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Soil Strip Maps

Preparation using aerial photographs may require only one-tenth the time of field surveys, and the accuracy can be 75 to 85 per cent where the basis is parent material and where the geology is not complex.

(*Abstract on page 1032*)

THE VALUE of pedologic soil maps for highway engineering purposes has been recognized since about 1926. The value of vertical aerial photographs in the preparation of such maps has been recognized since the middle 1930's. Belcher (1943) first showed that aerial photographs could be utilized directly to predict engineering soil characteristics. Since the appearance of Belcher's work the use of airphoto interpretation techniques in engineering has increased steadily. The University of Illinois began an investigation of soil exploration and mapping techniques in 1949. The basic approach was to adapt available information on the geology and pedology of surficial deposits of Illinois to highway planning and construction. Airphoto interpretation techniques were utilized from the start to extend the use of available information to unmapped and inadequately mapped areas.

In its early stages, this project was largely concerned with the preparation of engineering soil maps, first on a county basis and later as strip maps prepared especially for areas where new highway construction was contemplated. It was early recognized that the maps were of greatest value in areas lacking adequate pedologic maps. Thus, greater dependence was placed on air photo interpretation in the preparation of the engineering maps. It was found that correlations between soils in various parts of the state could best be provided by preparing the strip maps in terms of pedologic series. Soil information obtained during the detailed exploration program of a mapped area was to be utilized to correct errors in the map. Typical engineering data on the pedologic series encountered was thus to be accumulated and correlated. Difficulties in correlation existed, however, until 1959, when the first maps were prepared on an airphoto base. This improvement enabled the engineering soil survey crew to designate precise field locations on the maps.

SOME OF THE FIRST maps to be prepared on a photo background appeared in manuscript reports covering parts of Woodford and McLean County, Illinois (Liu, *et al.*, 1959). These strips partially covered the proposed route of Interstate 74. These two reports, combined, cover an alignment of nearly 20 miles. The maps show soils within a strip extending approximately 1,000 feet on each

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FIG. 1. Airphoto Representative of Area Studied. Outlined area indicates one mile strip mapped in Figures 2 and 3. (BXM-1-33, USDA, AAA, Woodford County, 1939). (See text page 1035.)

side of the proposed centerline. Subsequent to the preparation of these reports a question was raised with regard to the accuracy of the maps. Therefore, in 1961 arrangements were made for the preparation of a pedologic map based on field mapping by a qualified soil scientist. A five-mile strip of the proposed Interstate (highway) 74 alignment, extending from Congerville in Woodford County to Carlock, in McLean County, was selected for the comparative study. The comparison of the results of the two mapping methods is reported here to augment the meager literature on this subject.

The area under consideration falls within the Bloomington Ridged Plain Subsection of the Till Plain Section of the Central Lowlands Physiographic Province (Leighton, *et al.*, 1948). This area is characterized by a concentric system of morainal ridges, alternating with till plains or lakebed plains, which surround the southern end of Lake Michigan. More specifically, it lies in a triangle between the front of the Normal Moraine, the Mackinaw River Valley, and the Bloomington Moraine. The glacial drift in this area is approximately 150 feet thick. The uppermost till is Bloomington ground moraine of Wisconsinan Age, which is covered by a layer of Peoria loess of variable thickness. Generally, the thickness of loess is governed by the distance from the Illinois River Valley, approximately 20 miles to the west, and the degree of erosion which has taken place subsequent to the loessial deposition (Smith, 1942). Some local deposits of outwash from the Normal

Moraine lie between the Bloomington till and the loess. Because of these variations in the nature and thickness of parent materials, the areal distribution of pedologic series is quite complex. The situation is further complicated by the fact that some soils developed under forest vegetation and others developed under prairie grasses.

