# Report for 1974 - Part 1

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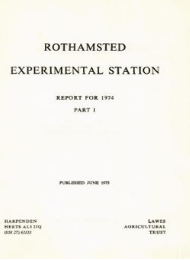

## Pedology Department

### C. Bloomfield

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# PEDOLOGY DEPARTMENT

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## Introduction

We previously referred to the difficulty of adequately characterising soil clay minerals (*Rothamsted Report for 1972*, Part 1, 67–68). We have continued our detailed study of the identification of the components of a range of soil clays, and to assist in the interpretation of the X-ray diffraction patterns of soil clays we have calculated the patterns to be expected from a further range of interstratified minerals that are thought to be components of soil clays.

Our studies of the mineralogy and weathering of boulder clays have clarified the glacial stratigraphy of eastern England; the Hessle Till is not a separate depositional unit, as was previously thought, but a weathered form of either of the two main boulder clays that were deposited during the last glaciation, approximately 18 000 years ago.

Re-examination of soils from sewage-sludge treated plots of the Market Garden experiment at Woburn showed that their contents of acetic acid-soluble heavy metals has declined to less than half the values obtained in 1959. However, although it is 11 years since the last application of sludge, the sludge-treated soil still contains 5–10 times more readily extractable Co, Cr, Cu, Ni, Pb and Zn than soil from the control plots. We have shown that liming aerobically incubated sewage sludge/soil mixtures can increase or decrease the extractabilities of the toxic metals they contain, depending on the element and the extractant.

Our study of the effects of fumigation on soil metabolism, which is now finished, has led to the development of a new method for measuring the soil biomass that should prove useful in the study of the mineralisation of soil organic matter. We have started to study the effects of mechanical disturbance on the decomposition of soil organic matter and, in collaboration with the International Institute of Tropical Agriculture, on the accumulation and release of organically combined nutrients in soils of the humid tropics.

Work was continued on metal-organic matter interactions in soils and on the mechanism of podzolisation; a rapid routine method for identifying potential acid sulphate soils has been proposed.

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## Mineralogy

**Mineralogy of some English soil clays.** Work has continued on the identification of the poorly crystalline swelling minerals that form an important and often dominant part of the clay fractions of soils. Last year we reported the results of a study of a Denchworth series soil in weathered Oxford Clay (*Rothamsted Report for 1973*, Part 1, 68–69). The <0·04 μm fraction of this soil was shown to be a randomly interstratified illite-smectite with about 45% smectite layers. We have extended this work by examining the clay minerals in the B horizons of 11 soils that have previously been reported to contain much poorly crystallised smectite. The soils belong to the Denchworth series developed on Kimmeridge Clay, the Denchworth and Wicken series on Gault Clay and on Oxford Clay, the Trip series on Jurassic Fullers Earth Clay, the Woolhampton and Windsor series on London Clay, and the Swanmore series on Reading Beds Clay. The clay fractions were quantitatively sub-divided into 2–0·2 μm, 0·2–0·04 μm and <0·04 μm fractions. The sub-fractions comprise 15–45%, 32–48% and 10–38% of the <2 μm fractions, which themselves form 37–72% of the whole soils.

Preliminary X-ray diffraction examination of these clay separates showed that mica, kaolinite and iron oxides are concentrated in the 2–0·2 μm fraction and that the <0·04 μm fractions are usually monomineralic swelling interstratified clay minerals with appreciable proportions of expanding layers. The 0·2–0·04 μm fractions are intermediate in composition.

The characteristics of the swelling interstratified minerals are most easily studied in the monomineralic fine clays. In nine of the samples the minerals seem to be randomly interstratified illite-smectites, with proportions of smectite layers varying from 40–90%. There is an indication that the proportion of swelling layers in these minerals decreases with increasing age of the parent rock, but the clays from the soils on the Fullers Earth Beds, thought to be derived from volcanic ash, are exceptions. The two remaining fine clay fractions also contain interstratified expanding minerals, which, although they give differing X-ray patterns, both show tendencies to ordered stacking of interstratified components. Partially ordered interstratified minerals have also been recognised in the clay from a soil derived from Carboniferous Limestone Shale.

