# SOIL CLASSIFICATION AND PHOTO INTERPRETATION

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**Abstract** Soil classifications for engineering (*e.g.* Casagrande) are based upon physical characteristics of soils. Soil classifications for agriculture emphasise the morphology of the soil profile. Agricultural classifications which group soils by selected profile characteristics present problems to the interpreter because aerial photographs cannot directly provide information concerning soil profiles. Where soil mapping units are defined by profile characteristics and are also regarded as fundamental taxonomic units (Soil Survey Manual) they are often unsuited for photo interpretation. In these circumstances accuracy of interpretation depends upon occurrence of surface phenomena reflecting the boundaries of selected profile characteristics.

Experience has shown that mapping units based solely upon profile characteristics are not always practicable in field surveys. It is sometimes better to define soil units (*e.g.* Series) as landscape units with limited ranges of parent materials and soil profiles [Avery, 1956]. These units are better suited for photo interpretation.

A common difficulty facing the interpreter is the lack of detailed knowledge of the surface pattern of soil individuals included within a mapping unit. This arises because soil surveyors concentrate upon vertical profiles and subsoil conditions.

Recent examinations of soil maps produced by ground survey methods indicate that they may have limited practical value. Therefore photo interpreters and soil surveyors should co-operate so seek visual key criteria (*e.g.* Gilgai patterns) from which selected soil properties can be mapped.

**Résumé** Les classifications des sols destinées au projet de génie civil (ex.: Casagrande) se basent sur des propriétés physiques, tandis que celles destinées à l'agriculture mettent l'accent sur la morphologie de leurs profils. Ces dernières présentent donc des problèmes aux interprétateurs car les photographies aériennes ne fournissent pas d'informations directes sur ces profils. Il en résulte que lorsque les unités cartographiques pédologiques sont définies par des caractéristiques du profil et constituent en cela les unités taxonomiques fondamentales (Soil Survey Manual); elles ne conviennent pas à l'interprétation photographique. Dans ces conditions, la précision de l'interprétation dépend de la présence en surface de phénomènes réflétant les caractéristiques choisies du profil.

L'expérience a démontré que des unités cartographiques basées uniquement sur des caractéristiques du profil pédologique n'étaient pas toujours utilisables dans des levés de terrain. Il est parfois préférable de définir des unités (ex.: séries) en tant qu'unités de paysages ne reposant pas trop sur les roches-mères ni sur les profils pédologiques [Avery, 1956] car ces unités de paysages conviennent bien mieux à l'interprétation photographique. Une des difficultés que rencontre fréquemment l'interprétateur est le manque de renseignements détaillés sur l'aspect superficiel de chaque sol compris dans une unité cartographique. Cela tient à ce que les pédologues-prospecteurs accordent toute leur attention au profil vertical ainsi qu'au "soussol".

L'examen récent de cartes pédologiques issues de méthodes de levés de terrain indique que leur valeur pratique peut être très limitée. C'est la raison pour laquelle interprétateurs et pédologues-prospecteurs devraient collaborer pour rechercher des criteria visuels clefs comme celui des Gilgai à partir des quels il soit possible de cartographier les propriétés pédologiques désirées.

**Zusammenfassung** Boden-Einteilungen für Ingenieurs-Arbeiten (z.B. Casagrande) beruhen auf physischen Merkmalen der Böden. Klassifikation für landwirtschaftliche Zwecke betont die Morphologie des Boden-Profiles. Eine solche Einteilung, welche die Böden nach