ABSTRACT: *Two pedologic soil strip maps that were prepared for a 5 mile section of proposed interstate highway alignment in Woodford and McLean Counties, Ill., are compared. One map was made by photo interpretation procedures utilizing 1:20,000 and 1:9,600 scale photography in conjunction with available soil reports, soil association maps, and geologic information, but without field mapping. The other map was made subsequent to the completion of the airphoto map by the Area Soil Scientist of the Soil Conservation Service using standard field procedures of agricultural soil survey. The surficial deposits consist of glacial till covered by a layer of loess of variable thickness. Both light and dark colored soils developed under forest and prairie vegetation, respectively, were represented. Comparison maps were prepared on the basis of pedologic soil series, profile drainage characteristics, Great Soil Groups and parent materials.*

THE ORIGINAL STRIP map of the alignment was prepared without any soil sampling or field observations. The following materials were available and were utilized, in conjunction with airphoto interpretation techniques, to map the pedologic series.

- Illinois Loess (Smith, 1942)
- Illinois Soil Type Descriptions (Wascher, *et al.*, 1950)
- McLean County Soils (Hopkins, *et al.*, 1915), Map Scale 1:126,720
- McLean County Soil Association Map, Scale 1:144,820, unpublished
- Woodford County Soils (Smith, *et al.*, 1927), Map Scale 1:126,720
- Woodford County Soil Association Map, Scale 1:126,720, unpublished
- Vertical Aerial Photographs, Commodity Stabilization Service, USDA, Scale 1:20,000
- Vertical Aerial Photographs, Aerial Survey Section, Illinois Division of Highways, Scale 1:9,600

Miscellaneous publications of the Illinois State Geological Survey were also used to determine the general geology of the area. Soil association maps and soil type descriptions (Wascher, *et al.*, 1950) were utilized primarily to revise available soils information contained in the county soil reports in terms of modern pedologic nomenclature.

The field map was prepared by the Area Soil Scientist of the Soil Conservation Service, using modern techniques of pedologic soil survey and nomenclature, on a base of USDA photography which had been enlarged to a scale of approximately 1:13,000 (Soil Survey Manual, 1951).

Table 1 lists the 33 pedologic series which were used in mapping the five-mile strip by the two procedures. The field survey used 32 series as map units, but only 10 were employed in the map made by photo interpretation. In view of the complexity of the surficial materials and the differences in type of vegetation, shown in Table 1, it is evident that detailed variations in pedology were overlooked in the preparation of the airphoto map. It is to be expected that agreement in detail between an interpretive map and the true soil distribution depends partly on the adequacy of the available information used to prepare the map and partly on the competence of the map maker in interpretation. Thus, the detailed map of the competent soil scientist would be expected to agree more closely with the true soil distribution than a map prepared in the office from generalized maps and interpretive procedures. However, some of the variations in profile characteristics may be relatively unimportant from the engineering standpoint. The degree of map detail required by a potential user depends upon the intended use. In the initial planning stages for a new highway, a highly accurate detailed map is unnecessary, although it would be useful in the design stage. If the strip maps prepared by photo interpretation are reasonably accurate, they can be quite useful for the planning stage. Furthermore, they have the advantage that they can be prepared rather quickly. Thus, the comparison of the two maps on the basis of pedologic series alone does not fully indicate the value of the airphoto map. Grouping the soil series on the basis of soil characteristics of interest to the engineer provides other bases for comparison.