**Calculation of diffraction patterns of interstratified expanding clay minerals.** Three new models of interstratified clay minerals have been added to those for which X-ray diffractometer traces have previously been calculated (*Rothamsted Report for 1972*, Part 1, 67–68 and for *1973*, Part 1, 68–69). In the first, provision has been made to add a layer of organic molecules to the outside of diffracting packets. Previous models were calculated for two-component random interstratifications of packets each containing from three to seven interlayers, the packets terminating at the outside layer of the oxygen atoms of the silicate sheet. In models in which the components are illite and smectite, the smectite interlayer would normally include ethylene glycol or glycerol molecules. In actual ethylene glycol or glycerol-treated samples, the outsides of the packets would be coated with one or more layers of the organic molecules. The computer model has therefore been modified to allow the outside of the packet to be terminated by layers of organic molecules of variable thickness. The second modification to the models allows the interstratification to be ordered as well as random. With this facility the variations in diffractometer patterns to be expected for differing degress of order, and of the proportions of illite and smectite interlayers, were studied. With complete order of minerals containing 50% smectite and illite interlayers, the effective basal spacing is the sum of the two components, 10 + 17·8 = 27·8 Å for glycerol-solvated smectite-illite, and the first order reflection of this spacing is very well resolved. However, the resolution of the reflection decreases rapidly as the degree of ordering is decreased, so that at one half maximum ordering the reflection is represented by a point of inflection in a sloping background. The second order reflection, at 13·9 Å, is resolved when the first is hardly discernible. Such a second order reflection, if considered in isolation, could easily be mistaken for the first basal reflection of vermiculite. The resolution of the first reflection of the 27·8 Å spacing also diminishes rapidly when the proportions of interstratified interlayers vary at maximum order from 50% smectite: 50% illite, so that only in the range between 70% and 40% of smectite interlayers is the first reflection resolved. When the first reflection is discernible the recognition of an ordered or partially ordered mineral is a simple matter; it is also possible, although more difficult, to use the second reflection when the first is missing. The spacings of the two reflections do not migrate when the relative proportions of the two components of the interstratified mixtures are varied. However, the sixth reflection does migrate, and the use of its peak position, together with the degree of resolution of the first two reflections, enabled the proportions of the two components in the mixtures, and the degree of ordering, to be deduced.

The third development of models for computer-calculated traces allows random interstratifications of three-component mixtures to be computed. This is likely to prove of particular value in the study of soils in which smectite-illites are modified by partial chloritisation during weathering to give mixtures of 10, 14 and 16·8 Å components in ethylene glycol-treated samples. In such interstratifications the first reflection migrates from a position corresponding to a smectite spacing to that of chlorite, and then to that of illite, as the relative proportions of the components are varied. This is in contrast to the smectite-illites where the first reflection loses resolution but does not migrate as the proportion of illite interlayers increases. First reflections with spacings corresponding to those of smectite : chlorite : illites have been observed in clay minerals from soils, and samples are being sought in which the proportion of other minerals is small enough for the whole pattern to be compared with the computed patterns. (Brown, Rayner, Ormerod and Weir)

**Potassium release from soil clays.** Earlier it was suggested that the decline in the potassium concentration of successive 0·1 M-$CaCl_2$ extracts of soil clays could be used to estimate the ability of the soil to supply K to plants. It was shown that soil clays varied considerably in their ability to release K, in a way that was not related to their total K content; in seeking the reason for this variation, we compared, in more detail than was previously possible, the clays from two soils (a Swanmore series soil formed on Reading Beds parent material, and a Whimple series soil on Permian marl), that differ two-fold in their ability to release potassium. To avoid any complication that might arise from the presence of much organic matter, we used clays from the B-horizons of both soils, and for comparison with the soil clays we included an illite, from Beavers Bend, Oklahoma, and a glauconite, from the Upper Greensand, Dorset.

