Variations in Airphoto Patterns of Illinoian Drift in Southern Indiana

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One of the major engineering soil areas of Indiana is that of Illinoian glacial drift which occurs as a surface cover in all or parts of sixteen counties in southeastern Indiana. This glacial material is old and, when found in deep beds, has a marked uniformity in character and in associated problems. Shallow deposits of this material vary considerably, thus adding to the complexity of the engineering problems.

Although surface soils are predominantly Illinoian drift, the influence of underlying bedrock creates local variations in surface features. Bedrock in Indiana dips slightly toward the west; in this way varying materials are found near the surface. Interbedded limestones and shales, massive limestones, and massive shales would be encountered in surface exposures if one should cross southeastern Indiana from east to west.

Each of these underlying materials, where they occur near the surface, influences topography, drainage characteristics, and resulting airphoto patterns. In addition, the drift materials have been reworked locally by the transporting agencies of wind and water to present distinct variations. To facilitate discussion, the airphoto patterns can be classified into major and minor soil groups, and each of these groups then can be subdivided further: Illinoian drift and drift on various types of bedrock comprise the major soil group; while granular materials and lacustrine soils form the minor soil group.

MAJOR SOIL AREAS

ILLINOIAN DRIFT

Deeply-leached Illinoian drift soils have a highly-developed profile which generally consists of a well-drained A horizon, a poorly-drained plastic B horizon, and a C horizon of unaltered till. In southeastern Indiana these soils extend from the Knobstone escarpment eastward
Figure 1. Map of Indiana showing the location of this study. The cross-hatched area is that of Illinoian Drift, while dots indicate major areas of granular material.
Figure 2. This stereo-pair represents the typical airphoto pattern of Illinoian Drift—flat topography, light color tones, and white-fringed gullies.
almost to the state line and from the Wisconsin glacial border southward to the Ohio River.

Where these drift soils are deep, broad interstream divides are flat and poorly drained, and are generally cultivated. The flat areas of drift always have light color tones; but gully bottoms, which are generally moist and support moisture-tolerant vegetation, photograph dark. Gullies with distinctive low, white-fringed side slopes and broad, flat, dark center depressions extend for miles into the flat upland (Figure 2).

The silt A horizon of Illinoian drift is frequently subjected to severe sheet erosion. Where this erosion occurs many small "knife cut" gullies, appearing as scars on the ground surface, can be observed on an air-

![Figure 3. Severe erosion of a side slope of highway cut into Illinoian Drift.](image)

photo. Severe erosion (Figure 3) will result subsequent to construction unless side slopes are soon stabilized by sod or vegetation. Highway slabs constructed upon the well-drained A horizon generally perform satisfactorily (Figure 4); whereas pavements placed upon the poorly-drained B horizon in slight cuts are subject to severe pumping under heavy loads (Figure 5).
ILLINOIAN DRIFT ON LIMESTONE AND SHALE

One of the major variations occurs when Illinoian drift occurs on limestone and shale. The interbedded limestone-shale area in Indiana consists of many flat-topped ridges all of about equal height. Glacial debris was probably deposited over much of this region and has since been removed by normal erosional processes; but on many of the flat-topped ridges there is a thin veneer of drift, and drift is found to be deep in the headward ends of some stream valleys. The long uniform side slopes of this region, mostly composed of colluvial detritus, are subject to landslides and solifluction, and do not display Illinoian drift characteristics.

Variations in the pattern and the presence of drift can be identified. Generally on the flat ridgetops drift can be identified by typical white-fringed shallow gullies. Where the drift is quite thin, gullies cease to have a lacy, fringed appearance and, therefore, other airphoto pattern elements must be used; the silty drift, which is more subject to sheet
erosion than are the underlying materials, may appear as a white-fringed crust capping each ridge. Color tones for the cultivated fields are light gray to white and are strongly contrasted to the timber-covered slopes and darker color tones of residual soils in the area. Since field borders follow along the crests of ridges, field patterns have irregular shapes. Most ridges are separated by broad stream channels which have steep gradients, and the ridge-ends are quite rounded when viewed on an airphoto (Figure 7).

