The Soil at Rothamsted

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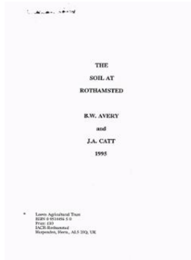
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Mineralogy

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(7.5YR5/6) to yellowish red (5YR5/6-8) and show additional micromorphological features (Avery & Bullock 1969; Avery *et al.* 1972) attributed to soil development in one or more earlier interglacial stages of the Quaternary. Soils with B horizons of this kind have been grouped as paleo-argillic brown earths in England and Wales, and are typically more strongly leached and weathered than younger soils in parent materials of originally similar composition. Those on Clay-with-flints include typical paleo-argillic brown earths (Carstens and Winchester series) with uniformly coloured B horizons, and stagnogleyic paleo-argillic brown earths (Batcombe and Hornbeam series) in which the B horizons show varicoloured mottling within 60 cm depth, indicative of reduction/mobilization and redeposition of iron (gleying) under periodically water-saturated conditions.

Following construction of the Redbourn by-pass, soils of the third class are of very limited extent, occurring only in Flint Field and the adjoining Ver Spinney (Fig. 1). They have very dark coloured topsoils rich in organic matter and greyish gleyed subsurface horizons with ochreous mottles and streaks.

Texture and stoniness

As the topsoils generally contain substantial proportions of loess-derived material, they are predominantly silty in texture. Over at least 75 per cent of the area mapped, the estimated particle-size (textural) class is silty clay loam (Fig. 2b), or silt loam according to the U.S.D.A. system (Fig. 2a), with between 18 and 27 per cent clay and less than 20 per cent sand (60 μm - 2 mm). Topsoils of finer texture, mainly heavy silty clay loams with 27-35 per cent clay, occur chiefly on upper slopes susceptible to erosion, as in Barnfield (Avery *et al.* 1972) and Claycroft, and only sporadically on the plateau. Lighter soils, mainly silt loam or sandy silt loam containing less than 18 per cent clay, have been recorded only in parts of Flint, Scout, Ver and Osier fields (Fig. 1).

The topsoils nearly everywhere contain angular, or angular and rounded, flint stones in proportions which locally exceed 15 per cent by volume. Under old grass, as in Highfield (profile 13), they are concentrated in a layer some 10-20 cm below the surface as a result of earthworm activity. Of the predominant 'Clay-with-flint soils' (Batcombe, Carstens and Winchester Series), those on the nearly level plateau are generally less stony than on bordering slopes, and the subsoils contain fewer but larger flints. Average weights per acre of stones (> 6 mm) in successive 23 cm layers, quoted for the chief experimental fields by Hall (1917), exemplify these trends. Thus the surface layer of Barnfield is significantly more stony than those of Broadbalk and Hoosfield but not quite as stony as Agdell, and the topsoils of both Barnfield and Broadbalk are on average two to three times more stony than the subsoils at 46-69 cm. In the generally loamy soils at lower levels, however, the subsoils are in places much more stony than the topsoils, particularly alongside and west of the R. Ver in Flint, Osier and Scout fields (Fig. 1).

Mineralogy

The mineralogy of the fine earth < 2 mm has been studied only in Batcombe and associated soils in Broadbalk (Weir *et al.* 1969) and Barnfield (Avery *et al.* 1972). The results indicate that the Batcombe soils in both fields are developed in a relatively silty (loess-containing) superficial deposit overlying and mixed with the Clay-with-flints. The fine sand and more particularly the coarse silt fractions of the latter contain around 95

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per cent quartz, small amounts of flint and feldspar, and heavy fractions dominated by iron oxides, zircon, tourmaline, rutile, staurolite and kyanite. In samples from the superficial layer, however, the coarse silts contain up to 17 per cent feldspar and heavy fractions yielding chlorite, epidote, garnet and amphiboles in addition to the more resistant mineral assemblage typical of the lower deposit. As well as flint, the fine sand fractions contain small amounts of chalcedony derived ultimately from shells of partially silicified fossil lamellibranchs, brachiopods and echinoids in the Chalk (Brown *et al.* 1969). The data also support the conclusion that upper horizons of the soils in the lowest parts of both fields (profiles 23 and 27) are developed in recent colluvium (Notley series).

The clay (< 2 μm) fractions of the soils examined are composed mainly of interstratified expanding-layer silicates containing smectite and other layers, with subsidiary mica and kaolinite and small amounts of feldspar (in coarser clay fractions), chlorite and crystalline (goethite) or amorphous ferric oxides. In general, the clay fractions of loess-rich horizons differ from those consisting mainly or entirely of Clay-with-flints in containing vermiculite, chlorite and feldspar; they also contain more mica, kaolinite and quartz, but less smectite. Data on soils elsewhere in the Chilterns (Avery *et al.* 1959; Loveday 1962; Avery 1964) show that clay fractions of the Clay-with-flints *sensu stricto* immediately overlying the Chalk in Winchester and Carstens soils are normally richer in smectite than those of overlying horizons. As this layer also contains more clay, amounting in places to more than 80 per cent of the fine earth (e.g. in profile 5), it has a correspondingly larger shrink-swell capacity.

Organic matter content and pH

Under semi-natural conditions, as in woodland or old grassland, the calcareous soils on Chalk or chalky drift contain significantly more organic matter, and hence more nitrogen, than the moderately to strongly acid soils on Clay-with-flints and associated deposits. This trend is well exemplified in profiles 6-9 in Knott Wood (Fig. 3). Still larger amounts, ranging up to 7-8 per cent organic carbon in the upper 20 cm, occur under old grass in the Ver valley (profiles 17, 37-39), where humus accumulation has been favoured by the former prevalence of high water table levels as well as by high base status.

Broadbalk and Geescroft Wildernesses (Fig. 1), uncultivated since 1882 and 1885 respectively and both on Batcombe soils, provide further evidence of the effect of calcium carbonate in promoting accumulation of organic matter under semi-natural conditions. In Broadbalk Wilderness (profiles 10 and 11), the topsoil of which still contains $CaCO_3$ remaining from heavy applications of chalk before the 1880s, there was a rapid increase in organic matter content such that by 1964 it was greater than in the nearby arable plot that had received 35 t/ha of farmyard manure annually since 1843 (Jenkinson 1971). On Geescroft Wilderness, now bearing deciduous woodland dominated by oak, previous chalking had been less generous; the topsoil pH (in water) declined from 7.1 in 1883 to 4.2 in 1990 (Johnston *et al.* 1986), and the accumulation rates of organic carbon and nitrogen were slower, less than one half that for carbon and less than one third that for nitrogen in Broadbalk Wilderness.

On the farmed land, both pH and organic matter content are primarily dependent on management history, including experimental treatments. As already indicated, Broadbalk, Hoosfield and other land regularly cropped during and before the 19th century traditionally received heavy dressings of chalk, each amounting to as much as

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