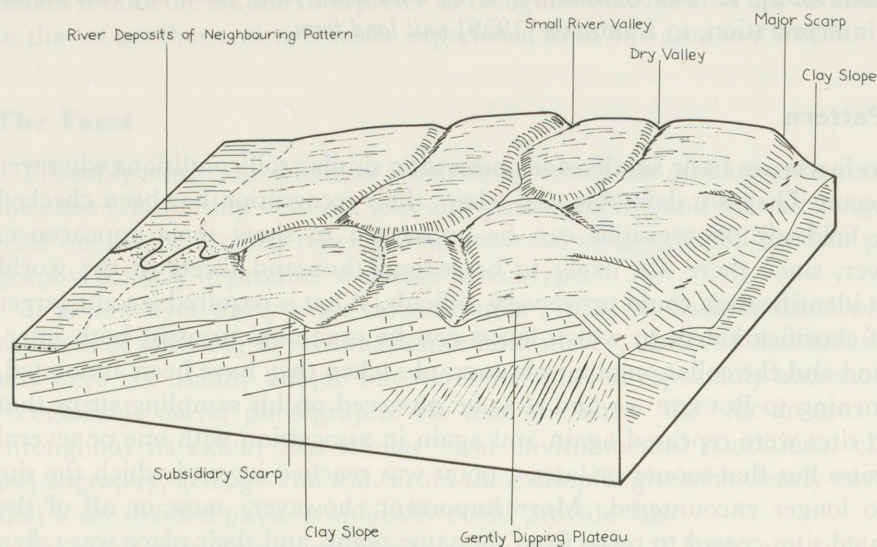


FIG. 2. Scarpland pattern in a temperate maritime climate as developed in the English Cotswolds

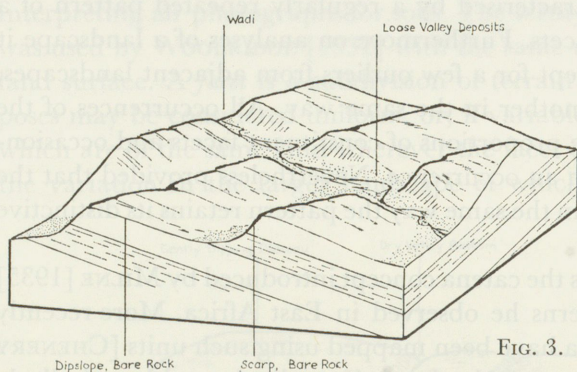


FIG. 3. Desert scarpland pattern

An Index of Patterns

Patterns of this nature, that is assemblages of inter-related facets could thus be the basis for indexing annotated air photographs. The photographs would be accompanied by a description and diagram showing how the pattern is composed of its constituent facets. But although each pattern covers an appreciable area and any country can be subdivided into a limited number of them there are probably still a large number in the world as a whole. If one wishes

to look for annotated air photographs of an area analogous to that in which one is interested one still requires a means by which it can be located. At this stage it is worth considering the genetic aspect.

CHRISTIAN [1957] has pointed out that a land system, or pattern, owes its existence to a broadly uniform genesis; the result of a particular climate or climatic sequence acting on a particular type of lithology in a given stage of development. In fact one may expect to find similar patterns wherever these factors, DAVIS' process, structure and stage DAVIS [1899] are the same. In soil survey work it is usual to have preliminary data of this sort and the location of an analogous pattern could be aided if patterns and the air photographs illustrating them were indexed under these headings also. Unfortunately one cannot assume that a given combination of climate, rock type and stage of development, or major relief, will produce only one pattern, or that one's data are sufficiently precise to locate it. Perhaps the best that one can hope for is that reference to the index will suggest a few patterns, two or three, which are likely to be relevant in the study of a new area. But by a comparative study of the new area with the annotated photographs and descriptions of each of the possible analogues the selection of the correct analogue should be relatively easy.

Conclusion

It is believed that implicitly physiographic units of the type described above are already widely used in interpretation. But by giving them explicit recognition it would be possible to index and annotate air photographs to stress analogues and thus facilitate air photo interpretation in areas of difficult access.