TABLE 1

PEDOLOGIC SERIES MAPPED BY TWO METHODS

Map No.	*Pedologic Series*	*Mapped by Photo Interpretation*	*Mapped by Field Survey*	*Native Vegetation*	*Slope %*
24	Miami		×	Deciduous hardwood forest	1–5
25	Hennepin		×	Deciduous hardwood forest	>15
36	Tama	×	×	Prairie grasses	3.5–7
41	Muscatine	×	×	Prairie grasses	0.5–3.5
45	Denny	×	×	Prairie grasses	<0.5
60	LaRose		×	Prairie grasses	7–15
61	Atterberry		×	Mixed grass and hardwood forest	0.5–4
68	Sable	×	×	Swamp grasses	<0.5
74	Radford		×	Grass, scattered trees, and brush	<0.5
77	Huntsville	×	×	Grass, scattered trees, and brush	<0.5
81	Littleton		×	Prairie grasses	0.5–2
107	Sawmill	×	×	Swamp grasses	<0.5
145	Saybrook		×	Prairie grasses	1–7
151	Ridgeville		×	Prairie grasses	0–2
152	Drummer		×	Swamp grasses	<0.5
171	Catlin		×	Prairie grasses	3–7
224	Strawn		×	Deciduous hardwood forest	5–15
233	Birkbeck		×	Deciduous hardwood forest	2–8
278	Stronghurst	×	×	Deciduous hardwood forest	0.5–2.0
279	Rozetta	×	×	Deciduous hardwood forest	2–15
280	Fayette	×	×	Deciduous hardwood forest	1–15
281	Hopper	×		Deciduous hardwood forest	>15
327	Fox		×	Deciduous hardwood forest	0–12
330	Peotone		×	Swamp grasses	<0.5
376 (198)	Elburn		×	Prairie grasses	0–4
377 (199)	Plano		×	Prairie grasses	0–5
381 (105)	Batavia		×	Mixed grass and hardwood forest	0–5
383 (243)	St. Charles		×	Deciduous hardwood forest	1–4
385	Atlanta		×	Mixed grass and hardwood forest	1–5
386	Downs		×	Mixed grass and hardwood forest	2–12
451	Lawson		×	Grass, scattered trees, and brush	<0.5
632	Manlove		×	Deciduous hardwood forest	4–12
633	Traer		×	Deciduous hardwood forest	0–1
Total 33		10	32		

A TAXONOMIC KEY of the 33 soil series is given in Table 2. This key permits grouping the soils on the basis of similar characteristics. The second column from the left indicates the parent materials from which the soils were derived and the symbols in the first column designate the groups which formed the basis for one comparative study. The symbol P1 designates those soils developed on thin loess over calcareous loam Wisconsinan till at less than 40 inches. P2 indicates those soils developed on loess more than 60 inches thick, P3 indicates a loamy material 24 to 40 inches thick on calcareous gravel, etc. Six groups were required to include all significant variations. From the standpoint of engineering considerations, such as stability of cut slopes, compaction characteristics, and sources of granular material, the soils of a given parent material group are very similar.

The soils were also grouped on the basis of profile drainage characteristics. Such a grouping is significant in highway engineering since it differentiates between those soils in which the water table is high during much of the year and those in which free water presents few problems. In Illinois the drainage situation is also related to frost action. The symbol D1 designates those soils with well-drained profiles, D2 those with well and moderately well-drained, D3 the moderately well-drained, etc. Six groups were required to include the significant natural drainage variations.

TABLE 2

TAXONOMIC KEY FOR PEDOLOGIC UNITS SHOWING PARENT MATERIAL, DRAINAGE AND GREAT SOIL GROUPS

		Great Soil Groups													
		G1[3] *Alluvial*			*G2* *Regosol*	*G3* *Gray-Brown Podzolic*			*G4* *G.B.P.-Brun, Intergrade*		*G5* *Brunizem*		*G6* *Humic Gley*		*G7* *Planosol*
Parent Material ↓	*Drainage*→	*Well and Moderately Well D2*[2]	*Imperfect D4*	*Poor D5*	*Well D1*	*Well D1*	*Moderately Well D3*	*Imperfect D4*	*Well and Moderately Well D2*	*Imperfect D4*	*Well and Moderately Well D2*	*Imperfect D4*	*Poor D5*	*Very D6*	*Poor D5*
P1[1]	Loess <18″ on calc. loam Wisc. till at <24″				25 Hennepin	224 Strawn					60 LaRose				
P1	Loess 0–36″ on calc. loam Wisc. till at 24–40″					24 Miami					145 Saybrook				
P6	Loess 36–60″ over calc. loam Wisc. till, 40–60″					632 Manlove	233 Birkbeck		385 Atlanta		171 Catlin		152 Drummer	330 Peotone	
P2	Loess >60″ thick				281 Hopper	280 Fayette	279 Rozetta	278 Stronghurst	386 Downs	61 Atterberry	36 Tama	41 Muscatine	68 Sable		633 Traer (forest) 45 Denny (grass)
P3	Loamy material 24–40″ on calcareous gravel					327 Fox									
P4	Sandy material											151 Ridgeville			
P5	Colluvial loamy material with weak B horizon											81 Littleton			
P5	Dark, medium textured alluvium	77 Huntsville	451 Lawson												
P5	Dark, moderately fine textured alluvium			107 Sawmill											
P5	Dark, silty alluvium over mod. fine text. material			74 Radford											
P6	Loess 36–60″ over mod. coarse Wisc. drift (till and outwash)						383 St. Charles		381 Batavia		377 Plano	376 Elburn			