Solutions of 0·1 M-$CaCl_2$, $BaCl_2$ and NaCl were used as extractants. The concentrations of K in the first four or five extracts declined steadily, but no further systematic decrease was observed in the subsequent extracts. It was presumed that surface-adsorbed K was being removed while the K-concentration was declining, whereas the later extractions were removing interlayer K.

The order of surface-K release for different size fractions of the Swanmore (SW) and Whimple (WH) clays was: SW ($<0·3$ $\mu$m) $>$ SW($0·3$ $\mu$m $-$ $1$ $\mu$m) $>$ SW ($>1$ $\mu$m) $>$ WH ($0·3$–$1$ $\mu$m) $>$ WH ($<0·3$ $\mu$m) $>$ WH ($>1$ $\mu$m), the Swanmore clays yielding approximately twice as much K as the Whimple. Comparison of the fine clays with illite (IL) and glauconite (GL) gave the following sequence: GL $>$ IL $>$ SW $>$ WH. The order of effectiveness for different cations was Ca $>$ Ba $>$ Na, but the same sequence of K-release from the clays was found for each cation, so that the nature of the cation used for comparison was not critical. It was noteworthy that the soil clays were able to release considerably less K than GL or IL, and the soil clays were therefore treated with dithionite and boiling 0·25 N–NaOH to remove amorphous hydrous oxide coatings that might hinder K-release. No alteration in the rate of K release in any of the samples resulted from these treatments, so that external coatings apparently do not modify the process.

The categories of mineral present in the clay fractions and their chemical compositions were determined by X-ray diffraction and chemical analysis, and infrared spectra were recorded for supporting evidence. Approximately equal proportions of mica and smectite are the main components in the Swanmore clay, together with about 10% kaolinite and a little goethite, whereas the dominant mineral in the Whimple clay was an interstratified mica-smectite with about 90% mica layers (illite), together with small amounts of chlorite that is mainly of the intergrade (interlayered) type, goethite, hematite and possibly kaolinite ($< 1\%$); the Swanmore clay contained 3·5% $K_2O$ and the Whimple 6·0% Otherwise, the chemical composition of the 2 : 1 alumino-silicate layers differed mainly in the octahedral layers, which for the Swanmore clay contained ($3{\cdot}1\ Al + 0{\cdot}6\ Fe^{3+} + 0{\cdot}3\ Mg$) per $O_{20}(OH)_4$, whereas the composition of the Whimple clay was ($3{\cdot}1\ Al + 0{\cdot}3\ Fe^{3+} + 0{\cdot}6\ Mg$). This could imply that the net negative charge in the Whimple clay was greater than in the Swanmore, so that the former would be expected to have a stronger affinity for potassium. This interpretation is not entirely convincing, because the compositions quoted, being derived from the overall chemical composition, are averages for the whole clay, and the Swanmore contains much more smectite, a low-charge layer silicate that does not normally contain much potassium; nevertheless, the approach may prove useful for investigating whether K-release correlates with the chemical composition of soil clays. (Branson and Newman)

**Boulder Clay soils in eastern England.** Our study of the genesis of boulder clay soils was extended to include samples from profiles in the Late Devensian tills of south-east Yorkshire (Holderness), east Lincolnshire and the coastal strip of north Norfolk. Most workers have regarded the surface boulder clay in these areas as a lithologically homogeneous unit, called the Hessle Till in Yorkshire and Lincolnshire, and the Hunstanton Till in Norfolk, although on the basis of detailed geomorphological studies Straw has distinguished two Marsh Tills in Lincolnshire, the products of two separate glacial advances (*Transactions of the Lincolnshire Naturalists Union 1969*, **17**, 85–98).

In Yorkshire the Hessle Till is red-brown (5YR 4/4, and occasionally 5YR 3/4 or 5YR 4/6), up to 5 m thick, and overlies two other boulder clays, the Purple (dark brown, 7·5YR 3/2) and Drab (very dark greyish brown, 10YR 3/2) Tills; all three were deposited between approximately 18 000 and 13 000 years B.P. The middle member of this sequence (the Purple Till) is seen only in the Holderness coastal cliffs between Hornsea and Easington, but the Drab occurs almost continuously along the Yorkshire coast, and also at depth beneath the Hessle Till in inland areas of East Yorkshire.

