IDENTIFICATION OF SOIL PARENT MATERIALS

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This paper is intended for guidance in identifying soil parent materials when soil profiles are described in accordance with the Soil Survey Field Handbook (1974).

Parent material is defined for the purpose as the rock, using that term in its widest sense to embrace unconsolidated mineral and organic sediments, in or from which soil horizons have formed by alteration in place. This definition accords with those of Brewer (1964) and Whiteside (1953) and differs from that of the U.S.D.A. Soil Survey Manual insofar as consolidated rocks are included and no distinction between 'geologic' and 'pedologic' weathering is implied.

When a profile is described, the composition, stratigraphic age, and mode of origin of the parent material or materials should be characterized as accurately and precisely as possible in accordance with the guidelines given below. The parent materials of altered (e.g. A, E and B) horizons cannot be observed and must be inferred from their properties in conjunction with available stratigraphic and geomorphological data. In some soils the parent material is evidently little altered and one can deduce what it was like with confidence : in others, especially those associated with old ground surfaces, it has been so greatly and deeply altered that its original composition and mode of origin are conjectural. In some profiles, too, one can infer with reasonable certainty that the parent material of upper horizons is represented by the rock that now underlies them : others clearly have horizons formed in more than one kind of material, while for others again there is considerable uncertainty about these relationships, particularly without supporting laboratory data. Both knowledge and judgement are therefore needed to avoid unwarranted inferences and to decide what degree of precision is justifiable when characterizing the parent material of a particular soil after appraisal of all relevant data.

Identifying parent materials is useful, firstly as a basis for relating soil-profile data to geological data and terminology, and secondly because efficient and accurate soil mapping is greatly aided by understanding of the origin and stratigraphic relationships of soil horizons and of the sedimentary bodies in which they are mostly formed. However, to the extent that parent-material characteristics are inferred, they are less suitable as a basis for soil classification than profile characteristics that can be directly observed or measured, and this distinction must always be kept in mind.

Mineral Parent Materials

1. Pre-Quaternary rocks that have weathered in place.
2. Quaternary deposits.

Pre-Quaternary rocks as soil parent materials

Mainly because downslope movement of weathered material is a ubiquitous process, and also because disturbance by cryoturbation and additions of wind-borne sediment were widespread during the Quaternary period, profiles with parent materials conforming wholly and strictly to the first category are comparatively rare. Conventionally, however, a pre-Quaternary rock is identified as the parent material when (1) it occurs in place at the base of the profile, (2) properties of overlying horizons (e.g. particle-size distribution, content and nature of stones) are consistent with derivation from similar rock, and (3) evidence of admixture with extraneous material or significant modification by movement are lacking. There are also soils in which one or more horizons have evidently formed in place from a pre-Quaternary stratum (e.g. clay-shale interbedded with limestone) unlike that immediately below.

When the soil is considered to have originated by weathering of consolidated bedrock in place, the parent material is identified by specifying the rock type (Field Handbook, tables 14-17) and currently recognized formation name. For the latter, reference should be made to Geological Survey Special Reports (e.g. Cocks *et al.* 1971) on correlation of rocks in particular systems, as they become available.

This mode of origin can be inferred with the greatest confidence when the profile is shallow, the underlying rock is homogeneous, and there is a progressive upward transition from unweathered rock to soil. In other situations special studies may be needed to identify the parent material with reasonable certainty. This is particularly the case where the soil overlies limestone and may or may not consist of non-calcareous residue accumulated in place.

When the soil is considered to have formed in an unconsolidated pre-Quaternary sediment, the deposit is characterized in terms of predominant grain size and accessory minerals or impurities as in Table 17 of the Handbook, using the terms clay, silt, sand, loam, gravel and marl for clayey, silty, sandy, 'mixed', coarse and carbonatic materials respectively, in conjunction with the stratigraphic age and/or recognized formation name, e.g. London Clay, Folkestone Beds sand, flint gravel

(Haldon Beds). In some cases the formation name effectively connotes the lithology : where it does not, the lithology should be specified separately.

