ASSESSMENT OF ANCIENT LAND USE IN ABANDONED SETTLEMENTS AND FIELDS - A STUDY OF PREHISTORIC AND MEDIEVAL LAND USE AND ITS INFLUENCE UPON SOIL PROPERTIES ON HOLNE MOOR, DARTMOOR, ENGLAND

by

Nicholas Guy Aubrey Stephen Allott Ralph

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Department of Prehistory and Archaeology
University of Sheffield

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REFERENCES

REFERENCES - note on abbreviation and forms of citation

In general references are presented according to modern scientific convention, and the abbreviations used follow British Standard 4148 (BS 4148, The Abbreviation of Titles of Periodicals. Part 2, Word-abbreviation List. British Standards Institution 1975). Exceptionally, non-standard abbreviation has been employed for the six frequently cited periodicals listed below:

Anc. Mon. Lab. Rep.	Ancient Monuments Laboratory Reports, Department of the Environment.
Rot. Exp. Stn. Rep.	Rothamsted Experimental Station Reports, Lawes Agricultural Trust.
J.S.S.	Journal of Soil Science.
P.P.S.	Proceedings of the Prehistoric Society.
T.D.A.	Transactions of the Devonshire Association for the Advancement of Science.
P.D.A.S.	Proceedings of the Devon Archaeological Society. (Note that the proceedings of the Jubilee Conference of the Society held in 1978 were published under the title 'Prehistoric Dartmoor in its context' but formed volume 37 of the regular P.D.A.S.; the latter citation has been used in this list).

Note also that where more than one part of a multi-author publication has been cited, an abbreviated form of citation has been adopted to save unnecessary repetition. Thus:

Barber J. 1970 Early men. In Gill C. (ed.) :55-75

indicates that an article by Barber appears on pp. 55-75 of a publication edited by Gill, and that the latter is separately listed. Thus:

Gill C. (ed.) 1970 Dartmoor: a New Study. David & Charles.

Although in the thesis text, the formulation 'et al' has been used where more than two authors contributed to a work, in the list of references this formulation is restricted to the relatively rare instances in which more than three authors are credited.

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APPENDICES

APPENDICES - list of contents

Appendix 1 Soil and vegetation mapping and sampling

Mapping and sampling locations and their identification codes

1) Mapping grid (see Fig. 3.8) - Location letter (B-L, excluding I) and number (1-14) defined by position on grid. Small pits at 80 locations.

2) Subsidiary mapping soil pits (see Fig. 3.8) - No location codes. 120 locations.

Soil sampling locations - 1977 - Pilot sample

3) Zone A (see Fig. 3.9)
Large pits - GSP 4-9 Small pits - SP 10-30

4) Zone B (see Fig. 5.111) - Small pits - PP 1-19

5) Zone C (see Fig. 5.1)
Large pits - GSP 2-3 Small pits - SP 1-8

6) Stone Row (see Fig. 3.8)
Large pit - GSP 1(= SRW 125) Small pit - SP 9 (=SRW 109); see (11) below.

7) Archaeological sites (profiles in or adjacent to excavations) (see Fig. 3.5; see also (18) below).
Large pits - Site C - HM77C 1-4 (bank-lynchet)
- Site F - HM77F 11, 5, 6 (palaeosol)

Soil sampling locations - 1978 - Main sample

8) Zone A (see Fig. 3.9) Small pits
Zone is divided into 14 sub-zones most of which correspond to land units delimited by land boundaries (prehistoric and medieval); these are lettered A to R, excluding I, O and P. Profiles within each sub-zone are numbered 1, 2 . . . n; thus A1, A2. . . An and M1, M2. . . Mn. In addition profiles located close to fie d edges were sampled (in groups of three, closely-spaced pits set ca. 0.75 - 1.0 m from the boundary edge) - ED1-21.