[1] Map designation for parent material group 1, pedologic series developed on thin loess over calcareous loam Wisconsinan till at <40 inches.
[2] Map designation for drainage group 2, pedologic series with well and moderately well-drained profiles.
[3] Map designation for Great Soil Group 1, pedologic series developed on alluvial material.

A THIRD GROUPING was based on the similarity in profile characteristics as indicated by the Great Soil Groups. Seven groupings were required to include all significant variations in profile characteristics. The symbol G1 designates Alluvial soils, which have little profile development. Regosols, G2, are those which show little profile development primarily because they are formed on steep slopes and are subject to active erosion. Gray-Brown Podzolic soils, G3, are formed under deciduous forests in a cool-temperate humid climate, whereas Brunizems, G5, are formed under grass vegetation in a similar climate. The intermingling of the two vegetation types gives rise to intergrades, designated as G4. Humic Gley soils, G6, occupy depressed or nearly level areas and develop under swamp grass vegetation. Planosols, G7, exhibit profiles in which excessive eluviation has produced a highly leached A horizon and a fine textured B. Although the engineering significance of Great Soil Groups is not completely understood, the poor performance of pavements on Humic Gley soils is in marked contrast to those built on Gray-Brown Podzolics.

FIGURE 1 (page 1031) shows the airphoto pattern representative of the general area studied. Near the center of the photo is Congerville, Illinois. A segment of the map area one-mile long which will be considered in more detail, is outlined south of the town. This photo shows a change from dark color tones on the lower right, which indicate Brunizem soils, to light tones in the upper left which indicate Gray-Brown Podzolic soils. The area outlined occupies a transition position between the two Great Soil Groups. The photo also shows that the topography is more rugged in the area to the west (left).

In this region loess is about 8 feet thick on the nearly level terrain, but is often thinner on more rolling topography. As the depth of the loess affects the pedologic classification, the mapping situation is further complicated by these variations. Figure 2 shows the one-mile segment of strip map south of Congerville prepared by airphoto interpretation. The dotted lines indicate intermittent drainageways and the solid lines represent boundaries between adjacent soil series. Nine of the ten series mapped over the five miles of alignment occur within this section. A large area of Alluvial soil, No. 77, Huntsville, appears near the center of the strip. This photograph taken in early November at a scale of 1:9,600, does not show the color contrast of Figure 1. This lack of contrast may have been partly responsible for errors in mapping Gray-Brown Podzolic soils as Brunizems.

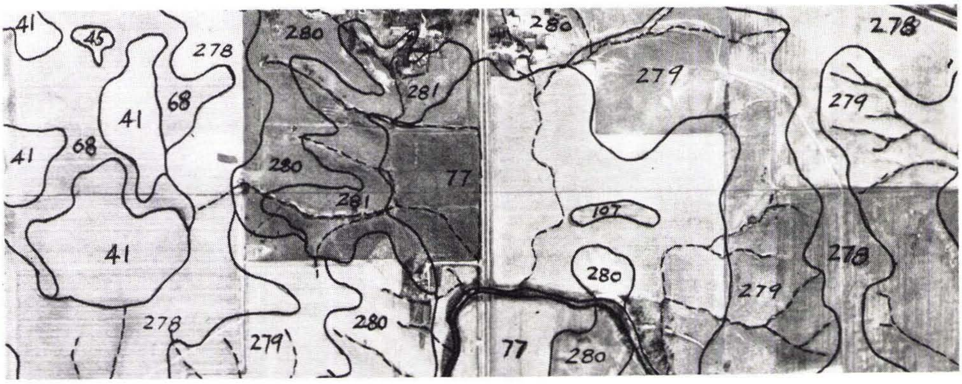

FIG. 2. One Mile Segment of Soil Strip Map Prepared by Photo Interpretation. (Pr No. 132, 0033·11:9:1250, Illinois Division of Highways, 1956.)

