INHERITED MICROFABRICS OF SOILS DERIVED FROM MICACEOUS SANDSTONE IN IRELAND

by

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INTRODUCTION .-

Many of the soils developed in the Old Red Sandstones of the Slieve Feilim, Slieve Aughty and Slieve Bloom mountains of central and southwest central Ireland are poorly or very poorly drained. Since these are coarse-textured soils and occur on moderate slopes and at relatively low elevations and rainfall conditions, the causes of poor drainage were investigated with a view to improving their land-use potential. In the course of the study, physical, chemical and mineralogical measurements, as well as micromorphological observations, were carried out on four selected profiles. Only those aspects of the micromorphological observations which pertain to features regarded as common to both the parent rock and the derived soils are reported here.

General Characteristics of site and soils.

The parent rock of the study area is Old Red Sandstone which consists of coarse, yellow, grey and purplish sandstones, often more or less conglomeritic and occasionally interstratified with red shale and thin red sandstone. They are at times ferrugineous, micaceous and horizontally bedded (Geol. Survey of Ireland, 1863). The climate of the area is cool temperate oceanic with mean annual temperature of approximately 8.5º C and mean annual rainfall of approximately 1250mm. Potential evapotranspiration is in the region of 400 mm. The vegetation of the

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area is typical moorland with heather (Calluna and Erica, spp.), gorse (Ulex sp., etc.) rushes (Juncus spp) and poor grasses (Molinia sp., etc) dominant.

Four profiles were chosen for study - two Gleys (Aquepts) and two Podzols (Orthods). One of each Order (Suborder) was located at approximately 750-800ft. (225 240mm) O.D. on the northeast and northwest slopes of an interfluve with slope gradients of 6-8º. The Gleys occupy most of the area with the Podzols occurring on isolated humocks. Abbreviated and summarized compositional data for the four profiles are given in Table 1.

General Micromorphological Observations:

A number of thin sections were made from undisturbed samples of each horizon by the method of Fitzpatrick (1971). They are described mainly according to Brewer (1964). General features and patterns are described below and more specific features are recorded in following paragraphs.

(a) Gleys (Plates 1 and 2).

Generally dense porphyroskelic fabrics grading towards agglomeroplasmic in the more organic-rich surface horizons; plasma orientation increasing in kind and continuity from surface downwards. Sepic elements range from free grain argillans, mainly in the A1 horizons, to skel- and vosepic in the A2 (and B) horizons to an omnisepic fabric in the C horizons where the sand grains are engulfed in a dense continuous matrix of golden and honey coloured mica (sericite). (This distribution may be better described as chlamydomorphic according to the terminology of Kubiena, 1938). Few structural units visible except in A1; porosity low to very low; colours variable and mottled

(b) Podzols (Plates 3 and 4).

Basic fabric ranges from single grain silicic lithiskel (Barratt, 1968) in the A21 to pellety in parts of the spodic B to porphyroskelic (Chlamydomorphic of Kubiena,

1938) in the C horizon. Apart from organic matter, there is very little matrix in the A2 horizons. Plasma separations increase in content from A to B to C and grade from free grain argillans in the A21 and A22, to skel- and vosepic in the B horizon to omnisepic in the C. The most distinguishing characteristic is the occurrence of loosely -clustered, rounded, pellet-like peds in parts of the Bir/Bh horizons, showing large interconnected packing voids and high porosity. The colours are very variable especially around the accumulations of amorphous constituents in the spodic B horizons. Otherwise, they vary from pinkish grey in the A2 to reddish brown in the C horizons.

Specific Features of the Microfabrics :

One of the most distinctive features of the micromorphology and one common to all horizons of the study soils was the prevalence of fabrics inherited from the parent rock. Confirmation of the rock fabric was made by reference to thin sections of rock taken from nearby outcrops and of stones from beneath the solum. These microfabric units (which may also be compared with lithorelicts in the same horizon) are found in increasing content with depth in all profiles.

(a) Coatings around grains.