Our mineralogical analyses of sand and coarse silt fractions from subsoil samples at many localities shows that there are two main types of Hessle Till in Holderness. One occupies an arcuate area extending along the coast from Hornsea to Easington, and up to 5 km inland. The other occupies all the remaining area, including the boulder clay soils on the eastern footslopes of the Yorkshire Wolds. However, a narrow third zone, in which the soils have an intermediate mineralogical composition, can be traced between these two main areas. Comparison of the composition of these two types with the unweathered Purple and Drab Tills shows that the Hessle Till of the arcuate coastal area is formed by weathering of the Purple, whereas that of the other area is weathered Drab. The narrow intermediate zone is probably an area where thin Purple Till overlies the

Drab, and the soils are formed from mixtures of the two. All the samples from Norfolk and Lincolnshire correspond to weathered Drab Till, and there were no detectable differences between samples from the areas of Straw's two Marsh Tills. The Hessle Till is therefore not a separate stratigraphic unit in the Devensian Till sequence, but is merely the weathered form of whichever of the two tills (Drab or Purple) occurs at the surface.

The main mineralogical changes caused by weathering in the sand and silt fractions are the oxidation of pyrites and siderite to iron oxides. This results in an overall reddening of the soil to a colour which Avery (*Journal of Soil Science* (*1973*) **24**, 333) suggests is typical of palaeo-argillic horizons, i.e. those with features attributable to pedological reorganisation before the last (Devensian) glacial period. However, in these boulder clay soils the colour must have developed later than this, as the tills were deposited during the last glacial period. (Catt and Madgett)

**Mineralogy of Nigerian soils.** The soils of the humid tropics have received less attention than those of temperate regions; the aim of our study of these soils is to provide mineralogical data on defined soil profiles from the main climatic-vegetation regions in Nigeria. The project is supported by the Ministry of Overseas Development (ODM) and is being done in collaboration with the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The results will provide information on soil formation in the humid tropics, and, it is hoped, will assist the extension of the intensive management systems being developed at the Institute to other parts of the humid tropics.

The soils we are studying are from toposequences in Nigeria, mainly those developed on acid-intermediate Basement Complex rocks under climatic conditions ranging from Guinea savanna to superhumid forest. The soils were selected and sampled by Dr. F. R. Moorman, IITA and Dr. G. Murdoch of the Land Resources Division of ODM.

One hundred and forty-two samples from 28 soil profiles covering eight toposequences have been subjected to preliminary analysis to obtain an overall impression of the soils under investigation. The soils have been subdivided into coarse and fine sand, silt and $< 2\ \mu m$ clay fractions. The clay fractions have been examined by X-ray diffraction and transmission electron microscopy, to establish their mineralogical compositions; the fine sand fractions have been examined optically to obtain an indication of the reserves of weatherable minerals.

These preliminary studies of the clays show that kaolin-like minerals are predominant, with accessory iron oxides. Mica occurs in some soils and appears to be related to the presence of mica in the parent rock. Smectites are dominant only in low-lying soils in the more arid regions, but smaller amounts of expanding minerals are found in many soils. The kaolin mineral is usually of the disordered type, but tubular halloysite is also present in many soils. The crystalline iron oxides have been recognised as hematite and goethite, the former being more common in the better drained members of toposequences in the drier areas. Small amounts of gibbites have also been found in some soils. The fine sand fractions consist predominantly of quartz with subsidiary hornblende, staurolite, tourmaline and other resistant minerals. The less weathered soils also contain appreciable amounts of micas, both muscovite and biotite, chlorites and feldspar. Generally, however, the sand mineral assemblage reflects the parent material. (Brown and Hughes)