9) Zone B - Transect sampling (see Fig. 5.111) Small pits
Transect across droveway - Outer South Field - PTS series
- Droveway - PTD series
- North Field - PTN series

10) Zone C (see Fig. 5.1)
Large pits (excavation of boundary) - HM78 C and B (palaeosol)
Small pits - SP 31-37

11) Stone Row - Transect sampling (see Fig. 3.8) Small pits
Transect across Row - ST series Transect along Row - SRW and SRE series

12) Prehistoric House in zone A, sub-zone (=field) D (see Fig. 3.9) - Small pits
North-south Transect - PHA series, East-west Transect - PHB series

13) Stoke Farm (field) - Bench Tor (moor) (see Fig. 5.87)
Large pits - GSP 10 (moor), GSP 11 (field)
Small pits - SP 50-53 (moor), SP 46-49 (field)

14) Rowbrook Farm (field) - Vag Hill (Moor) (see Fig. 5.88)
Medium pits - RF 1-4 (fields) RV 1-6 (moor)

Soil sampling locations - 1979

15) Zone A (see Fig. 3.9) Small pits
Profiles in corners of fields use sub-zone lettering plus additional letter C (=corner) and new number series. Thus profiles in corners of sub-zone (=field) L are coded: LC 1, LC 2, LC 3 etc. Pits were dug ca. 1.5 - 2.0 m along the diagonal from the apex of the corner.

16) Zone B - Transect sampling - B horizons (see No. 9 above)

17) Zone C - Replicate and additional samples (see No. 10 above)
HM79 B (palaeosol) HM79 Q

Special sampling

18) Some 300 samples were taken from the Ah/E and B horizons on archaeological site F in zone A; the excavator's grid reference system was used as a sample code (see Fig. 5.51). Most samples were recovered in 1977; a few additional samples were taken in 1979.

19) Animal faeces samples were taken from Holne Moor and within and near Rowbrook Farm in 1979.
Rowbrook Farm - XRF Vag Hill - XRV (see No. 14 above)
Holne Moor, zones A and B - XHM series zone C - XMA series
Suffix indicates animal :- C = Cow; S = Sheep; H = Horse

In this and subsequent appendices, groups of pits are referred to by a number corresponding to their number in this list or by their code number where this is necessary. Thus (5) refers to the investigations in zone C in 1977 and (10) refers to the additional sampling in this area in 1978.

Information recorded at mapping and sampling locations

SMALL PITS 1977 - see (1) (3) (5) (6) Medium pits 1978 - see (14)

Site

Slope angle, slope form, aspect, micro-relief, vegetation, proximity to cultural landscape features.

Soil

Horizons present, horizon thickness, nature of horizon boundaries.
Mottles and speckles (ferruginous micro-mottles and concretions) present, their size, abundance, contrast and the nature of their boundaries.
Munsell colour of horizons and mottles (colour assessed on wet soil away from direct sunlight).
Organic matter distribution, abundance, character.
Particle size distribution and abundance of clay, silt, sand.
Stone size and abundance.
Depth of auger penetration.

LARGE PITS in all years - see (3) (5) (6) (7) (10) (13)

All variables listed above plus:
Stone shape and lithology.
Cutan distribution, abundance, composition, distinctiveness.
Ped size, development, shape.
Macropore size and abundance.
Root size, abundance, type.
Presence of nodules, concretions, fissures, channels, burrows, soil fauna.
Carbonate (HCl) and Manganese (H_2O_2) tests.

SMALL PITS 1978, 1979

(4) and (10)

Details of site recorded on maps for groups of profiles; variables as for small pits 1977 above. Details of soil:

Horizons present, horizon thickness, nature of horizon boundaries.

Mottles and speckles present, their abundance and type (organic, gley, ferruginous).

Presence of burrows, channels, fissures.

Any unusual features (e.g. exceptionally high or low stone content, indications of profile disturbance, etc.).

(8) and (15)

Details of site as for small pits 1977, recorded intermittently for groups of profiles in close proximity, except that vegetation and nearby cultural features were noted for each profile location and the major patterns of vegetation were mapped in this zone (A). Details of soil: as for (4) and (10) above plus Munsell colour of B horizon soil and mottles. Fuller records of zone A were made in 1977 - see (3).

(9) and (16)

No details of site. Details of soil: Thickness of L, Oh, Ah/E; Presence of E, Eg, Bir; Depth to surface of B horizon only. Fuller records of zone B were made in earlier sampling - see (4) above.

(13)

No details of site. Details of soil for SP 50-53: Thickness of L, Oh, Ah/E; presence of E, Eg, Bir; nature of boundaries. No details of soil for SP 46-49 (cultivated field). Fuller records of these sites were recorded at large pits in each area - see GSP 10, GSP 11.

(11)

Details as for (9) and (16) above. Fuller records at the Stone Row were recorded in 1977 - see (6).