In the A11, A12 or A21 horizons the microfabrics consist of coated or partially-coated single grains, or small clusters of grains, scattered throughout the horizons. The coatings are usually thin, often discontinuous and weakly or moderately oriented, and consist of weathered (sericitic) mica. Where discontinuous the coatings tend to occur mainly in pits and concavities on the grain surfaces and less often on the convex surfaces or on rounded grains (Plates 5 and 6). Individual grains couplets and triplets of grains with associated plasma are and often observed in close proximity and show strongly accordant

Table 1. Summarized and Abbreviated Compositional Data for the Four Study Profiles.

Horizon	Depth(cm)	pH	BD(g/cc)	% Clay	% O.C.
			Gley (Ross)		
01	10-0	3.8	0.20	ND	19.1
A1g	0-11	4.2	1.02	10.0	2.9
A2g	17-36	4.5	1.80	9.7	0.15
A3g	30-45/50	4.7	1.89	13.4	0.08
Bg/C1	45/50-60/70	4.7	1.44	19.9	ND
C2	60/71+	4.9	1.57	16.7	ND
			Gley (Coolnamony)		
A11g	0-8	4.2	1.10	17.8	4.5
A12g	8-22	4.9	1.87	13.7	0.10
A2g	22-44	4.9	1.99	15.8	0.07
(B)g	44/48-75	5.0	1.81	26.1	0.04
Bg/C	75-81	5.0	1.90	30.5	0.06
C2	81+	5.1	2.05	26.3	0.01

			Podzol (Ross)		
O1	12-0	3.8	0.20	ND	18.0
A21	0-7	4.1	1.35	11.4	1.45
A22	7-22/30	4.5	1.54	18.8	0.40
B2irh	22/30-32/36	4.2	1.55	16.2	0.54
B3	32/36-52/60	4.8	1.57	18.3	0.13
B/C	50/60+	4.9	1.74	24.7	0.01
			Podzol (Coolnamony)		
O1	9-0	4.1	0.52	ND	10.2
A21	0-7	4.5	1.72	7.4	0.59
A22	7-15/21	4.7	1.73	14.8	0.01
B1h	15/21-24/37	4.7	1.28	24.3	1.02
B2irh	24/37-48/50	4.7	1.14	27.1	0.74
B3h	48/50-70	4.9	1.04	27.6	0.72
C	70+	5.1	1.80	27.5	0.18

BD = Bulk Density: O.C. = Organic Carbon: N.D. = No Data surfaces and an internal fabric closely similar to lithorelicts and rock fragments in the same horizons.

These fabric units are most obvious and continuous in the more organic-free and clayey B horizons. They occur throughout the Bir and Bh horizons where they are surrounded and masked by the humus-rich, isotropic plasma, but they are clearly evident in cross polarized light at 63X and greater magnifications (Plates 7 and 8).

The skeletal grains of the C horizons are almost all engulfed in the micaceous groundmass, which has very few pores or channels. Occasional single grains dislodged into a channel are invariably coated with plasma, i.e. they do not come away cleanly. The groundmass (or plasma cement) between the grains is often 'vermiform' in character, i.e. its layers lie almost normal to the surface of grains on both sides and are continuous from grain to grain in a repeating concave/convex manner.

(b) Linings of voids

Typical illuviation argillans similar to those of argillic B horizons occur in most A2, B and C horizons of the study soils. However, these often grade towards and may be confused with other kinds of void linings which appear to have identical counterparts in the parent rock. Spherical or oval pores in these horizons (Plate 9) and in the rock (Plate 10) are lined with crystallites of mica giving a weak strial fabric around the pores. Oblique transverse sections show the concave arrangement of these cristallites around the pores, but while each one is parallel to the pore wall the do not show the optical continuity and illuviated argillan or papule (Stephen, 1960).

Some pores are associated with unweathered or partially weathered mica flakes. These appear as cracks along the cleavages of the larger flakes and thus resemble void argillans sectioned longitudinally. Similar pores occur within mica flakes in the parent rock, especially where these flakes are bent. The degree of distortion is usually not great but some are bent into crescent shape (Plate 11) and may be mistaken for well-developed argillans cut transversely, but at a slight angle. In both these instances, the pores are small and the boundary of the "lining" furthest from the pore is quite sharp. They may however be easily mistaken for papules.

(c) Other features common to rock and soil sections.

