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SOME CONSEQUENCES OF PERI-GLACIAL PROCESSES AND POST-GLACIAL ADJUSTMENT IN SOUTHERN ENGLAND

Abstract

Many Pleistocene gravel terraces in Southern England are obscured beneath clay material on their uphill or landward side. This is described in one instance, when it is shown that the clay contains drift material from some distance upslope. The clay-over-gravel soils are of considerable agronomic value: indeed within this particular landscape many of the soil properties which most directly affect current land use may be attributed to the results of peri-glacial and post-glacial processes. It is also demonstrated how "stone-lines" may be formed by the burial of alluvial gravel deposits in minor drainage ways. The deposition of gravel and its burial beneath clay cannot have taken place under the same climate. It is pointed out that "stone-lines", if formed by the burial of erosion pavements as has been commonly suggested, must be similarly polygenetic.

In many parts of Southern Britain gravel terrace deposits are covered, partially or wholly, by clay, sometimes to depths of 6 feet or more. Supposedly this is the result of clay movement by creep or solifluction. Such mixed soils are locally of considerable agronomic value.

The aim of the present study was to clarify the genesis of such clay-over-gravel soils. It also drew attention, incidentally, to some interesting buried stone-lines. The study is based upon a detailed soil survey of the Oxford University Field Station (fig. 1) at Wytham near Oxford, supplemented by auger-traverses and stone counts.

BACKGROUND

The farm lies on the NE spur of Wytham hill (540 ft a.s.l.). A small brook (A—A) [1] has given rise to a shallow valley almost down the point of the spur: its water is now intercepted by the ditch at B—B. Until recently the valley of the river Thames was occupied by a belt of wet marshy ground, traversed by subsidiary channels, with small gravel islands (eyots) and

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[1] These refer to fig. 1 which also indicates the sites of stone-counts.

peaty hollows. Though regulated now by locks, the river is still liable to winter floods.

The local geology is simple. Wytham hill is capped by a coralline limestone (Coral Rag), greatly cambered by solifluction and spring-sapping (Arkell 1947). The Coral Rag lies over a calcareous sandstone (Calcareous Grit) and this over the thick Oxford Clay. All are of middle Jurassic age. Early Pleistocene deposits of rounded quartzite, flint and sarsen (siliceous sandstone) pebbles, (Northern Drift) locally cap the hill: they were probably more extensive formerly.

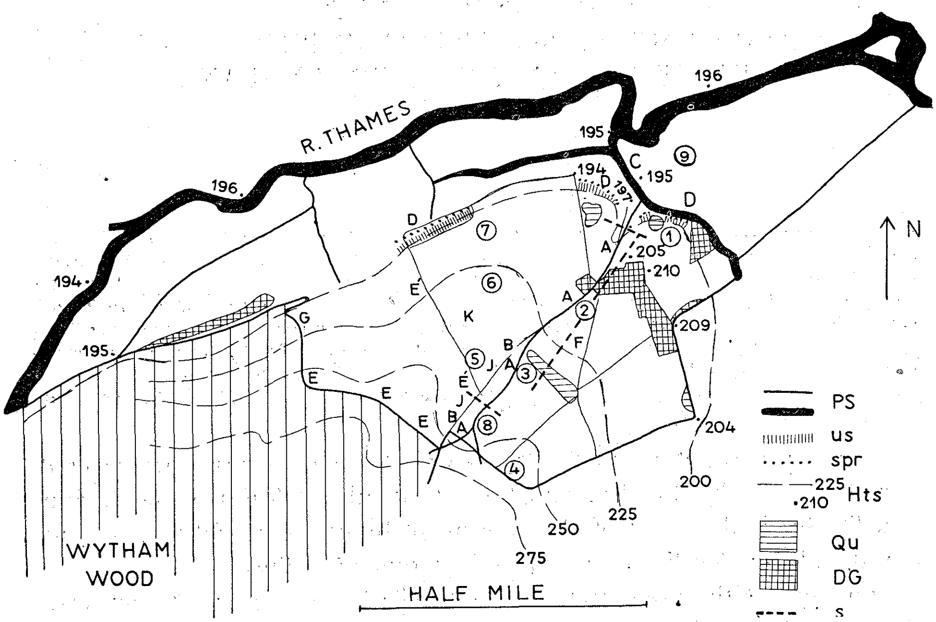

Fig. 1. The University Field Station, Wytham, Oxford

PS — river and streams; us — undercut slope; spr — spring line; Hts — heighst in feet a. s. l.; Qu — quarries; DG — disturbed ground; s — sections of fig. 3
Letters refer to comments in text; numbers to stone-counts (Table I) and pollen analysis