Where the upper part of a profile is in a distinct Quaternary deposit (as evidenced, for example, by the occurrence of 'foreign' stones) and the lower part in more or less weathered pre-Quaternary rock, the presence and nature of the superposed parent materials should be clearly specified, e.g. flinty clayey Head over Gault clay; flinty silty (loessic) Head over Upper Chalk.

Quaternary deposits as soil parent materials

Most mineral soils have formed wholly or partly in Quaternary deposits variously described in the geological literature by terms denoting inferred mode of accumulation (e.g. alluvium, glacial drift), stratigraphic age (e.g. Pleistocene, Devensian), composition (e.g. Coombe rock) or some combination of these attributes (e.g. Chalky Boulder Clay, lake marl). Some of these terms have been used with differing meanings. For example, alluvium has been applied by some to all materials moved by, or deposited in, water, and by others to fluvial deposits only, while on British geological maps it is generally restricted to Recent (Flandrian) sediments. The latter usage is adopted here.

Terms recommended for use in describing Quaternary deposits as soil parent materials are listed below. To aid correlation they should be used whenever applicable, and other terms in common use, on geological maps or elsewhere, cited in parenthesis. For detailed guidance on the classification and identification of Quaternary sediments, particularly glacial deposits, reference should be made to the works of West (1969), Flint (1971) and Francis (1975).

Recent (Flandrian) and Pleistocene deposits should be distinguished whenever possible, and the stratigraphic age of the latter, if known, should be designated using the British stage names recommended by Mitchell *et al.* (1973). When the term used to describe a deposit has no specific lithologic connotation (e.g. till, head, drift), its distinctive lithologic features (e.g. broad particle-size class, type of contained stones, presence of carbonates) should be indicated. Pre-Quaternary source rocks should also be recorded when they can be inferred with reasonable confidence.

Pleistocene Deposits

These include marine, fluvial, lacustrine, glacial, aeolian and head deposits, accumulated in glacial, periglacial and temperate (interglacial) environments.

Marine deposits of Pleistocene age are chiefly represented by raised beaches. They contain remnants of marine life and/or show other evidence of having been deposited by the sea.
Fluvial (river) deposits of Pleistocene age are usually terraced (river-terrace deposits) but may also underlie existing floodplains. They are normally stratified and at least moderately well sorted by grain size. The older (pre-Devensian) deposits have often been disturbed by cryoturbation and/or covered by head (q.v.).

Predominantly coarse textured, water sorted and stratified sediments deposited by meltwater streams in outwash plains or valley trains in proglacial environments are termed glaciofluvial deposits. As soil parent materials they resemble fluvial sediments laid down in non-glacial environments but are generally less well sorted.
Lacustrine deposits include sediments deposited in freshwater lakes in temperate (e.g. Hoxnian lake muds) or proglacial (glaciolacustrine deposits) environments. They are typically silty or clayey, finely stratified (e.g. varved clays), and stoneless or nearly so, but coarser sediments deposited as beaches or deltas also occur.
Glacial deposits As generally defined by geologists, these include water-worked proglacial (glaciofluvial and glaciolacustrine) deposits and ice-contact stratified drift as well as till, recently defined by Francis (1975) as'a sediment deposited by or from glacier ice without the intervention of running water.'

Typical till (basal till), composed of materials transported within and close to the base of the ice, shows little sorting or stratification and is usually dense and compact. Other variants commonly distinguished are ablation till and flow till. The former is considered to include materials that were transported superglacially or released from the ice by surface melting, and may form a relatively thin layer over basal till: it is normally less dense and shows evidence of some sorting by meltwater. Flow tills have a more or less stratified or banded appearance believed to result from solifluxion or slumping of fine textured, water saturated, morainic material at the ice margin.

Ice-contact stratified drift, which commonly forms eskers, kames or kame terraces, has internal characteristics intermediate between those of till and glaciofluvial deposits, but is generally distinguishable from the former by extreme range and abrupt changes in grain size, included bodies of till, or evidence of deformation by slumping when confining ice melted.