FIGURE 3 SHOWS the map prepared during the field survey and covers the same area shown in Figure 2. In addition to the series designation, this map also shows slope and erosion phases. Of the 32 pedologic series included in the five-mile strip, 17 appear in this segment. The large area of alluvium near the center of the figure, designated as No. 451, Lawson, corresponds to No. 77 shown in Figure 2. Series No. 451, was not in use at the time the airphoto map was prepared, therefore it is considered to be the equivalent of No. 77 for the purpose of this study.

Even though this map was developed from a field survey, it cannot be assumed that it is perfectly correct. Another experienced surveyor might draw the soil boundaries differently or even change some classifications. Pomerening and Cline (1953) have shown that different surveyors will not produce exactly the same map. In their comparison of maps

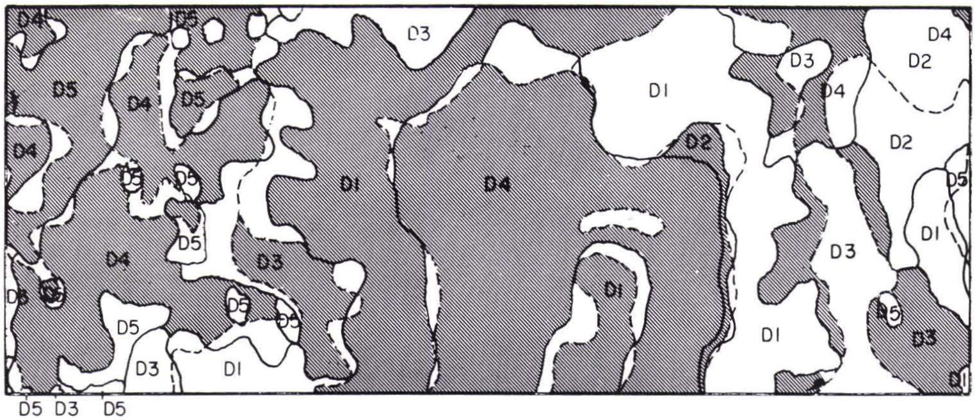

FIG. 5. Comparison of Airphoto and Field Survey Maps on Basis of Drainage Groups. Shading indicates areas with corresponding map units. (One mile segment.)

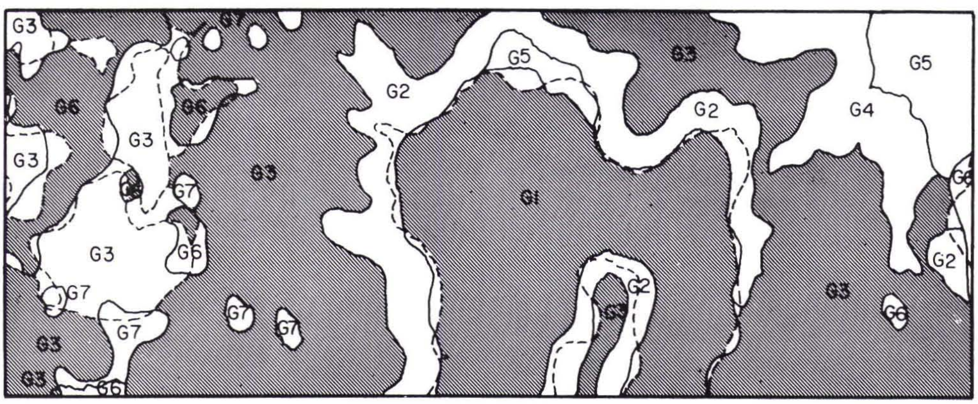

FIG. 6. Comparison of Airphoto and Field Survey Maps on Basis of Great Soil Groups. Shading indicates areas with corresponding map units. (One-mile segment.)