The gentle clay slopes extend down to and beneath the alluvium of the present flood-plain at 193—195 ft. which fills the valley to a depth of 20—40 ft. Gravel terraces lie at 205—215 ft. and 235 ft. The lower appears to be late Riss or last interglacial in age (Summertown—Radley terrace; see Arkell 1947; Tomlinson 1963). The gravel has been exploited in numerous small quarries and the lower terrace has been occupied from the early middle ages if not before.

SOILS

Figure 2 indicates the soils encountered.

Heavy clay or clay loam soils from the Oxford Clay (C) occupy the upper slopes. The clay contains frequent quartzite pebbles, and sarsen stones up to 12″ in size, down to 30″ or more. Samples 4 & 5 (Table I) are typical.

Sections exposed in ditches at E—E and E′—E′ reveal thin interrupted layers of stones and thin lenses of Calcareous Grit sand. The sand lenses

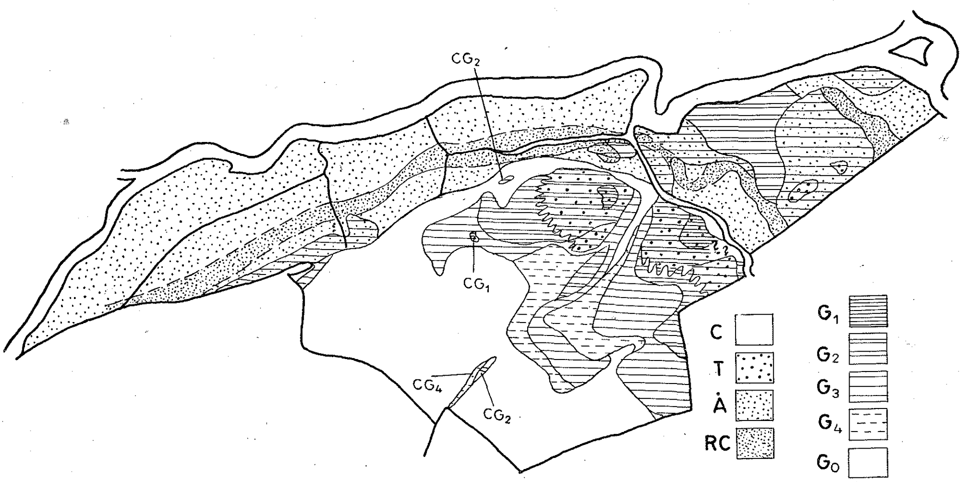

Fig. 2. Soil map of the Field Station, parent material only

C — Oxford Clay; T — Terrace Gravels; A — flood-plain alluvium; RC — abandoned river channel; Go — soil with no gravel horizons; G_1, G_2, G_3 — soils with continuous gravel from 0-6″, 6-15″, 15-36″; G_4 — thin layer of gravel or sand in yellow sandy clay matrix between 24—36″

appear to be present only at a depth below the limit of worm activity, which is roughly marked by a thin very tenuous layer of small stones. In general the bands and layers are reminiscent of the shoes of solifluction lobes as sketched by Williams (1957): from their constitution it is clear that the stones are derived from deposits two—three hundred feet upslope. The clay soils extend right down to the flood-plain.