(12)

Details of site: vegetation in house and its surrounds noted. Details of soil: thickness of L, Oh, Ah/E; abnormalities of horizons and/or stone content.

(18)

Informal field notes recorded the appearance of the soil on this archaeological site; fuller records of site and soil were recorded in 1977 - see (7) site F.

With the exceptions of measurements of horizon thickness and depth of auger penetration, all site and soil properties recorded at all profiles represent estimates based either on the assistance provided by charts (e.g. Munsell Soil Colour Strips (colour), Soil Survey Field Handbook (abundance and size of stones, mottles, macropores, peds, roots, etc. - Hodgson 1976)) or the unaided observations of the author (e.g. hand texturing estimates of silt, clay and sand content, estimates of slope angle and form, vegetation abundance, etc.). Laboratory estimates of particle size, LOI and stone content provided some 'control' over these estimates. All the procedures and terminology used above follow Hodgson (1976).

Soil sampling procedures

1977

(3) (5) (6)

Standard sampling procedures as described in the text (see 3.3.1). Bulk samples from all horizons; volume samples from Oh horizons (most), from Ah/E horizons (all) and from B horizons (few); micromorphological samples (selected profiles only).

(7)

Sampling as for (3) (5) (6) plus soil pollen samples and large stone content samples.

(4)

Sampling as for (3) (5) (6) but bulk samples only.

1978

(8)

Standard sampling procedures as described in the text (see 3.3.1). Volume plus some bulk samples from all Ah/E horizons; Volume and/or bulk samples from Oh and B horizons.

(9)

Sampling as for (8) but volume samples taken from all Oh as well as Ah/E horizons. No B horizon samples taken - see (16) below.

(10)

Sampling as for (8) plus soil pollen samples and stone content samples from HM78 B and C.

(11)

Sampling as for (8) but volume samples taken from all Oh as well as Ah/E horizons. B horizon samples recovered by augering in base of pit after removal of Ah/E; these samples were taken from a standard depth of 20-40 cm below the mineral soil surface.

(12)

Small bulk samples (ca. 0.1-0.2 kg wet weight) taken from Oh and Ah/E horizons only.

(13)

Sampling of small pits as for (11) but volume samples also taken from Ap horizons; GSP 10 and 11 sampled as (8) plus large stone content samples.

(14)

Sampling as for (8) but volume samples taken from all upper soil horizons (i.e. Ah/Ap, Oh/Ah, Ah, Ah/E); soil pits were of intermediate size (0.5 m X 0.5 m X 0.7 m (depth)).

1979

(15)

Sampling as for (8).

(16)

B horizon samples recovered by augering in base of new soil pits immediately adjacent to the pits sampled in 1978 - see (9) above; these samples were taken from the first 20 cm of the B horizon.

(17)

Sampling as for (8).

(18)

Small bulk samples (ca. 0.1-0.2 kg) of Ah/E horizon taken from trowelled surface during excavations; estimated to sample the middle of the Ah/E horizon. B horizon samples recovered by augering or from very small pits or from trowelled surface of B horizon at a late stage of the excavation; estimated to sample first 18 cm of B horizon.

Appendix 2 Laboratory preparation and physical analysis

Amounts of soil taken for laboratory analysis

In general either complete volume samples (= 182 cm^3 undisturbed soil volume, which had a 'disturbed' soil volume of *ca.* 250 ml, a wet weight of *ca.* 200 - 300 g and an oven-dry (OD) weight of *ca.* 150 - 200 g) or sub-samples of similar 'disturbed' volume (i.e. 'beakerful' sub-samples from bulk samples) were taken, but in several instances smaller samples were used (see below).

Drying

Three days air-drying in polythene bags in the laboratory (at *ca.* 20° C) was followed by oven-drying for 24 h at 105° C and cooling in dessicators for at least 2 h.

Weighing

Wet weight of soil and OD weights of soil and stones were determined to 0.00 g. (see Tables A2.1 - A2.5)

Sieving

The fine earth and stones were separated by crushing soil through a brass sieve (2 mm mesh) with a rubber pestle. Stones were transferred to a 'nest' of sieves containing 4 mm and 8 mm meshes (and in some instances 2.8, 5.6, 16 and 32 mm meshes).

Sub-sampling of fine earth

The residual fine earth fraction of *ca.* 100-200 g was sub-sampled by riffle box division until a 15 - 25 g sub-sample was available.