## Clay physics

**Soil structure.** Work on the pore structure of soils has been resumed after a break caused by the death of Dr. Greene-Kelly. The application of mercury porosimetry to supercritically dried clay soils appears to be feasible for determining the pore size distribution of moist soils, and during the last few months preliminary work on techniques has been restarted in the expectation that they will be required for cooperative studies on soil structure. In this application it is essential to be sure that mercury injection does not modify the pore structure as it is being measured; one possible artefact of such modification is an overall compression of the relatively soft material, so that the apparent pore size distribution would in fact be a measure of bulk compression of the sample. Fortunately, this does not seem to be a serious factor, and recovery of mercury from intruded samples shows that at least 80%, and probably more, of the pore volume is penetrated. Further work will be undertaken to establish whether distortion of the pore size distribution occurs when most of the pore volume is intruded. (Newman and Perrins)

## Soil geochemistry

**The distribution of minor elements between size fractions of a clay soil.** Major and minor element contents and other characteristics of Denchworth soils were investigated by multivariate analysis, and the relationships between parameters were depicted by computer models (*Rothamsted Report for 1973*, Part 1, 73). To test these relationships in the laboratory, two profiles (0–90 cm) of soil mapped as Denchworth series (one calcareous and one non-calcareous) were divided into horizons; these were separated into various size fractions by wet sieving, decantation and centrifugation after dissolving $CaCO_3$ with $CO_2$ under pressure. The major and minor elements of the silt and clay fractions were determined by X-ray fluorescence spectrometry.

Si, Ti, Y and Zr were concentrated in the silt fraction. Si, Zr and Ti are probably concentrated as the resistate minerals quartz, zircon and rutile; Y may also be present in zircon, and possibly in apatite. Mg, Al, P, K, Ca, Mn, Fe, Ni, Cu, Zn, Ga, As, Br, Rb, Sr and Pb were concentrated in the clay fraction. Of the major elements, more Fe, Ca and Mg occurred in the coarse ($< 2\ \mu$–$0{\cdot}2\ \mu$) than in the fine ($< 0{\cdot}2\ \mu$) clay, and Al and K were equally distributed between coarse and fine clay. In the few samples that yielded enough fine clay to permit the determination of minor elements, Sr was concentrated in the coarse clay and Rb was equally distributed in the two clay fractions.

To a certain extent, the computer models also show these relationships; this detailed study of the fractionation of major and minor elements in the soil thus shows that computer models can be used to interpret the more general data that is available for a wider range of soils. (Carolyn Williams and Jean Devonshire)

## Soil chemistry

**The measurement of soil biomass by the fumigation technique.** To calculate the soil biomass from the relationship $B = F/k$, where B is the biomass carbon and F the increase in $CO_2$–C caused by fumigation, a value must be assigned to k, which is the fraction of the killed biomass carbon that is decomposed to carbon dioxide in the 10 days after fumigation. To establish a broadly-based value for k, 12 different organisms, which were chosen as representative of different sections of the soil population, were mixed with soil and fumigated; the extra carbon dioxide coming from the killed organisms was measured. (The organisms included yeasts, fungi, an actinomycete, bacteria and earthworms.) From 40–60% of the organic carbon in the different organisms was mineralised to carbon dioxide, giving a mean value of 0·5 for k. This is considerably larger than the provisional value of 0·3 proposed some years ago (Jenkinson, *Journal of Soil Science*, (1966) **17**, 280–302). Our studies on the effects of fumigation on soil metabolism are now finished; the new method for measuring soil biomass that was developed during this work should be widely applicable in the study of the dynamics of soil organic matter. (Jenkinson)

**The effects of mechanical disturbance on the decomposition of soil organic matter.** This topic has become of practical interest because of the increasing importance of 'minimum cultivation' in British farming. It is also of theoretical importance as it has been suggested that much of the organic matter in soil is protected from decomposition because it exists in areas that are inaccessible to microorganisms. In our initial work on this problem we have used disruption techniques that are far more drastic than anything likely to be encountered in the field.