ausgewählten charakteristischen Profilen gruppiert, stellt den Auswerter vor Probleme, da die Luftbilder keinen direkten Aufschluss geben über das Bodenprofil.
Wo Bodenkartierungs-Einheiten auf Profil-Kennzeichen beruhen, und zugleich als grundlegende taxonomische Einheiten betrachtet werden, (Soil Survey Manual), sind diese öfters für die Luftbild-Interpretation unbrauchbar. Unter diesen Umständen beruht die Genauigkeit der Interpretation auf dem Vorhandensein von Oberflächen-Erscheinungen, welche die Umgrenzung ausgewählter Profil-Kennzeichen wiederspiegeln.
Die Erfahrung hat gezeigt, dass Kartierungs-Einheiten, welche ausschliesslich auf Profil-Kennzeichnen beruhen, bei der Geländearbeit nicht immer anwendbar sind. Es ist manchmal vorteilhafter Boden-Einheiten (z.B. Serien) als Landschafts-Einheiten mit beschränktem Einfluss des Mutter-Materiales und der Bodenprofile zu definieren [Avery, 1956]. Solche Einheiten sind in Luftbildern besser zu interpretieren.
Eine sich dem Auswerter häufig darbietende Schwierigkeit besteht aus dem Mangel einer detaillierten Kenntnis des Oberflächen Musters der Boden-Individuen innerhalb einer Kartierungs-Einheit. Dies ist darauf zurückzuführen, dass Boden-Untersucher sich auf Vertikal-Profile und auf den Untergrund konzentrieren.
Neuere Betrachtungen der auf Geländearbeit beruhenden Bodenkarten weisen darauf hin, dass sie nur beschränkten praktischen Wert besitzen, Deshalb ollten Luftbild-Auswerter und Boden-Untersucher zusammenarbeiten in der Suche nach sichtbaren Schlüssel-Kriterien (z.B. Gilgai-Muster), auf Grund welcher ausgewählte Boden-Eigenschaften kartiert werden könnten.

The general problem of classification is to arrange objects in groups so that they can be recognised and studied in an orderly manner. Classifications are not static things because they are developed to suit the purposes of man and to accord with the knowledge which is available at a particular time. Thus soil classifications have been developed for various purposes and have shown progressive changes with the expansion of knowledge. Meanwhile the increasing use of aerial survey has led to the development of photo interpretation techniques which aim to provide information relevant to both the mapping units and purposes of existing soil classifications.

An examination of the literature concerning photo interpretation of soils shows that it can be separated into at least two fields of application *i.e.* engineering and agricultural purposes. The different outlooks of soil interpreters in engineering and agriculture are well shown in Chapter 5 and Chapter 11, Appendix A, of the Manual of Photographic Interpretation, [1960]. These differences largely arise from the use of different definitions and classifications of soils. The engineer often regards soil as regolith or any unconsolidated material regardless of depth or mode of formation. The agriculturists and pedologists define soil as material in which plants grow, possessing properties due to the combined effects of climate, living matter, parent material and relief, acting over periods of time. Thus photo interpretation is required to serve several classifications based upon different definitions of soil and different basic concepts. In these circumstances there is a grave danger that the use of words in different senses may give rise to confusion in the literature of photo interpretation *e.g.* the use of the terms "soil", "drainage", "texture". In fact a reappraisal of the terminology used in soil interpretations may soon be desirable.

In the case of soil surveys based upon pedological classifications the mapping units defined in the Soil Survey Manual [Soil Survey Staff, 1951] have been widely used in U.S.A., Britain, and elsewhere. These units include Associations, Complexes, Series, Types and Phases. The Soil Series has been used extensively as a mapping unit on scale of about 1 : 50,000 and survey organisations have shown considerable interest in aerial photographs as aids for the delineation of Series boundaries. It is therefore appropriate to examine the problems which arise due to the definitions of the Soil Series.

According to the current definition [Soil Survey Staff, 1951] Soil Series are to be regarded both as mapping units and as fundamental taxonomic units linked to Major Soil Groups in the classification. The Soil Series consists of a group of soils possessing similar profile characteristics and developed from a particular type of parent material. In practice the uniformity required in a Soil Series is looked for in that part of the profile below the ploughed layer or its equivalent.