The alluvial fill of the flood-plain (A on fig. 2), clay to sandy clay loam, is crossed by abandoned stream channels filled by peat or peaty clay, and by numerous patches of gravel (Northmoor or flood-plain terrace, Würm or post-glacial). Several auger borings and a section at C reveal buried gravel eyots and *levées*. Buried peat at 40—50″ below gravel in an abandoned

Table I

Stone-counts

No.	Site	Northern drift pebbles as percent of all pebbles	Relative nos. of pebbles, site 6 only
1	Lip of lower gravel terrace: surface sample	13.2%	—
2	Surface sample: clay-over-gravel (G4) between two terraces	25%	—
3	Surface sample: uphill limit of clay-over-gravel (G4)	46%	—
4	Surface sample: upper clay soil	82%; much of remainder are Oxford clay fossils	—
5	Surface sample: side of the brook-valley (G4)	70%	—
6	Uphill limit of clay-over-gravel (G4): 0—5 ins	40%	5
	5—10	100	0.5
	10—15	85	2
	15—20	10	2.5
	20—25	2	40
	25—30	2	100
7	Surface sample: shallow clay-over-gravel (G3) near terrace edge	23%	—
8	Buried gravel horizon at 40 ins in brook channel	100%; N.D. + unrounded coral rag	—

channel (site 9, fig. 1) gave a pollen spectrum more consistent with a mediaeval than an earlier dating. Part of the flood-plain terrace at G is buried by clay, apparently from upslope.

The Terrace soils (T on fig. 2) consist of sandy clay loam, 0—30 inches thick, over medium water-rounded limestone gravel, with only a small proportion of northern drift material (site 1, table I). At its base the gravel grades into Oxford clay through a layer of small limestone pebbles in a bright yellow gritty, sandy clay matrix.

Along its uphill edges the lower terrace feathers out into a thin sheet (easily penetrated by an auger) of small stones in a bright yellow gritty sandy clay matrix, or locally into a thin sheet of sand or yellow sandy clay alone, over *in situ* clay. The thin gravel layer extends upslope to where it finally disappears altogether, or else it merges into the thick gravel of the small upper terrace (fig. 3a). A similar layer extends upslope from the upper terrace. These layers are continuous and relatively smooth. They are quite different in form from the discontinuous and irregular stone layers observed in the clay higher up. They appear to represent a thin veneer of gravel deposited on a cut-off slope during a period when the river Thames was cutting down into the 235 ft. flood-plain until a new flood--plain was established at the lower level.

In the same direction, but from nearer the river-ward edge of the lower terrace, the texture of the surface soil becomes heavier and the frequency of the northern drift pebbles increases. Compare sites 2 or 7 (Table I) with sites 3 or 6 (0—5 inch sample). A section along the ditch at F—F revealed how the nearly horizontal top of the terrace gravel disappeared beneath an increasing depth of clay containing northern drift pebbles, and stone-counts in a vertical section at site 6 confirm that clay containing predominantly northern drift pebbles overlies a predominantly limestone gravel. Fig. 2 also shows how the depth of clay-over-gravel increases upslope: note the lobe of clay at K—K. Most of the upper terrace has been quarried away: from what remains it would seem that the upper terrace had been almost wholly buried. Only the outer parts of the lower terrace remain uncovered. It seems clear from the above that the clay-over--gravel material is the result of the creep or solifluction movement of clay from upslope, bringing with it northern drift and coral rag material ultimately derived from the crest of Wytham Hill 300 ft above.

The valley of the little brook also contains buried gravel. In its upper part, at least down to the upper terrace, the present flat valley form conceals a buried valley floored with gravel. The gravel, about 12 inches thick, and 40 inches below present ground level consists (site 8, Table I) of northern drift, shattered but unrounded Oxford Clay fossils, and almost totally unrounded fragments of coral rag. Some of the fragments are up to 9 inches in size. The gravel extends up the sides of the shallow valley where it was observed at 40 inches in the ditch at B—B, and was encountered locally within auger depth at B—B, and was encountered locally within auger depth at J—J: it appears to feather out sideways (fig. 3 b).

The channel of the brook skirts the upper terrace and cuts through the lower terrace. A belt of shallow gravel marks its passage over the deposits on the slope between the terraces. Where the brook cuts through the lower terrace the former level of its channel is marked by another buried gravel horizon beneath 40 inches or so of clay alluvium. In transverse sections the gravel dips from the base of the terrace gravels (fig. 3 c): in projected longitudinal section the gravel extends to a level some feet below the present flood plain.