Aeolian deposits include loess and cover sand. Loess is a homogeneous sediment consisting chiefly of quartz silt, with subordinate fine sand and clay, and is normally calcareous when unweathered. Although transported primarily by wind, it is commonly redistributed after deposition by sheetwash or solifluxion, and thin deposits are commonly mixed with subjacent materials by cryoturbation or otherwise. It can generally be distinguished from other silty deposits by the mineralogy of the silt fraction, which indicates a non-local provenance.

When describing soil parent materials, the unqualified term loess should be restricted to thick (e.g. >80 cm) deposits meeting the above specification, including much of the 'brickearth' mapped by the Geological Survey. Where the profile has a distinct silty upper layer apparently derived mainly from loess, the parent material should be described as loess over a specified substratum, e.g. Clay-with-Flints. Thicker, more or less stony deposits that appear to contain loess mixed with locally derived detritus by solifluxion (e.g. many 'coombe deposits') should be classed as Head and the occurrence of loess as a source material noted.

Cover Sands are well sorted sandy aeolian deposits, mainly of Devensian age, accumulated under periglacial conditions and occurring as superficial layers of fairly uniform thickness or as 'fossil' dunes. (e.g. Matthews 1970). As with loess, thin accumulations of cover sand may be irregularly mixed with subjacent deposits by cryoturbation, and Head deposits may incorporate variable proportions of sand previously transported by wind. Where there is good evidence of this, the parent materials should be described accordingly.

Head deposits are unsorted or irregularly sorted and stratified sediments attributable for the most part to downslope movement by solifluxion or melt-water action under periglacial conditions. The source materials may be pre-Quaternary rocks or pre-existing Quaternary sediments of fluvial, aeolian or glacial origin. Particularly in the latter case, Head may be difficult to distinguish from till by internal characteristics alone.

Deposits of this type accumulated beyond the ice fronts in each glacial period. They vary greatly in composition and degree of weathering, and some have been given specific or local names, e.g. angular chert drift, taele gravel, coombe rock. Those on lower ground often show evidence of some sorting by water and grade into Devensian river deposits : others form dissected sheets on hills or plateaux and are clearly older. Those in the latter category, including the heterogeneous accumulations grouped as Plateau Drift (Clay-with-flints sensu lato and Pebbly Clay and Sand) by Loveday (1962), often appear to represent the weathered remains of pre-existing deposits which have been disturbed and re-arranged to varying degrees by the action of local snow-caps or ice fields.

As defined by Dines et al (1940), Flandrian sediments accumulated under temperate conditions may also be classed as Head. Other authors have restricted it to older deposits and this usage is recommended for the present purpose, with the intention of separating recent 'colluvial soils' in soil series or higher categories as far as possible.

Although mainly of Pleistocene age, landslips involving downward displacement of large masses of rock as a result of shear failure are considered as Head deposits only if the original rock structure of the slipped mass has been so disrupted as to be no longer recognizable. Otherwise the rock is treated as if it were in place when describing the parent material of a soil formed in it, and the observation that it has slipped below its normal position is also recorded.

Recent (Flandrian) Deposits

These are detrital and biogenic sediments accumulated under temperate conditions during the last 10,000 years, partly as a result of accelerated erosion attributable to human occupation. They can generally be distinguished from older deposits by some combination of internal and external characteristics, but detailed stratigraphic studies involving examination of contained biotic or archaeological remains may be needed for positive identification. As indicated above, the terms alluvium and colluvium are here restricted by convention to Flandrian deposits. Terms used to describe other types of deposit have no specific stratigraphic connotation, though in some cases (e.g. tufa, lake marl) older (i.e. interglacial) deposits of the same type have not yet been identified in soil profiles in England and Wales.

Marine alluvium comprises stoneless detrital sediments deposited by tidal water on coastal flats and in sheltered estuaries. It contains organic remains of salt-tolerant plants and animals characteristic of the depositional environment, and is usually calcareous when freshly deposited. The estuarine deposits can generally be distinguished paleontologically from fluvial sediments and marine deposits proper, but may be grouped with the latter for the present purpose.