"Clay balls" squeezed under pressure in the sedimentary rock show strong unistrial plasmic fabric (Plate 12). Similar fine-textured zones with well-developed laminae and good birefringence occur in many of the solum horizons (Plate 13). These are often a centimeter or more across but do not differ greatly in microfabric from some of the small laminated clay concentrations usually referred to as papules and domains in soil sections.

Typical illuviation cutans, usually very small and highly birefringent, occur within the C horizons. Likewise, ferrans and iron nodules were observed in many of the gley horizons but also in the rock sections where they are usually associated with weathering zones of biotite. The more ferrugineous and rusty-coloured rock sections closely resemble the coarser portions of the spodic B horizons. Only the organic matter contents differ.

Grain morphologies of the soil and geologic sections are quite similar. Grains in the A1 and more particularly in the A2 horizons differ very little from those of the parent rock. The only difference is in the amount of plasma (groundmass, matrix, cement) which diminishes sharply above the level of the B horizons.

DISCUSION AND INTERPRETATION.

The occurrence of inorganic plasmic coatings, particularly of clay-sized materials, in the surface horizons of soils is not usually reported in the literature. Since an explanation for the origin of argillans, other than those caused by stress, usually invokes movement in suspension followed by drying (Brewer and Haldane, 1957) it is exceedingly unlikely that favourable conditions for their formation would prevail in topsoils of humid regions. Nettleton (1972) has hypothesised that the rapid evaporation of rainwater in desert conditions may explain the occurrence of free grain argillans in the surface horizons of Argids, Xeralfs and Xerochrepts in the U. S. A. Perhaps a similar process obtains in Alfisols in Turkey which have plasma re-orientations (Mermut and Pape, 1971) and in Australia (Stace, et. al, 1968, p. 164). Similar looking free grain argillans in soils developed under conditions of high humidity and continuous large excess of rainfall over evapotranspiration (as reported here) are not regarded as having a pedogenetic origin. It is suggested that ample evidence exists to show that these features have a geogenic origin and that the only difference between them and lower-solum and rock-grain argillans is in thickness, continuity and regularity (Preliminary X-ray data suggests that they have lost some K, and give 11 Å and 12 Å d001 spacings rather than 10 Å as is the case deeper in the profiles). The lack of continuity of coatings on grains particularly on the convex surfaces and the fact that the more rounded grains are uncoated suggests that their removal is physical, the plasma being protected in the pits and depressions. The occurrence of partial coatings of weathered mica on framework members in the Ah horizons of soils developed in syenite and gabbro in Canada appear to be of similar origin (Protz et al, 1973).

It is also proposed that the etching of these quartz grains is an inherited feature as well. Cady (1960) suggests that the pitting and etching of grains in the A2 horizon of podzols is associated with weathering and leaching. In the study soils no significant differences in grain morphology was observed between horizons or between profiles and it is assumed that as the more weatherable micaceous cement is removed, the individual skeletal grains fall apart.

The observations made during this study in relation to the weathering of large mica flakes concur with those of Mermut and Pape (1971). Small pores develop between the layers of the mica grains on weathering, particularly so if they are bent. The cleavages of the mica grains often resemble the layering of illuviation argillans and the combination of pore and adjacent layering make it difficult to confidently separate onetype from the other on morphological characteristics. They are usually confined to the B and C horizons – horizons which, however, contain the highest proportion of illuviation argillans and papules. Somewhat similar contortion and exfoliation of mica flakes were observed by Castallet and Fitzpatrick (1973) in a soil from Spain.

Major voids in the rock appear to be confined to plasma rich areas within a skeletal framework of quartz grains. These microfabrics are apparently rigid enough to withstand deformation as similar ones occur in some B as well as C horizons. It is thought that many of them are masked by subsequent deposition of suspended clay.

Some of the clay that is lost from the A1 and A2 horizons of the study soils has accumulated in the B and C horizons as typical illuviation argillans and its presence has masked many of the inherited rock features. So also has the downward migration of humus and the accumulation of iron in the Podzolic (Spodic) B horizons. It should be noted however that some of the microscopic features traditio nally regarded as pedogenic may in fact be of geological origin . Weathering and realease of iron is not necessarily a soil phenomenon (especially where biotite is a common constituent of the parent material) and, in the soils studied, the iron nodules in many solum horizons, the "neo" ferrans in the gleyed horizons, and pellety and coated iron-rich fabrics in the Podzol B horizons have exact morphological counterparts in rock sections of the Old Red Sandstones examined. To this list we may add argillans and papules which exist deep within rock fabrics. If clay can move in suspension and settle out on walls of pores in water-logged soils such as the two gleys, there is reason to believe that it can do so in shallow lucastrine environments in which these micaceous sandstones are thought to have formed. Hence it is suggested that some, at least, of the illuvial argillans in the lower solum and C horizons are inherited from the parent rock.