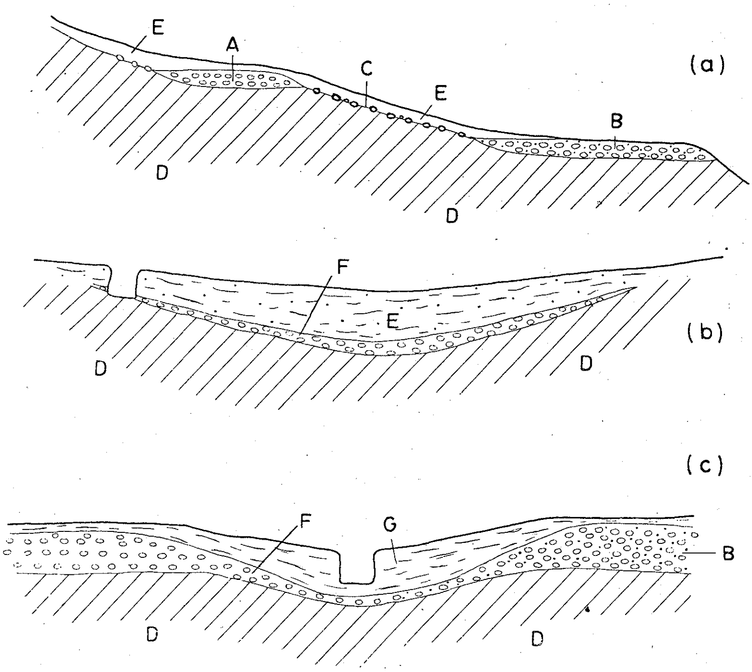

Fig. 3. Diagrammatic sections of: (a) the two terraces and the intervening slope, (b) the upper valley of the brook, (c) the brook where it crosses the lower terrace

A — upper terrace; B— lower terrace; C — gravel layer between the terraces; D — *in situ* Oxford Clay; E— creep or solifluction layer; F — torrent deposits of small brook; G — clay alluvium

DISCUSSION

CLAY-OVER-GRAVEL

The stone-counts and the soil map clearly indicate that the clay-over--gravel soils are the result of clay movement from the over-steepened slopes above. The form of the stone-lines and sand lenses suggests that solifluction is partly, it not wholly, responsible.

STONE-LINES

Several kinds of stone-line are apparent in this small area. There are the lines and lenses seen in section at the head of the clay slope, which have been attributed to solifluction movement. There is the thin stone-line attributed to worm activity — partly because it is associated with the lower limit of relatively uniform soil and the upper limit of undisturbed sand lenses, and partly from its similarity to the lines of fine pebbles associated with the level of worm aestivation chambers (Webster 1965).

Then there is the thin layer on the slope above and between the terraces, the result of fluvial erosion followed by creep or solifluction.

Finally there is the trough-like stone-line associated with the small brook. Here the gravel is clearly alluvial in origin: from its unweathered and unrounded appearance and its composition, it would appear to be the load of a peri-glacial melt-water torrent probably over frozen ground, deposited under conditions in which finer alluvium was carried away. Above the terraces Northern Drift material in the overlying clay shows that the gravel has been buried by the creep of clay from the sides of the little valley. The latter cannot have taken place under the climate which gave rise to the gravel layer. Similarly the burial of the gravel layer, by sharply differentiated clay alluvium in the valley through the lower terrace, can only have taken place under a climate different from that in which the gravel was deposited.

In transverse section these gravel layers appear very similar to some dipping stone-lines reported from SE USA (Parizek, Woodruffe 1957) and also, but on a much coarser scale, to some *cailloutis* material in the loess deposits of Lower Austria and the Paris Basin. The sources of many similar small streams near Oxford exhibit a similar burial of coarse torrent deposits beneath 1—4 feet of finer alluvium or colluvium.