Grinding

The fine earth sub-samples were ground with a porcelain mortar and pestle until all passed through a 250 micron mesh sieve. The mortar and pestle were cleaned after each sample and acid-washed periodically (and always before starting to grind a fresh batch of samples of different type (i.e. from a different horizon)).

Table A2 .1 Weight of stones in Oh horizon samples

	A O.D.Sample (g)	B Stones (g)	$\frac{B}{A}$ x 100	LOI (%)
ZONE	29.19	0.00	0.00	87.29
A	45.58	0.29	0.64	72.46
	44.25	0.65	1.47	71.97
	68.44 (1)	0.41	0.60	71.90
	71.05 (1)	1.48	2.08	67.18
	45.38	0.10	0.22	66.13
			Range: 0.00-2.08	
	52.00	0.17	0.33	61.21
	95.74 (1)	1.00	1.04	59.98
	63.92 (1)	0.82	1.28	58.36
	59.62	1.75	2.94	52.46
	92.14 (1)	4.42	4.80	49.88
	69.51	1.69	2.43	49.77
			Range: 0.33-4.80	
	56.70	0.72	1.27	47.88
	44.20	0.50	1.13	45.94
	39.70	0.20	0.50	45.65
	54.86	1.99	3.63	42.65
			Range:0.50-3.63	
	36.50	0.60	1.64	36.83
	78.98	1.87	2.37	36.03
	87.19	5.42	6.22	34.18
	50.80	2.80	5.51	31.29
	123.47 (1)	4.17	3.38	28.78
			Range: 1.64-6.22	
	75.15 (2)	8.77	11.67	21.32
VAG HILL	159.01 (1)(2)	26.32	16.55	21.28
VAG HILL	171.08 (1)(2)	29.81	17.42	18.87

Table A2.1 (cont.)

	A O.D.Sample (g)	B Stones (g)	B/A x 100	LOI (%)
ZONE	16.50	0.36	1.55	74.38
C	75.80 (1)	0.24	0.32	57.23
	79.18 (1)	0.18	0.23	48.89
	91.48 (1)	2.20	2.40	45.06
	31.97	0.08	0.25	44.81
	29.74	0.58	1.95	36.42
	69.90	1.09	1.56	32.82
	38.06	1.64	4.31	31.46
			Range: 0.23–4.31	
Buried Oh – Ah				
1979	34.99	0.19	0.54	26.10
Samples	40.88	1.63	3.99	26.04
1978	99.59	3.54	3.55	23.03
Samples	51.21	1.36	2.66	21.61
Peaty Ditch				
Sediment	111.54	7.64	6.85	21.78

(1) Volume samples taken in the field

(2) Treated as mineral soils

Table A2.2 Moisture in soil samples after 4 months storage (1)

Samples from the stone row

Oh	71.90	Ah/E	35.59 (2)
	56.19		37.02
	51.88		37.43
	55.97		38.89
	52.34		41.64
	60.71		38.26
	55.42		38.08
	61.47		42.41
	58.19		43.40
	61.48		29.49
	61.65		49.12
	71.19		49.39
	64.26		50.01
	64.06		48.56
	54.35		37.99
	54.22		40.90
	63.07		43.17
	55.80		40.15
	64.77		39.46
	61.06		33.06
	66.36		40.82
	51.74		31.59
	59.49		25.58
	62.95		42.93
	74.45		41.95
n	25		25
$\bar{x}$	60.60		39.88
SD	6.20		6.03
CV	10.23		15.12

(1) Figures show volume of water in samples expressed as a percentage of the volume of the undisturbed soil sample.

(2) Pairs of figures represent samples drawn from the same profile.

Table A2.3 Moisture in soil samples after 4 months storage[1]

Samples from Zone A (except where otherwise indicated)

	Oh	Ah/E	B	B	B
	35.91	34.94[2]			
	52.25	25.05			
	54.97	27.83			
	63.07	40.83			
	63.52	31.50			
	46.18	27.40			24.62
Zone	68.45	46.67	34.49		
C	67.04	47.06	31.72		30.84
	61.15	41.69		39.46	30.92
Bench	62.07	31.77	30.08	26.62	21.48
Tor		28.71			
		32.89	29.32		
		36.09	37.51		
			40.07		30.06
			43.46		26.66
			42.91	32.76	24.08
			32.69		21.91
			24.11		20.00
			31.64		22.97
			26.43		33.16
			24.47		26.24
			32.31		23.81
			32.75		26.72
			27.24		26.17
n	10	13	16	3	15
$\bar{x}$	57.46	34.80	32.57	32.95	25.98
SD	10.22	7.28	5.95	6.42	3.87
CV	17.79	20.92	18.28	19.49	14.88

(1) Figures show volume of water in samples expressed as a percentage of the volume of the undisturbed soil sample.