The taxonomic considerations of these observations are not dealt with in this paper apart from pointing out the hesitancy in regarding any of the B horizons as argillic and assigning the designation "t" in any of the profile descriptions (Table 1). While the genesis and classification of these soils continue to be studied, it is emphasised that microfabric studies are of considerable importance in understanding and assessing some, at least, of the pedogenic processes which are, or have been, operative in these soils.

List of Plates.

Plate 1. Dense porphyroskelic distribution of sand grains in a matrix of silt and clay. Some grains weakly coated ; very few pores or packing voids. Bg horizon of Gley, cross-polarized light, framelength 2.3 mm.

Plate 2. Vosepic plasmic fabric. Dark irregular diagonal area is a void lined with poorly-oriented plasma of varying thickness on one side. Light areas on the right are sand grains. C horizon of Gley, cross polarized light, framelength 0,87 mm.

Plate 3. Skel-vo- and omnisepic plasmic fabric. Many grains at extinction ; very few pores. Most sand grains surrounded by poorly oriented plasma (light-coloured borders), B/C horizon of Podzol cross-polarized light ; framelength 2. 3 mm.

Plate 4. Skelsepic plasmic fabric, with small areas of vo- and omnisepic fabric. Orientation of plasma (matrix) poor except between grains in upper centre, and around pore (top left). B/C horizon of Podzol , cross-polarized light ; framelength 0, 87 mm.

Plate 5. Simple, discontinuous free-grain argillans ; the darker material adhering to the large grain particularly in depressions on top and bottom is poorly-oriented plasma ; A2g horizon of Gley ; cross polarized light ; framelenght 0. 87 mm.

Plate 6. Pellety structure between etched and jagged grains. Small grain in centre has an almost continuous coating. Otherwise clayey plasma incorporated with iron and humus bridging grains. B2 horizon of Podzol, cross-polarized light, framelength 0. 87 mm.

Plate 7. Coatings on sand grains in spodic horizon, usually thin, occasionally cracked, and often "warty" in appearance ; dark to reddish brown in plane light. Bh horizon of podzol, plane-polarized light; framelength 2. 3 mm.

Plate 8. Same as Plate 7, in cross-polarized light. Most sand grains exhibit birefringent inner coatings especially in the upper half which is less porous. framelength 2.3 mm.