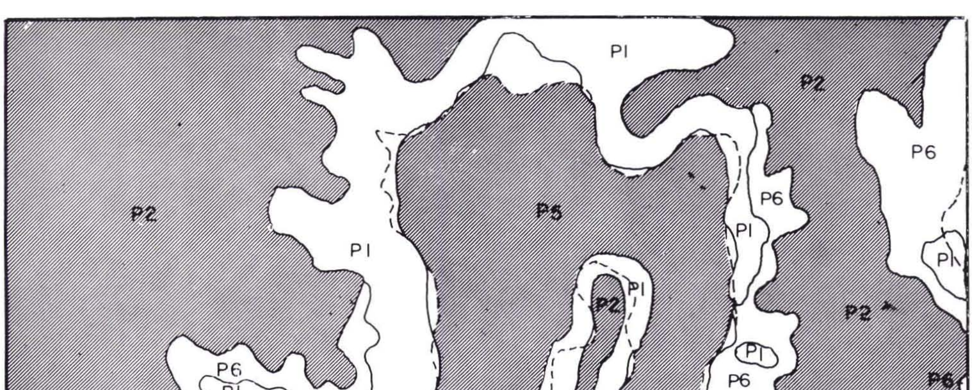

FIG. 7. Comparison of Airphoto and Field Survey Maps on Basis of Parent Material Groups. Shading indicates areas with corresponding map units. (One-mile segment.)

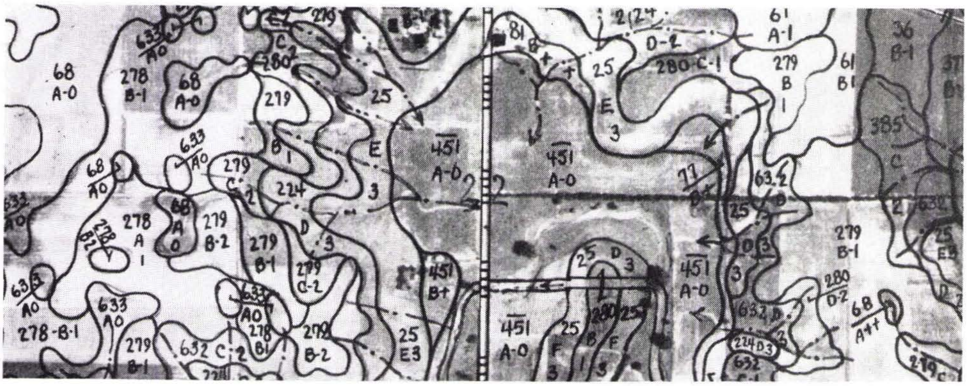

FIG. 3. One Mile Segment of Soil Strip Map Prepared by Field Survey.

prepared by airphoto interpretation and field surveys the "correct" map was produced by the reconciliation of detailed studies of several investigators. In the present study the degree of correspondence of the maps made by the two methods will be considered.

It must, however, be assumed that the field survey map is nearly correct pedologically. A comparison of the two maps covering the one-mile segment shown in Figures 2 and 3 is given in Figure 4. The solid lines show the soil boundaries as outlined in Figure 3 and the dotted lines represent the soil boundaries shown in Figure 2. The shading indicates areas in which the two sets of map units correspond. In this segment, 37 per cent of the total area is shaded, which indicates that 37 per cent of the area of the two maps were in agreement. Over the five-mile strip the pedologic map unit correspondence was 27 per cent, as shown in Table 3.