(2) Samples on the same line represent samples from the same profile.

Table A2.4 Moisture in soil samples after 4 months storage

	Ah_1	Ah_2
Rowbrook	26.44	24.64
Farm	24.95	26.05
	30.95	25.59
	32.96	24.83
Zone	32.39	33.84
C	40.67	34.51
	29.30	35.68
Stoke	35.22	29.59
Farm	30.91	
	33.50	
	29.25	
	35.25	
n	12	8
$\bar{x}$	31.82	29.34
SD	4.23	4.70
CV	13.29	16.01

1) Figures show volume of water in samples expressed as a percentage of the volume of the undisturbed soil sample.

2) Pairs of figures represent samples drawn from the same profile.

Table A2.5 Summary of moisture content in soil samples after 4 months storage[1]

	n	$\bar{x}$	SD	CV
Ah_1	12	31.82	4.23	13.29
Ah_2	8	29.34	4.70	16.01
Oh	25	60.60	6.20	10.23
Oh	10	57.46	10.22	17.79
Ah/E	25	39.88	6.03	15.12
Ah/E	13	34.80	7.28	20.92
B_1	16	32.57	5.95	18.28
B_2	3	32.95	6.42	19.49
B_3	15	25.98	3.87	14.88

1) Figures show volume of water in samples expressed as a percentage of the volume in the undisturbed soil samples.

Exceptions to the above standard procedures

The groups of samples listed below received identical treatment to other samples except with respect to the specific differences listed; in most of these cases the difference is limited to a smaller size of sample taken for analysis and is a consequence of the field recovery technique.

Oh samples - all sample groups

The stone component of Oh samples was only weighed in a limited number of cases. Very few stones occurred in samples with LOI greater than 30% and the stone component was taken into account only on a few samples with LOI of 25% or less (see 3.3.2 and Table A2.1).

(3) (5) (6) (7) - volume samples

All volume samples were oven-dried to an unchanging weight; since these samples had not been allowed to air-dry prior to oven-drying, this took up to 48 h for the wettest samples. None of these volume samples were used for chemical analyses.

(3) (5) (8) (10) (15) - stone content of B horizons

In zone A and C, stone content of B horizons has mainly been estimated from the stones present in undisturbed volume samples; most of these samples were taken during the 1978 sampling. In addition some values were obtained from equivalent volume, 'beakerful' samples (see 3.3.2), but, although the fine earth in these sub-samples from bulk samples was always separated from the stone component, the latter was not always weighed.

(10) - B horizon samples

All the sub-samples taken from the non-volume (bulk) field samples had OD soil weights of ca. 100 g, leaving ca. 60-80 g fine earth for sub-sampling and analysis.

(11) - B horizon samples

These auger-recovered samples had OD soil weights of *ca.* 40-70 g, le ving 30-60 g fine earth for sub-sampling and analysis.

(12) - Oh and Ah/E samples

These small bulk samples had OD soil weights of 25-50 g (Oh) and 50-75 g (Ah/E); the stones were separated as usual but were not weighed.

(13) - B horizon samples from the small pits

These auger-recovered samples had OD soil weights of *ca.* 70 g, leaving *ca.* 50 g fine earth for sub-sampling and analysis.

(14) - B horizon samples

Sub-samples with OD soil weights of *ca.* 70-100 g were taken from the bulk samples, leaving *ca.* 40-70 g fine earth for subsampling and analysis.

(16) - B horizon samples

These auger-recovered samples had OD soil weights of *ca.* 40-80 g, leaving 30-60 g fine earth for sub-sampling and analysis.

(18) - Ah/E and B horizon samples

These small bulk samples had OD fine earth weights of *ca.* 65 g: the stones were separated as usual but not weighed.