In this hilly region deep cuts and high fills are necessary for modern grade requirements; but where the stability of a colluvial slope is impaired by excavation, landslides are pre-eminent (Figure 8). On the
Figure 6. This sketch illustrates the relationship of grade alignment to soil profile.
Figure 7. Stereo airphoto pattern of Illinoian Drift on limestone and shale. Erosion along the edge of the capping drift is indicated by small arrows; the large arrow points to a broad, deep stream valley.
uplands, shallow cuts into either the lower horizons of Illinoian drift or underlying residual soil are detrimental to highway performance, for when these poorly-drained soils become saturated, much of their strength is lost. Heavily-traveled roads are subject to pumping, particularly in cuts, and erosion of either drift or soft shales frequently is severe.

**ILLINOIAN DRIFT ON LIMESTONE**

Another variation in the drift-covered area is that where drift occurs on limestone. Over an area covering several counties limestones occur near the surface and sinkholes are common. The eastern border of this limestone plain is well-defined, but the western border is ragged as a result of stream dissection through the diminishing overlying strata of black shale. Crevices within the strata of limestone are enlarged by solution and thus “sinkholes” are formed; likewise, stream channels are subject to solution, with the result that banks are generally near vertical.

The presence of a poorly-drained drift layer upon the limestone surface has retarded the development of solution topography, excepting near the streams where drift has been partially removed by sheet erosion. Here the sinkholes abound and appear as “pock marks” on the aerial

![Figure 8. A slope failure in a highway cut into Illinoian Drift on limestone and shale.](image)
Figure 9. An airphoto stereo-pair of Illinoian Drift on limestone. The arrow at B indicates a stream meander which has almost closed; numerous sinkholes appear as "pock marks" near the stream.
photograph. Frequently, small streams terminate in a sinkhole, or a chain of sinks may have partially coalesced.

Across this limestone region the meanders of streams flowing in rocky channels typify strong structural control, for often a stream meander will almost close, excepting a thin wall of limestone which resists the cutting action of the stream. Steep vertical banks can be recognized on the airphotos, and sinkholes are readily identified. Streams flowing in limestone form a drainage pattern that is characterized by curving branch streams (Figure 9).

The region of Illinoian drift on limestone has characteristics that are common to both materials. Small gullies are white-fringed with broad, shallow cross-sections, but the larger gullies are narrow and deep—generally flowing in limestone channels. Short gullies that terminate in sinkholes generally have the white-fringed pattern unless the drift is almost absent. Both the B horizon of drift soil and the remolded limestone residual soil are poorly drained and have little strength when saturated; therefore adequate drainage and insulation must be provided for highway and airport base courses. Since the drift is relatively thin—5 to 10 feet—shallow-grade cuts often involve rock excavation.

Figure 10. Failure of a flexible pavement in a shallow cut into drift and limestone.
Another broad lowland area consists of a plain of Illinoian drift underlain almost entirely by shales. Throughout the area many low swells or hillocks consist of a thin veneer of glacial drift on a shale mass. Slopes are generally quite gradual; however, locally stream dissection has produced some rather steep topography. Where this more rugged landscape exists, natural timber stands remain, thus accentuating the relief from surrounding lowland. Where gradient stimulates dissection, gullies have deep, prominent banks. Soft material is indicated by rounded interstream divides and meandering stream channels (Figure 12). Local variations in the airphoto pattern can mislead the airphoto interpreter unless he extends his examination beyond a local spot. In an area of five or six square miles landform and gully characteristics are more nearly representative than for a local spot, and predictions can then be made with some assurance.