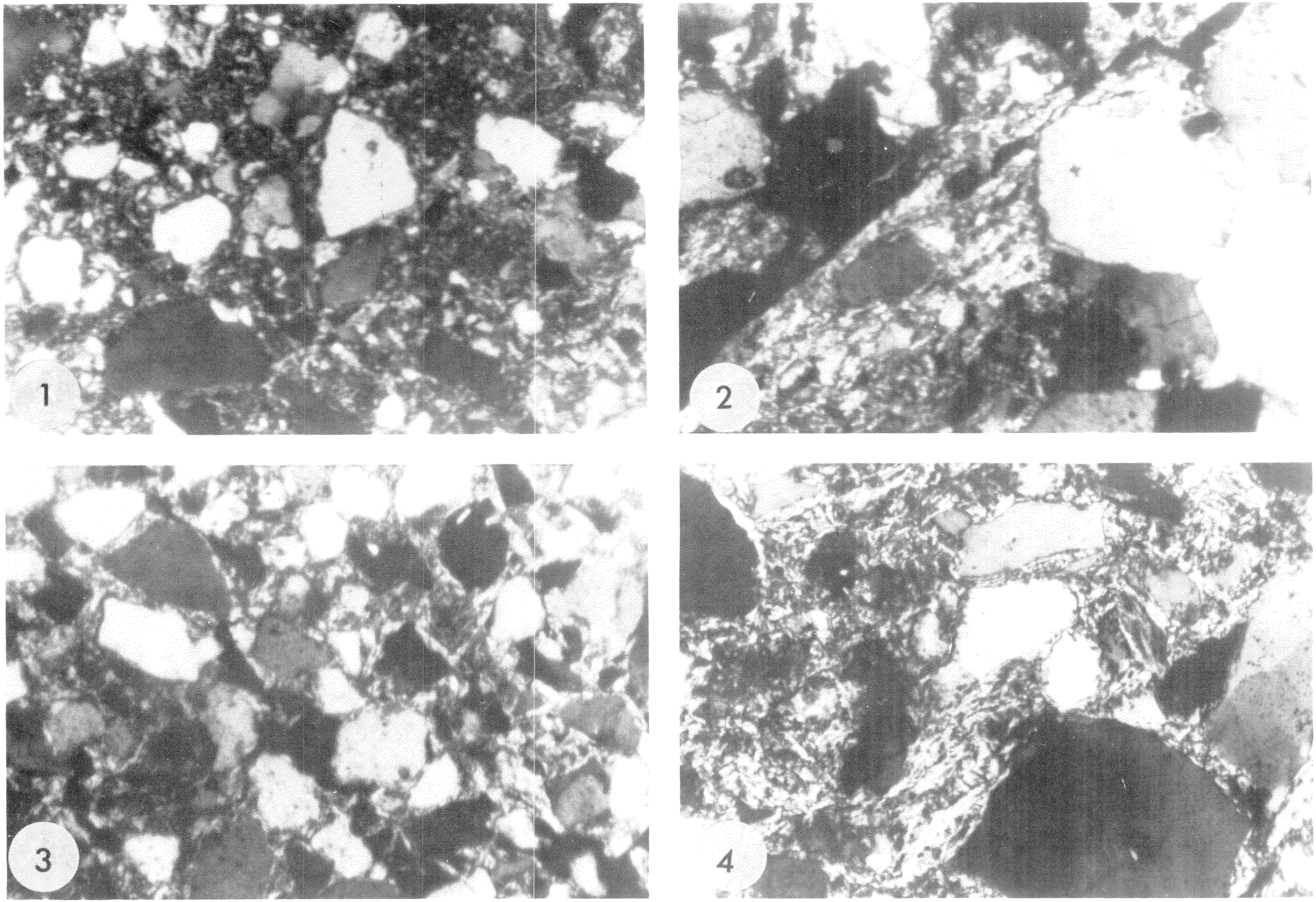
Plate 9. Rock section showing grains cemented with a micaceous (sericite) matrix. Almost all grains separated from neighbouring grains by matrix. Dark area top right is a pore with matrix oriented parallel to wall. Rock Sample 14, cross-polarized light; framelength 2.3 mm.

Plate 10. Void in rock sample, showing good to poor orientation of sericite. Many adjoining silt grains near bottom left arranged at angles of approx. 90º to pore wall and to one another. Rock sample 16, cross-polarized light; framelength 0.87 mm.

Plate 11. Weathered mica grain (top left) partially bent around quartz grain (<u>in situ</u> formed argillan), small elongated cracks along the cleavages. Otherwise poorly-oriented matrix; A21 horizon of Podzol. cross-polarized light; framelength 0.87 mm.

Plate 12. Part of large clay body showing lamination and striation; it is cracked and contorted, with neoferrans near grain on left. Channel on right traverses the clay body irregularly. C horizon of Gley, cross polarized light, framelength 2.3mm.