There is still controversy about the origins of stone lines, between those who see them primarily as buried erosion surfaces (e.g. Kellogg & Davol 1949, p. 9; Waegemans 1953; Ruhe 1959) and those who see in them the result of earth worm or termite activity (e.g. Nye 1955; Ollier 1959), so it seems worth drawing attention to one instance in which the burial of a gravel layer can be explained only in terms of a change in climate (as required by Waegemans 1953). Stone-lines may be the result of faunal activity and/or of the burial of lag gravel or erosion pavements by creep or alluvium. However in the latter case it must be noted that stone-lines commonly follow the ground surface quite closely: it is most unlikely that a slope steep enough to retain only gravel, against the prevailing process of erosion, will be gentle enough to retain fine covering material at the same gradient unless the dominant transportation process is also changed, e.g. surface-wash → windblown loess or parna, periglacial run off → humid-temperate creep, etc. A mere rise in base level may allow fine material to bury coarse, but only if it also produces a flatter gradient.

ADDENDUM

Though the original aim of the work was to study the clay-over-gravel materials it is of some interest to note how sharply the minor physiographic processes briefly discussed above have affected the agronomic value of the soils of the area surveyed.

At a time when fertilisers are universally if not excessively applied the primary edaphic problems are those deriving from soil physical properties. On this farm we have at one extreme the gravel soils, liable to severe drought. At the other extreme we have the clay soils, almost wholly impermeable, and normally water logged during the winter months. Yet the map of drainage conditions (fig. 4) indicates by how much this simple contrast is modified by the little brook, by the encroachment of clay over the ter-

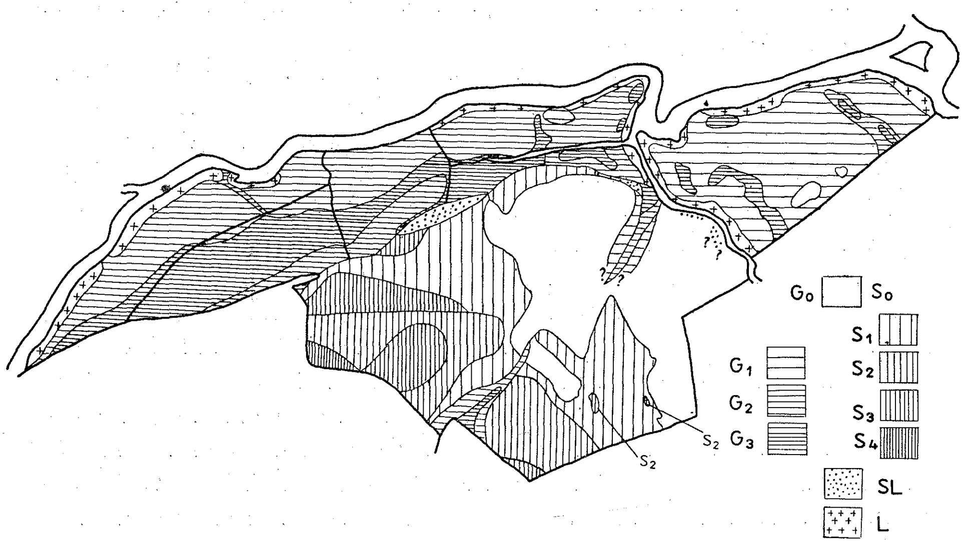

Fig. 4. Soil map of the Field Station, drainage conditions only

G_0—G_3 — ground water gleys with good, imperfect, poor and very poor drainage; S_0—S_4 — surface water gleys with unimpeded, slightly impeded, rather impeded, impeded and very impeded internal drainage; SL — spring line; L— dry *levée* soils races, by the concentrated spring-lines on the undercut slope, and by the abandoned channels or eyots of the flood plain. The clay-over-gravel soils combine both the water-holding capacity of the clays and the subsoil aeration of the gravels: on this farm they are the most highly favoured soils. Even on the flood plain buried gravel eyots at 30—50 inches depth provide surprisingly well-aerated horizons in the otherwise gleyed soils of the flood plain.

ACKNOWLEDGEMENTS

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