TABLE 3

COMPARISON OF SOIL STRIP MAPS PREPARED BY AIRPHOTO AND FIELD SURVEY METHODS

Basis of Comparison	*Percentage of Total Area with Corresponding Map Units*
Pedologic Series	27
Drainage Groups	38
Great Soil Groups	67
Parent Material Groups	77

FIGURES, 5, 6, AND 7 SHOW the comparisons for the same one-mile segment on the basis of the groups given in Table 2 for drainage, Great Soil Group, and parent material, respectively. These figures show that when the soils are grouped on the basis of broader characteristics, the degree of correspondence is considerably better than it is on the basis of pedologic series. Mapping on the basis of drainage groups showed a 59 percent agreement for this segment, but only 38 per cent agreement for the five-mile strip. If the comparison is made on the basis of Great Soil Groups, 63 per cent agreement is obtained for the one-mile segment and a value of 67 per cent for the five-mile strip. On the basis of parent material groups, the one-mile segment

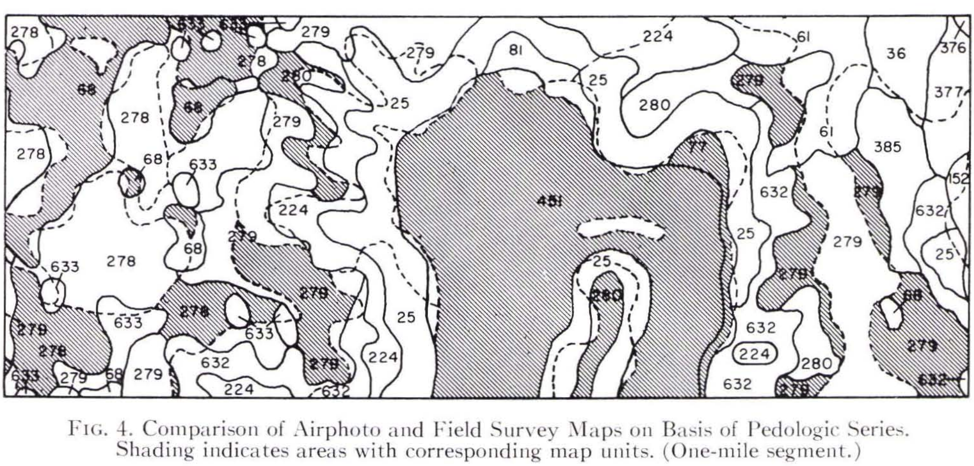

FIG. 4. Comparison of Airphoto and Field Survey Maps on Basis of Pedologic Series. Shading indicates areas with corresponding map units. (One-mile segment.)

showed an agreement of 69 per cent and the five-mile strip, 77 per cent.

For parent material groups, the best agreement was obtained where alluvial material, having little or no soil profile development, or loess greater than 5 feet thick were predominant. The poorest agreement was obtained in areas where the loess had been partially eroded. With this knowledge of the types of errors involved, it appears that the degree of accuracy with which the air photo maps represent the true soil distribution could be considerably improved with only a modest amount of field work. Such field work would be well worth while in those cases where the materials available for the preparation of a reasonably accurate interpretive map are inadequate.

IN GENERAL the results shown in Table 3 agree with those presented by Pomerening and Cline (1953). In simple glacial terrain, they found that airphoto procedures achieved 60 percent accuracy on the basis of pedologic series and 81 per cent on the basis of parent material. In a complicated glaciated region, only 10 per cent accuracy on the basis of pedologic soil series, and 43 per cent on the basis of parent material was achieved. Both studies indicate that, with the aid of the proper background material, soil strip maps can be prepared having a fairly high degree of accuracy, 75 to 85 per cent, provided (1) the mapping unit is based on parent material and (2) the geologic situation does not become exceedingly complex. On the other hand, variations in the morphology of natural soil profiles are so intricate that pedologic series mapping from airphotos alone cannot hope to achieve an accuracy much greater than 30 to 50 per cent unless the soil situation is very simple.

Fortunately, the highway engineer is more concerned with the variations in the parent material than in minor variations in the pedologic profile characteristics. For this reason maps prepared by airphoto interpretation techniques can be exceedingly valuable to him, especially when they are improved by a judicious amount of field survey. Furthermore, if it is considered that airphoto maps can be prepared in about one-tenth the time required for the field survey, the advantages of speed usually outweigh the disadvantages of inaccuracy. In areas where the soils are unmapped, reasonably accurate parent material maps can be prepared in minimal time by photo interpretation procedures. Such maps are invaluable in selecting route locations and planning the program of soil exploration.

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