The definition of the Soil Series, therefore, raises three points that are significant to the photo interpreter. First, the Series is defined in terms of profile characteristics which are not directly visible on aerial photographs. Thus photo interpretation of Series boundaries must rest upon the somewhat uncertain basis of correlation of profile characteristics with surface features. Secondly, the definition places emphasis upon the subsoil characteristics of the profile and largely disregards the surface soil horizons. Therefore, the surface conditions, which are observed and recorded by the photo interpreter, are largely excluded from consideration except where they reflect subsoil conditions. Thirdly, the Series represents a grouping of soil individuals on the basis of selected criteria. Thus the Series is a concept and does not represent a clearly defined natural phenomenon. Where the Series is used to mark an area on a map it means that 85% or more of the area contains soils which have selected criteria conforming to the concept of the Series. [7th Approximation, 1960]. There is no certainty that the boundary placed around these selected criteria will bear a close relationship to surface features. Indeed the criteria used for its definition may be unsuited for photo interpretation. It is hardly surprising, therefore, that estimates of the accuracy of photo interpretation of Series units [Pomerening & Cline, 1953] gave best performances of 72% correct in a simple area and 33% in a complex area.

The Series unit as defined above is also somewhat unsatisfactory for ground survey purposes. The boundaries of soil units which are defined solely on the basis of profile characteristics are difficult and time consuming to map.

Therefore, the surveyor seeks mappable surface features which mark the boundaries of the typical profile characteristics of the Series *e.g.* geomorphic inflexions, vegetation patterns. However, the surveyor is often unable to make full use of the elements of the landscape because surface features do not necessarily coincide with the conceptual boundaries of the Series and Major Soil Groups. It has been suggested, therefore, that Soil Series as mapping units should not be related directly to taxonomic Soil Groups. Instead the Series should be regarded primarily as a geographic concept, defined as a landscape unit with a limited range of profiles and parent materials [Avery, 1956]. Series units defined in this manner would be suitable for photo interpretation purposes, and techniques of pedological analysis [Buringh 1954, Veenenbos, 1956] would aid mapping. Therefore it seems clear that it would benefit ground surveyors and photo interpreters if landscape units played a larger part in the mapping, description and classification of Soil Series.

The practical value of mapping units based upon landscape units may be questioned by soil surveyors accustomed to general-purpose classifications based on profile characteristics. However, recent appraisals of soil surveys in Australia [Gibbons, 1961] have illustrated that surveys based upon general-purpose classifications may themselves have limited value. In consequence Gibbons puts forward two approaches aimed at making soil surveys more valuable. The first approach is to improve the general-purpose classification by selecting better key criteria and then to combine this improved classification with other environmental features in the mapping programme. Thus he suggests that "the use of the other environmental variables such as climate, geology, topography and vegetation, by defining and describing the components of the ecosystem is more likely to achieve the varied purposes of a soil survey than would soil survey alone". If the ecosystem approach be adopted there is ample evidence to show that aerial survey can contribute to the speed and efficiency of the work.

The second approach advocated is that specialist classifications should be developed for known purposes over limited areas. In these circumstances the ground surveyor must seek correlations between mappable soil features and soil factors relevant to land use. Likewise the photo interpreter must search for visual key criteria related to the purpose of the survey *e.g.* the use of Gilgai patterns to establish areas with soils of low permeability and high compaction, [Binnie, Deacon and Gourly, 1956]. In many instances it is likely that the key criteria will lie in the minor details of colour tones, drainage patterns and vegetation patterns, which are often so subtle that they are easily passed over. The significance of these micro-features may not be recognised owing to lack of experience or simply inability to visualise the object concerned [Belcher, 1959]. In the case of soil studies lack of recognition may also stem from the emphasis placed upon the soil profile in soil studies. Many soil surveyors find it easier to think in terms of vertical profiles rather than the surface patterns which soils present in plan view. Indeed it is probable that in many instances there is insufficient detailed knowledge of surface patterns of soils (and other landscape features) to allow adequate assessment of the meaning of patterns of micro-features seen on photographs. When soil maps and aerial photographs for the same area are compared they often show broad agreement but lack correspondence when matters of detail are studied. This lack of correspondence may arise in two ways. First, the soil map is usually not sufficiently detailed to show the intricate patterns which photographs reveal. Thus generalised boundaries occurring on soil maps do not accord with detailed boundaries which may be seen on photos. Secondly, the boundaries on soil maps may be unrealistic in that they are related to subjective groupings of soil individuals rather than the soil individuals themselves. For example British surveys group soils into drainage classes, *i.e.* excessive, free, imperfect, poor and very poor. The classes are determined by profile characteristics, especially the degree of mottling and gleying [Soil Survey Staff, 1960]. Although these characteristics are useful diagnostic features it is not certain that groupings derived from them form natural units. Therefore the surface conditions may not be wholly in accord with these groups. This situation was encountered in an assessment of the accuracy of photo interpretation of drainage classes made by the writer. An area of morainic drift country lying between Walton and Healaugh in Yorkshire was studied. A map showing areas of a. freely drained; b. imperfectly drained; c. poorly and very poorly drained soils was first produced by interpretation. The area was subsequently mapped on foot and the accuracy of interpretation was measured with a planimeter. The results were as follows:

| *Drainage classes determined by field observations* | *Total area mapped in field* | *Areas of each drainage class interpreted as:* Freely drained | | Imperfectly drained | | Poorly to very poorly drained | |
|---|---|---|---|---|---|---|---|
| | *acres* | *acres* | *% of total* | *acres* | *% of total* | *acres* | *% of total* |
| Freely drained | 813 | 497 | 61.1 | 286 | 35.2 | 30 | 3.7 |
| Imperfectly drained | 1015 | – | – | 785 *) | 77.3 | – | – |
| Poorly and very poorly drained | 276 | 4 | 1.5 | 62 | 18.8 | 220 | 79.7 |

*) The remaining 230 acres were interpreted as freely or poorly and very poorly drained which were present in about equal proportions.

In this example the surface characteristics showed a better correlation with the boundaries of poorly and very poorly drained soil profiles than with freely and imperfectly drained profiles. For interpretation purposes it would be better to abandon profile drainage characteristics and adopt instead surface drainage characteristics. For example soils can be grouped on photographs according to the surface drainage of the site, *e.g.* Shedding Sites, Normal Sites, Receiving Sites, *etc.* [Soil Survey Staff, 1960]. If photo interpretation is to play its full part in aiding soil surveys a new approach to the definition of soil mapping units must be sought.

**References**

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**Discussion**

Dr. R. SMITH (Ireland) commented that the range variation usually allowed in such profile characteristics as colour, texture, structure, pH, salinity *etc.* should be broadened over that usually allowed for soil series, so that such surface features as *e.g.* gilgai patterns and drainage characteristics will embrace one cartographic soil series. Although this is a very controversial matter he would give his support to Mr. CURTIS' suggestion.

Mr. C. KOECHLEY (U.S.A.) believed that we do not sufficiently distinguish between the application of photo interpretation to small scale surveys and that to highly detailed ones at 1 : 20,000 scale or larger. Photo interpretation is an excellent and useful tool, but one requiring a great deal more field checking for the more complex soil surveys.

Dr. R. MAIGNIEN (France) remarked that it is very dangerous to define the soil units only according to those superficial aspects which can be seen from the aerial photographs. It is necessary to multiply the studies on the correlation between the soils observed in the field and the phenomena which can be observed from the photographs. Intensive studies have revealed that this correlation was weak on the series level, but this was only the case for one particular region. Mr. CURTIS agreed that soil profile characteristics must remain the basis for much of our thinking about soils. However, his view is that soil mapping units can and should be defined in terms of landscape features. Soil surveyors and interpreters should cooperate in producing suitable classifications.

Dr. A. P. A. VINK (W.G. chairman) concluded that in the future a more careful distinction between the units of taxonomic classification, such as used in the Soil Classification (7th approximation), and those of cartographic classification as used in our mapping units, will be necessary. He stressed the need for a better appraisal of both kinds of classification.