(Recent) beach deposits include sand and shingle of active or recently stabilized beaches.

River alluvium consists of detrital sediments laid down on floodplains (levees and backswamps) of rivers and streams. It normally contains more organic matter than older river deposits with similar clay contents and is usually distinguishable by its physiographic position and particularly by the incidence of flooding. Special stratigraphic studies may otherwise be needed for positive identification, particularly when the deposit is coarse textured and where flooding no longer occurs. Some streams are evidently incised in flat lying fluvial or head deposits of Devensian age.

Lacustrine alluvium This term is used for Recent detrital sediments deposited in lakes, particularly those that occupied closed depressions in areas affected by late Devensian glaciation. The deposits are usually fine and appreciably organic; they may be interbedded with peat.

Colluvium This term is applied to recent deposits, also known as slope-wash or plough-wash, accumulated in minor valley bottoms, in fans, at the base of slopes, and against artificial obstructions such as hedge-banks, particularly as a result of accelerated erosion following clearance of the natural vegetation by man in Neolithic and succeeding periods. Like river alluvium, into which it may grade, it normally contains significant amounts of organic matter and shows little evidence of post-depositional weathering. It often overlies Head, and special stratigraphic studies may be needed to distinguish it with certainty.

(Recent) Blown Sand comprises well sorted aeolian sand of actively accumulating or recently stabilized dunes and 'links'. It is mainly confined to coasts but also occurs in inland locations such as Breckland and the Vale of York.

Tufa is a carbonatic deposit composed largely of secondary calcium carbonate precipitated from spring water where it issues from a calcareous substratum. The carbonate coats mineral particles and plant and animal remains (e.g. snail shells) and may cause cementation. Tufa of Flandrian age is commonly interbedded with alluvium, colluvium or peat, and occurs locally in all the main limestone areas of England and Wales, often forming low mounds in valley-bottom or footslope sites. Deposits more than 3m thick are described by Arkell (1947).

Lake Marl (also known as algal marl) resembles tufa in composition but is deposited under water in lakes or meres and consists mainly or partly of remains of *Chara*, a calcium-carbonate accumulating alga.

It contains varying amounts of organic matter and is commonly interbedded with autochthonous or sedimentary peat.
Diatomaceous earth (Diatomite) is a genetically similar sub-aquatic deposit consisting predominantly of the siliceous casts of diatoms.

Organic Parent Materials

Organic soil materials originated either as autochthonous peat, consisting of plant remains that accumulated in the position of growth, as biogenic sediment accumulated under water (sedimentary-peat), or as products of sub-aerial erosion of 'hill peat' (redeposited peat). Peaty interglacial deposits are important marker beds in Quaternary stratigraphy, but have seldom, if ever, survived near enough to the surface to form the parent materials of modern soils. Organic parent materials are therefore normally of Flandrian age.

While organic sediments are clearly parent materials in the sense defined above, autochthonous peat can be considered either as soil or as parent material depending on the viewpoint adopted. For the present purpose, autochthonous peat is considered as parent material when it forms a surface layer that is more than 40 cm thick or rests directly on bedrock or fragmental material, and when it occurs as a buried layer beneath mineral soil. In either case it is characterized as far as possible in terms of the content of identifiable plant remains (e.g. *Sphagnum-Calluna-Eriophorum* peat; *Phragmites* peat).
This procedure is primarily applicable to profiles in which all organic horizons are little decomposed or from which it can be reasonably inferred that more or less well humified upper horizons were originally similar to underlying fibrous or mesic peat. When the organic horizons are mainly amorphous, the parent material cannot be characterized reliably in this way, and may be difficult to identify as autochthonous or sedimentary when the material is well humified and its original structure is no longer identifiable microscopically. As a rule, however, material that originated as sedimentary peat (Field Handbook, pp.55-56) contains significant amounts of mineral matter and is commonly interbedded with other limnic deposits.

Identification of biogenic sediments is well treated by West (1968, pp.51-61).

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