Soil was ultrasonically dispersed (Genrich & Bremner *Soil Science Society of American Proceedings* (1972) **36**, 944–947) and the resulting paste freeze-dried and incubated. This treatment accelerated the decomposition of organic matter in both cultivated and uncultivated soils. Thus, the carbon dioxide carbon released in 10 days by undispersed fallowed soil from Broadbalk (plot 08) was 7 mg/100 g soil; after dispersion it rose to 24 mg. The corresponding figures for an old grassland soil (Park Grass plot 3d) were 24 and 102 mg/100 g soil. This flush of decomposition caused by ultrasonic dispersion is much too big to come from organisms killed during the treatment, and non-living parts of the soil organic matter must also have been exposed to attack. (Jenkinson)

**Effects of air-drying on the release of organically-bound nutrients by soils.** Our aim here is to gain an understanding of the mechanism by which air-drying increases the rates at which nitrogen and sulphur are released. Some preliminary studies were done on a Nigerian soil under secondary forest, supplied by Dr. B. T. Kang of IITA. So far we have succeeded in dividing the air-drying effect into two, firstly the decomposition of organisms killed during air-drying, and secondly an effect that seems to be associated with the release on drying of protected substrates from the humic/clay colloids. This was demonstrated on a sample of the soil that was fumigated with chloroform and incubated for 10 days. The soil was then either incubated alone, given a second chloroform treatment and incubated, or air-dried, remoistened and incubated. Air-drying produced a much larger flush than the second chloroform treatment, showing that most of the material rendered decomposable by air-drying could not have been derived from the biomass. This non-biomass component of the flush of decomposition appears to be particularly important in tropical soils. (Tuckwell and Jenkinson, with Dr. A. Ayanaba, International Institute of Tropical Agriculture)

**Effects of management and cropping on the organic matter and nutrient reserves of tropical soils.** The soils for this work came from Dr. B. T. Kang and Dr. A. S. R. Juo's field experiments in Nigeria on the clearing and cropping of secondary forest. When sampled these experiments were entering their third year of cropping. The soils were incubated, either directly, or after chloroform fumigation, a treatment known to mobilise the nitrogen reserves. The amounts of oxygen consumed, carbon dioxide evolved, and nitrogen and sulphur mineralised were measured; Table 1 gives some of the results. The total nitrogen content decreased on cultivation, but the greater the clay content the slower the rate of decline. Poor yields were reported from soil 3 (*IITA Annual Report for 1971*); these cannot have arisen from mineral nitrogen deficiency as this soil contains more fertiliser mineral nitrogen than any of the others listed in Table 1.

The untreated soils released little nitrogen when incubated, and the amounts thus released were unrelated to the nutrient reserves of the soil. However, mineral nitrogen was released after fumigation and incubation, in the order bush regrowth > maize (or maize/cassava) with residues > maize without residues. The nitrogen reserves (as measured by the nitrogen mineralised after chloroform fumigation) decreased dramatically, at a rate greater than the decrease of the total nitrogen content, when above-ground plant residues were removed. There was thus a decline in both the quantity and the

TABLE 1

*Nitrogen reserves and biomass in some Nigerian soils*

| Soil | Cropping | Fertiliser | Clay % | Total Nitrogen % | Mineral Nitrogen, ppm | | | Biomass Carbon ppm |
|---|---|---|---|---|---|---|---|---|
| | | | | | In soil when sampled | Additional N released after incubation | | |
| | | | | | | Untreated | Fumigated | |
| 1 | Bush regrowth | None | 14·3 | 0·126 | 12 | 1 | 44 | 340 |
| 2 | Maize with residues | NPK | 11·6 | 0·102 | 10 | 5 | 27 | 180 |
| 3 | Maize without residues | NPK | 9·5 | 0·068 | 27 | 3 | 6 | 60 |
| 4 | Maize/cassava with residues | NPK | 9·6 | 0·074 | 7 | 5 | 22 | 170 |

'quality' of the soil organic matter. The decline of the nitrogen reserves was much less rapid when residues were not removed. The biomass carbon content of the bush soil (340 ppm C) was sharply decreased by cultivation, but there was three times more biomass carbon in the soil to which residues were returned (No. 2) than in the soil from which they were removed (No. 3). The decline in organically-bound nutrients caused by forest clearance can thus be slowed by proper management of crop residues. (Tuckwell and Jenkinson, with Dr. A. Ayanaba, International Institute of Tropical Agriculture)