(19) - Animal faeces samples

After field recovery, these samples were kept in sealed polythene bags for 14 days (at temperatures of *ca.* 15-20^{o} C) before being placed in a freezer for 7 days (at a temperature of -25^{o} C). They were then oven-dried (48 h at 105^{o} C) and ground to pass a 500 micron mesh sieve. Wet sample weights ranged from 42 to 193 g; OD sample weights ranged from 12 to 47 g. Loss of weight on drying ranged from 13 to 595% of the OD weight of samples.

Appendix 3 Chemical analysis

For chemical analyses, all weights of soil samples and chemicals were determined to 0.0000 g and all volume measurements were made using 'A' class volumetric glassware, which like all other glassware was regularly soaked in an acid bath. Only Analar grade materials were used throughout the work. Several different phosphorus extraction procedures were used during the study; the principal methods, used on all samples (Pao and Pa determinations) are described immediately below. Procedures used experimentally are outlined later.

Extraction of Pao and Pa

Pao

A 2.0000 g sub-sample of ground fine earth was weighed into a 25 ml porcelain crucible; this sample was heated to 575° C in a muffle furnace, a temperature that was reached 40 min after the sample had been placed in the cold furnace and was maintained ($\pm$ 5° C) until its removal 1 h 20 min later (total time in furnace = 2 h). After cooling for at least 1 h in a dessicator, the sample was reweighed to determine weight loss-on-ignition and transferred to a 250 ml polypropylene wide-necked bottle.

Pa

A duplicate 2.0000 g sub-sample of ground fine earth was weighed into a polystyrene weighing boat and then transferred to a 250 ml polypropylene wide-necked bottle.

Pao and Pa

100 ml of 2N H_2SO_4 was added to the sub-samples in the polypropylene bottles which were then sealed and shaken on a reciprocal shaker for 6 h. The solutions were then filtered (Whatman 44 filter) and stored overnight in glass flasks.

Determination of P in solution

P in solution w as determined by the method of Murphy and Riley (1962) following precisely the procedural steps conveniently published by Watanabe and Olsen (1965). Absorbance was measured on a Cecil Instruments CE 272 Linear readout ultra-violet spectrophotometer set at 882 nm using 4.5 cm silica cells. A blank and 3 standards were run with each batch of 20 samples (either Pao or Pa samples in each batch). Initial tests were performed to check on the stability of the blue colour, the percentage recovery of added phosphorus, the effect of coloured sample solutions (Pa only) on measured absorbance and the effect of allowing solutions to stand overnight before colorimetry. No significant change in absorbance occurred between 15 min and 24 h; recovery of added phosphorus was always satisfactory; colouration of solutions did not affect absorbance measured at 882 nm; and no significant differences were found between sample solutions analysed 2 h after extraction and those left to stand for 3 days. Only very slight changes could be detected after 3 months.

Pao determinations

The level of P in these sample solutions necessitated a 4 X dilution; 25 ml of the solution was therefore made up to 100 ml with distilled water and a 2 ml aliquot of this dilute solution was taken for colorimetry. The dilution obviated the need for any adjustment of aliquot acidity.

Pa determinations

The level of P in these sample solutions neither required nor, in some cases, allowed dilution. In consequence, it was necessary to adjust the acidity of Pa aliquots and 2N NaOH was used to neutralise them. Initial tests were made to determine an appropriate routine procedure and these showed that a satisfactory adjustment could be made by adding 2N NaOH in amounts equal to that of the sample aliquot, which itself varied in size from 1 to 5 ml (but usually 2 or 3 ml) depending on the level of P in the particular sample solution.

Standards

Stock solution: 0.4393 g dry KH_2PO_4 was dissolved in distilled water and made up to 1 l; this solution contained 0.1 mg P ml^{-1}.

Working solution: 20 ml of the stock solution was diluted in distilled water and made up to 1 l; this solution contained 0.002 mg P ml^{-1}.

3 standards (containing 2, 5, and 10 ml of working solution) were analysed with each batch of twenty samples; in Pao batches a 2 ml aliquot of the diluted blank solution was added to all standards to ensure equality of acidity; in Pa batches an appropriate aliquot of the blank and the 2N NaOH solution used for sample neutralisation served the same purpose. The blank, standards and samples were all read (successively using the same cell) against a water reference and blank absorbance was subtracted from standards and samples before calculation of P in solution. The relationship between absorbance and the concentration of P in solution was determined for each standard (no deviance from linearity was detected) and the mean value was used to determine P in the sample solutions.