Plate 13. Masepic plasmic fabric; very few coated grains; very dense and fine textured. Most of the white areas (with the exception of grains) is striated plasma which constitutes the bulk of the s-matrix. Bg horizon of Gley; crosspolarized light; framelength 2.3 mm.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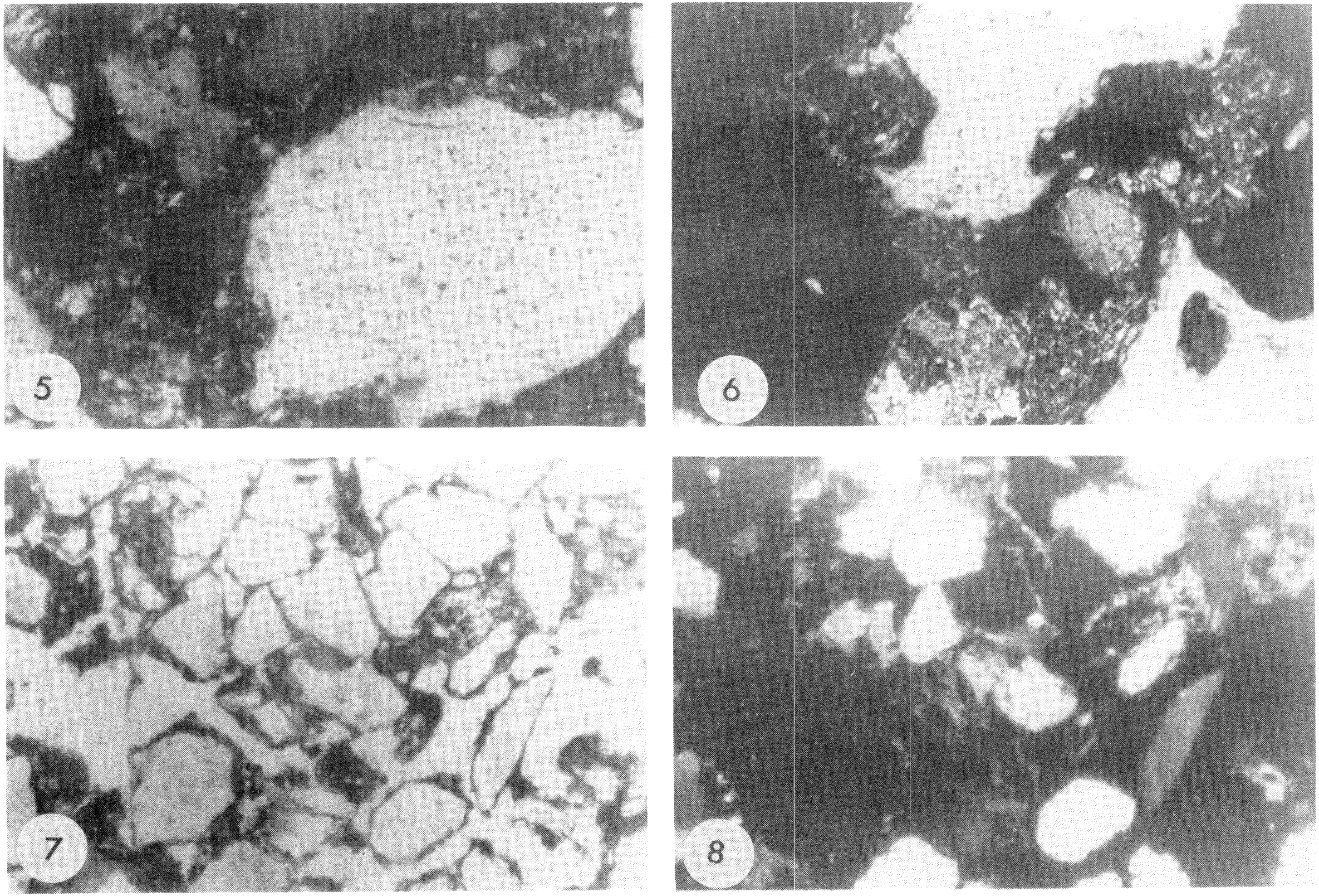
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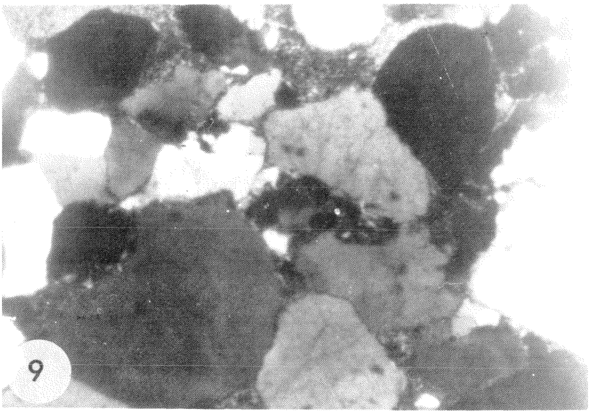
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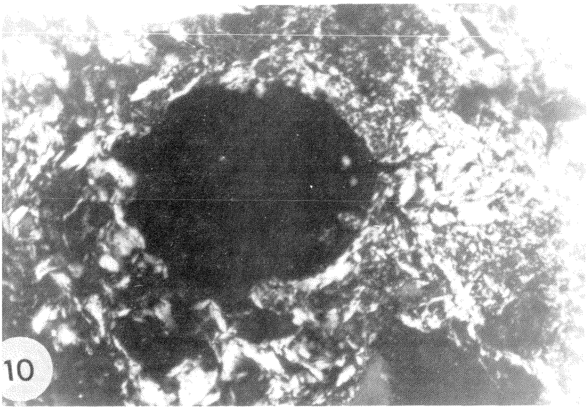
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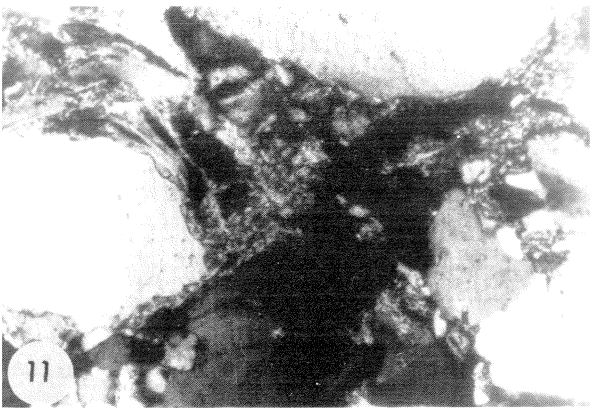
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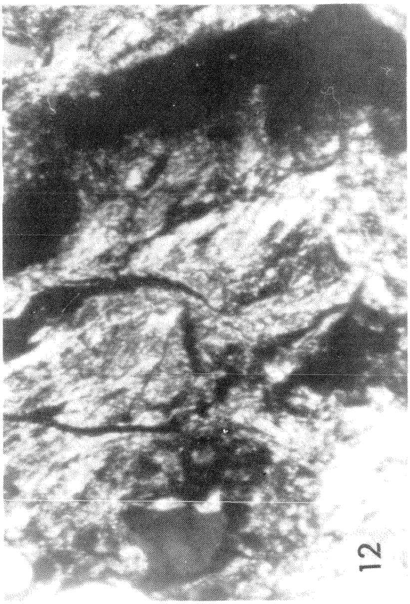
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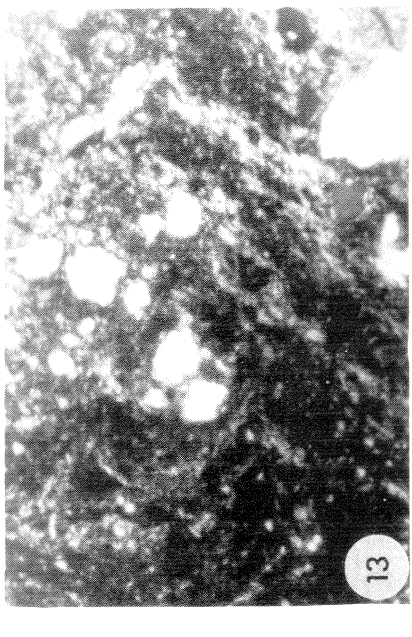
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SUMMARY

The microfabrics of four soils, two Gleys and two Podzols, developed in a micaceous sandstone were observed to contain preserved elements of the rock fabric right to the surface despite pedogenic modification. The parent rock consisted of a fine-grained sandstone with a golden-brown sericitic micaceous matrix in which the sand grains were embedded. The inherited features in the soils included individual, or groups of, sand grains, coated, partially-coated or linked with clay (mica) concentrations in the Al horizons, and fabrics dominated by such features in the C horizons. The occurrence of a spodic B horizon in some instances masked, and in others enhanced these features in the Podzols. The lower horizons in both the Gley and Podzol profiles contained layered accumulations/separations which may be variously interpreted as illuviation argillans, exfoliating micas and /or portions of the layered clay matrix inherited unaltered from the parent rock.

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