**Toxic metal residues from the Woburn Market Garden experiment.** It was shown previously (*Journal of Agricultural Science, Cambridge* (1968), **71**, 205–208) that plots treated between 1942 and 1961 with 568 tons sewage sludge/acre contained greater than normal amounts of 0·5 N acetic acid-soluble heavy metals. Crops grown on these plots contained larger amounts of the metals than those from control plots, and in 1967 this enhanced uptake still persisted. The acetic acid-extractable Co, Cr, Cu, Ni, Pb and Zn contents of soil samples taken from the same plots in 1972 have been determined. Although the content of extractable metals has declined steadily to less than half the 1959 values, 11 years after the application of sludge was discontinued they were still much greater than those of corresponding untreated soil—Table 2. (Le Riche)

TABLE 2

*Metal extracted by* 0·5 N *acetic acid from sewage sludge-treated plots of the Woburn Market Garden experiment, 1972*

| | ppm | | | | | |
|---|---|---|---|---|---|---|
| | Co | Cr | Cu | Ni | Pb | Zn |
| Plot 3 (treated) | 1·1 | 0·94 | 21 | 5·5 | 0·71 | 90 |
| Plot 8 (untreated) | 0·54 | 0·29 | 3·4 | 1·5 | 0·22 | 19 |
| Plot 39 (treated) | 1·3 | 1·4 | 45 | 8·2 | 2·5 | 140 |

**The effect of liming on the extractabilities of heavy metals from aerobically incubated digested sewage sludge.** Continuing our work on contaminated sewage sludge (*Rothamsted Report for 1973*, Part 1, 77), we have examined the effect of liming on the extraction of heavy metals from sewage sludge by water, acetic acid and EDTA, during aerobic incubation in the presence and absence of soil. The results show no consistent pattern. In the absence of soil, more Cu, Cd and Cr and less Ni and Zn were extracted by water from limed than from unlimed sludge; Zn, Pb, Cd, and ultimately Cr, became more soluble in acetic acid, whereas Cu and Ni became less so. EDTA extracted greater amounts of Cr, Pb and Cd from limed sludge, but the solubilities of Cu, Ni and Zn in this reagent were hardly affected by liming.

In the presence of soil, water extracts of the limed mixture contained more Cu and

Cr, and, in the early stages of incubation more Pb and Cd; Zn, Pb and Cr became more soluble in acetic acid, as did Cd and Cr with respect to EDTA. The solubilities of Zn and Ni in water, of Cu and Ni in acetic acid, and of Zn in EDTA, were decreased by liming.

The availabilities of heavy metals in sludge-treated soil are currently estimated by extraction with acetic acid and EDTA, and liming the soil is believed to decrease the availabilities of toxic metals to plants. In the light of our results the validity of these assumptions seems questionable, and, in collaboration with the Chemistry Department, we have started experiments with growing plants to test the effect of liming on the uptake of the metals, and to see how this compares with the chemically determined availabilities. (Bloomfield and Pruden)

**The identification of potential acid sulphate soils.** Large areas of pyritic, i.e. potential acid sulphate soils occur in the coastal plains of Malaysia and elsewhere. In their natural waterlogged state the pH of these soils is usually close to 7, but drainage causes the pyrite to oxidise, and unless the soil also contains shell fragments, the pH rapidly decreases, often to below 3. To identify potential acid sulphate soils a method is needed that is rapid enough to deal with the large numbers of samples involved in soil surveying, and that can be used where laboratory facilities are limited. The decrease in pH that results when the sample is allowed to oxidise is perhaps the most commonly used diagnostic test for potential acid sulphate soils, and oven- or air-drying are the most usual methods of oxidation. However, it seems that the catalytic oxidation of pyrite by *Thiobacillus ferroxidans* is inhibited as the moisture content of soil is decreased, and the magnitude of the decrease in pH caused by drying the soil is thus dependent on the rate of drying; the pH changes are often inconsistent and usually not much more than 1 unit. Aerating moist samples of soil from a Malaysian mangrove swamp for eight weeks in loosely closed polythene bags caused the pH to decrease from 6·5 to 2·8—a decrease that is large enough to enable the unequivocal recognition of a potential acid sulphate soil. Alternate air-drying and rewetting the sample, as is often practiced, involved more effort and gave a smaller degree of acidification; the method of allowing the moist samples to oxidise by keeping them in thin gauge polythene bags is recommended for routine survey purposes. (Powlson)