Since the region is either flat or gently rolling, both field and road patterns are rectangular. Small gullies, which have not cut down to shale, are broad but shallow with symbolic white fringing; where stream erosion has exposed the underlying shale, gullies have broad, shallow cross-sections but lack the white fringe associated with drifts. Principal streams have developed broad valleys wherein the stream channel is free to meander.
A ragged border between shale and adjacent limestone rocks to the east has been developed by stream dissection where limestones dip beneath the shales; glacial drift has been deposited over both materials. Gradual sloping stream banks in shale, as contrasted to steep-sided channels in limestone, serve to establish a border. Drift has modified many of the shapes, but gully shapes and the presence, or absence, of sinkholes serve to identify contrasting materials. Frequently a rock ledge will protrude from beneath a shale slope and will serve to identify the border between shale and limestone.

Poor subgrade support and drainage prevail throughout the Illinoian drift-on-shale region. When exposed in shallow cuts, the underlying

Figure 12. An airphoto stereo of Illinoian Drift on shale. Gully cross-sections are influenced by underlying shales. Soft materials produce the rounded interstream divides. Shale is exposed in the cut at location A.
shales weather to produce a plastic clay. Pavements constructed upon this material often settle, and pumping will result if traffic on these roads consists of many heavily-loaded trucks (Figure 13). Shale embankments must be carefully compacted and stabilized to prevent erosion or landslides.

Figure 13. Pavements such as this will pump and settle when constructed upon shale in shallow cuts. The contact between drift and shale is indicated on the side slope.

Granular Materials

Within the Illinoian drift area, good construction materials are scarce—many counties are almost without adequate sources. Hence variations of the drift patterns should be studied to determine more granular deposits.

Granular Terraces. Deposits of granular material are found along larger streams, heading in the more recent and granular drift areas to the north, in the form of terraces which are situated adjacent to the upland and well above the flood plain. Streams contained entirely within the Illinoian drift region are devoid of gravel terraces; thus the ability to delineate soil textures is of major importance in this area. Since the
Figure 14. Several materials are shown by this airphoto, including: alluvium (AL), sand terrace (Gs), gravel terrace (Gt), sand, and sand on Wisconsin drift (S/WD).
granular materials were deposited by running water, one can expect distinct gradation and stratification.

Granular terraces may have a texture ranging from clean sand to dirty gravel or coarse boulders, and each texture will have airphoto pattern elements peculiar to itself (Figure 14). There are certain pattern elements, however, that pertain to most granular terraces; among these are topography, drainage, and gully cross-section. A terrace is a flat plain, the elevation of which is intermediate between that of the upland proper and the flood plain, or first bottom. The face, or stream side, of a terrace is quite steep and is generally timber-covered. If gullies occur along the face, they are short, with steep gradients, and sharp, V-shaped cross-sections. There is a striking absence of surface drainage upon a granular terrace, but current markings might be mistaken for surface gullies. Current marks are elongated, shallow depressions which represent old channels when the surface was flooded by fast-moving waters. These depressions, which are now partially filled with silt or organic matter, appear as dark concentric streaks upon an otherwise light airphoto pattern. Streams that issue from upland watersheds change direction and flow along the contact line between terrace and upland or develop alluvial fans where the water is absorbed into the terrace and debris is deposited. Occasionally a stream will cut across a terrace, but this is true only of larger streams.

Since granular deposits are well-drained, color tones can be expected to be light; but some materials produce lighter tones than others. The color tones of granular terraces are exceptionally light, although somewhat spotted by exiguous, darker current markings. The presence of infiltration basins and current marks, both of which photograph dark, creates a continuous speckled airphoto pattern (Figure 14).

Subgrade support and drainage conditions are excellent where construction is located upon a granular terrace. However, construction practices should include the excavating of silt pockets from infiltration basins and current marks, and filling with granular borrow material.

Windblown Sands

A minor type, yet of major importance locally, is that of windblown sands. Wind, a very selective transporting agency, is restricted to fine sands and silts. Windblown silts are not extensive in southeastern Indiana; however, the sands, which are seldom conveyed far from their origin, are found along the lee-side of alluvial flood plains.