Acknowledgements

The work on which this paper is based has been carried out under contract from the Military Engineering Experimental Establishment. Thanks are also due to F. MOSELY from whose original FIG. 3 is drawn.

References

- BOURNE, R. (1931). Regional Survey. Oxford Forestry Memoirs, 13.
CHENERY, E. M. (1960). An Introduction to the Soils of Uganda Protectorate. Dept. of Agric. Memoires Res. Div. Ser. 1 No. 1.
CHRISTIAN, C. S. (1957). The Concept of Land Units and Land Systems. Proc. 9th Pacific Sci. Congr. 20, 74.
CHRISTIAN, C. S. and STEWART, G. A. (1952). Survey of Katherine - Darwin Region, 1946. Land Res. Ser. No. 1. C.S.I.R.O., Melbourne.
CHRISTIAN, C. S., STEWART, G. A. and PERRY, R. A. (1960). Land Research in Northern Australia. Aust. Geographer 7, 217.
DAVIS, W. M. (1899). The Geographical Cycle. Geogr. J. 14, 481.
LUEDER, D. R. (1959). Aerial Photographic Interpretation. McGraw Hill, New York.
MILNE, G. (1935). Some Suggested Units of Classification and Mapping particularly for East African Soils. Soil Res. 4, 3.
ENGELN, O. D. VON. (1942). Geomorphology, Macmillan, New York.
WOOLDRIDGE, S. W. (1932). The Cycle of Erosion and the Representation of Relief. Scottish Geogr. Mag., 48, 30.

Discussion

Dr. MAIGNIEN (France) asked on which photo scales the interpretation was carried out and, considering these scales, at which level of classification were the units described as "facets" by the author? Mr. WEBSTER answered that the photo scales were from 1 : 20,000 to 1 : 30,000. In some physiographic situations the soils were very similar, whilst in others there was considerable heterogeneity. Four cases have been recognised: (1) a facet may correspond to a single series; (2) a facet may embrace several similar series; (3) a facet may be a soil complex; (4) a soil series would rarely be mapped physiographically as two or more facets. The sense and form of soil variation within the facet is one of the criteria by which the facet is defined.

Prof. N. W. RADFORTH (Canada) asked what delineates pattern and facet. One school may tend to split features (units) that another school might insist on being a single facet. Mr. WEBSTER answered that so far he had adopted a purely pragmatic approach – whether further subdivision would create units which differ significantly in their broad agricultural or engineering potentialities.

Prof. D. W. MCKENZIE (New Zealand) asked what objectivity or measurement determines the facets? Are these particular to areas investigated and subjectively determined by the investigator? New Zealand experience has been that the mathematical approach of STRAHLER is excessively time consuming for the resultant classification of landscapes. Mr. WEBSTER answered that he is sure that ideally it would be desirable to describe all parts of the earth's surface using sets of numerical parameters. However this does not appear to be practicable: the determination of the parameters for even a small portion of the earth's surface is time consuming and difficult. Whilst the landscape is continuously variable, it is believed that facets, as defined in his paper, correspond with commonly occurring groupings of parameters.

Mr. J. L. RETZER (U.S.A.) remarked that: (1) It is important to know for which survey the method of Mr. WEBSTER is to be used. (2) It is necessary to design mapping units to meet the objective. Toponomic units are not necessarily the same. (3) There is a need for objective classification of land forms based on shape, the genesis being an inferred opinion which, as such, cannot be mapped. Mr. WEBSTER answered that: (1) The purpose of the survey may dictate the scale of mapping, but in general the more fundamental the classification of the mapping units the wider the application of the map. (2) Facets are defined on the basis of general morphology and on the nature of the variations of minor relief and soil within them. They are not defined on their genesis, though it is convenient to give them genetic names where these are widely used. At a later date it may be possible to put numerical limits to the attributes of facets. At present for the definition of facets we rely on the precision of verbal descriptions aided by block diagrams.