### Staff and visiting workers

J. R. Sanders joined the department in August and Mr. Tie Yiu Liong of Reading University spent two months with us.

Carolyn Williams returned from Israel after working for nine months at The Hebrew University in Jerusalem on the artificial weathering of iron oxides and unconsolidated sediments. G. Brown visited Spain, at the invitation of the Consejo Superior de Investigaciones Cientificas, and lectured at the Instituto de Edafologia y Biologia Vegetal in Madrid.

D. S. Jenkinson visited Poland, and gave lectures at the Universities of Agriculture at Szczecin and Warsaw, and at The Institute of Soil Science and Plant Cultivation at Pulawy.

A. H. Weir visited laboratories in Strasbourg and Paris, and attended the second European Clay Conference at Strasbourg as the delegate of The British Clay Minerals Group.

C. Bloomfield visited Malaysia under the auspices of the Ministry of Overseas Development (ODM), at the invitation of The Malayan Agricultural Research and Development Institute (to which D. S. Powlson has been seconded for two years), to advise on future research on acid sulphate soils. Also on behalf of ODM, D. S. Jenkinson and S. B. Tuckwell visited Nigeria to initiate joint work with the International Institute of Tropical Agriculture on the organically-bound nutrients of soils in the humid tropics.

A. C. D. Newman was granted two years' leave of absence to take up his appointment as Visiting Reader at The University of Reading.

## Publications

### THESIS

1 MADGETT, P. A. (1974) The mineralogy and weathering of Devensian Tills in Eastern England. Ph.D. Thesis, London University.

### GENERAL PAPERS

2 BROWN, G. (1972) Comments on: X-ray diffraction studies on the crystallinity and molecular weight of humic acids. *Soil Biology and Biochemistry* **4**, 109–110.

3 BROWN, G. (1974) The agricultural significance of clays. In: Soil type and land capability. Ed. D. Mackney. *Soil Survey Technical Monograph* No. 4, 27–42.

### PAPER IN ROTHAMSTED REPORT, PART 2

4 CATT, J. A., KING, D. W. & WEIR, A. H. (1975) The Soils of Woburn Experimental Farm. Part I. Great Hill, Road Piece and Butt Close. *Rothamsted Experimental Station. Report for 1974*, Part 2, 5–28.

### RESEARCH PAPERS

5 BLOOMFIELD, C. & PRUDEN, G. (1975) The effects of aerobic and anaerobic incubation on the extractabilities of heavy metals in digested sewage sludge. *Environmental Pollution* **8**, 217–232.

6 BROWN, G., CORBETT, D. C. M., HIDE, G. A. & WEBB, R. M. (1974) Bromine residues in potato and wheat crops grown in soil fumigated with methyl bromide. *Pesticide Science*, **5**, 25–29.

7 CATT, J. A., WEIR, A. H. & MADGETT, P. A. (1974) The loess of eastern Yorkshire and Lincolnshire. *Proceedings of the Yorkshire Geological Society* **40**, 23–39.

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13 WEIR, A. H. & RAYNER, J. H. (1974) An interstratified illite-smectite from Denchworth Series soil in weathered Oxford Clay. *Clay Minerals*, **10**, 173–187.

14 (WEST, R. G., DICKSON, C. A.), CATT, J. A., WEIR, A. H. (& SPARKS, B. W.) (1974). Late Pleistocene deposits at Wretton, Norfolk. II. Devensian deposits. *Philosophical Transactions of the Royal Society*, B **267**, 337–420.

15 WILLIAMS, C. (1974) The accumulation of Pb in soils and herbage at Rothamsted Experimental Station. *Journal of Agricultural Science, Cambridge* **82**, 189–192.

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