Dune shapes, formed by drifting sands, vary, but probably the most common are the "barchane dunes." These dunes form crescents upon the
Figure 15. Chestnut Ridge and other small ridges are indicated on this map by lightly-shaded areas.
ground and may occur as an individual dune or as a system of coalescing dunes (Figure 14).

Sands are well-drained; therefore, the airphoto pattern consists of very light color tones and a marked absence of surface drainage. In addition, barchane dunes and parallel sand ridges are quite conspicuous. These elevated topographic features, being excessively drained, have even lighter color tones than the surrounding sand plain. In general, dunes and ridges are not productive for agricultural pursuits; therefore, timber stands often outline these surface features. When erosion of a dune or ridge is observed, the gullies are distinct and sharply notched as though carved by a knife.

OTHER GRANULAR MATERIALS

In Jackson County (Figure 15), there is a long sinuous ridge which is said to be an old Illinoian moraine. Locally this is called “Chestnut Ridge.” In addition, other small ridges create a continuous trend which extends for about twelve miles. The materials of this ridge, as shown by well drillers' logs and exposures in highway cuts, are granular and somewhat stratified. Stratification indicates that the materials were subjected to washing during the period of deposition. Gullies, extending almost to the hilltop, have dark, flat bottoms; deep, broad cross-sections; and white-fringed side slopes (Figure 16). For instance, shapes of the gullies that flow from Chestnut Ridge are influenced both by soil texture and stream gradients. For comparable watershed areas, the gullies of Chestnut Ridge are deeper and narrower than those found in the un-assorted soils of the till plains.

LAKE BEDS

During the glacial epoch many streams were blocked by ice and debris so that large inland lakes were formed along the stream valleys; a local example is that of the “flats” near Scottsburg. The lakes served as settling basins for fine sand, silt, and some clay, which were deposited thickly upon the lake bottoms. Low depressions, which were filled by sedimentation, remained intact as broad, poorly-drained swampland after natural drainage was restored (Figure 16).

Lacustrine soils of the low depressions have a high ground-water table and are poorly-drained; therefore, these soils present a dark airphoto pattern which is strikingly contrasted to the light pattern of Illinoian drift. Straight, dredged ditches have been constructed to increase drainage; but natural streams meander across the “flats” with no
Figure 16. Gullies of Chestnut Ridge, in Jackson County, are clearly shown by this airphoto.
Figure 17. This is a portion of the lacustrine deposits along Stuker's Fork, near Scottsburg. Straight-dredged ditches are indicated by arrows.
semblance of control. Few gullies develop in the low, flat areas; where they occur their cross-sections are shallow with broad rounded bottoms and sides.

The flat topography of lakebeds may influence an engineer to overlook objectionable qualities for the sake of earthwork; however, these soils are so poorly drained that other characteristics should govern. Poor subgrade support has resulted in extensive damage to highways that cross lacustrine soils—pumping and settlement are most common. Some of the areas can be avoided, but if a road must be built across lacustrine soil, a high-level profile is necessary. Granular material is scarce in a lacustrine plain unless sand dunes are present.

RESULTS AND CONCLUSIONS

An engineer acquainted with the techniques of airphoto interpretation can select areas in advance for construction materials. Proposed construction areas can be examined in the office in a relatively short time, and soils can be mapped in detail. In this way, areas of poor soil conditions can be avoided or designs can be altered to provide for these conditions. Sites at which samples should be obtained can be selected, and in this way sampling operations can be simplified, for airphoto interpretation is based upon repeating patterns. Thus if a given airphoto pattern is found to exist at various sites, a sample from one site should be representative for the other sites. In this way airphotos should prove to be a valuable tool in most preconstruction planning.

This study provided information for a general engineering soils map of southeastern Indiana. In preliminary location and planning this map should provide general areal information. Once a proposed site or route has been selected, local details can be determined from further examination of the aerial photographs in that area.