Contamination

Blank absorbance rarely exceeded 0.0050 and on Pao batches was often less than 0.0020; Pa batches, to which NaOH had been added, typically showed higher blank values than Pao batches. Differences in cell absorbance account for much of the blank value and none of the ca. 90 batches processed had to be rejected due to suspected contamination. Since the polypropylene bottle employed for a blank was deliberately rotated such that blanks were shaken in bottles used for samples in the previous batch, any carry-over should have been apparent but none was detected. Similar observations apply to all glassware.

The above routine procedures were used on all soil samples and samples of animal faeces (though in the latter cases substantially higher dilutions had to be employed) and such analyses provide the basic soil phosphorus and LOI data used in these studies. In certain cases additional or exceptional procedures were used. The LOI of all volume samples collected in 1977 - (3) (5) (6) (7) - was determined by igniting a ca. 5-10 g sub-sample of the fine earth from these samples for 16 h at 390° C. The chemical analyses of bulk samples from the same locations provided a second estimate of LOI for these sampling locations and the second estimate has been used in calculation of organic matter and Po - LOI relationships for these profiles. However, the mean of the two estimates of LOI, which in nearly all cases were very similar, was used in the assessment of the relationship between BD and LOI discussed in section 3.3.2. Similarly, some of the volume samples from B horizons recovered in 1978 were not used for chemical analyses and LOI was determined in these samples by ignition of fine earth for 3 h at 575° C. The data in Table A3.1 shows that such variations in procedure, which do not affect the reported chemical properties of the soils in any way, are also unlikely to have had any significant effect on the estimations of bulk density derived from the BD/LOI regression equations.

Experimental extractions

Alkaline oxidation - NaOBr

The method of Dick and Tabatabai (1977) was tested on 20 samples representing all types of soils within the study area. The published procedures were followed precisely except that filtering (with a Whatman 44 filter) was substituted for the centrifuge step. In very brief outline, the method consists of adding 3 ml of sodium

Table A3.1 Loss-on-ignition experiments: the effects on LOI values of variations in timing and temperature of ignition.

Sample	UNGROUND FINE EARTH (SOIL < 2 mm) 390°C	16 hr	540°C	1½ hr	640°C	2¼ hr	GROUND FINE EARTH 575°C	2 hr
	42.27		42.83		42.76		43.40	
Oh	41.94		42.34		44.22		44.04	
	41.94		43.51		43.51		41.69	
	42.18		42.58		42.88		38.62	
		$\bar{x}$ 42.08		$\bar{x}$ 42.81		$\bar{x}$ 43.43		$\bar{x}$ 42.08 (2)
	10.01		10.35		10.53		11.24	
AhE	10.16		10.66		10.69		11.17	
	10.50		10.80		10.68		11.15	
	10.34		10.25		10.79		11.11	
		$\bar{x}$ 10.25		$\bar{x}$ 10.51		$\bar{x}$ 10.67		$\bar{x}$ 11.16
	11.24		11.64		11.99		11.44	
Bs	10.83		11.80		12.07		11.36	
	10.86		11.73		12.15		11.50	
	10.84		11.84		11.77		11.47	
		$\bar{x}$ 10.94		$\bar{x}$ 11.75		$\bar{x}$ 11.99		$\bar{x}$ 11.44

(1) Individual LOI measurements have been rounded to two decimal places, but $\bar{x}$ values were calculated before rounding.

(2) $\bar{x}$ = 43.23 if the fourth sample is omitted from calculations.

hypobromite to a 200 mg soil (ground fine earth) sample in a 50 ml boiling flask, which is then placed on a sand bath at 275° C. Heating is continued for 30 min after the contents have evaporated to dryness. The results of this experiment are listed in Table A3.2 which also includes the results of analyses of the same samples using Na_2CO_3 fusion (Rothamsted standard procedures) and using the standard method of analysis described above. Despite its success with many other soil types, it is evident that the alkaline oxidation method cannot extract more than about 70% of the phosphorus in these samples; Dick and Tabatabai (1977: Table 2) also reported two soil types (Nos. 10 and 14) in which the method extracted substantially less than total phosphorus (91.5 and 82.5% respectively), and, although the method is fast and relatively unhazardous, it clearly cannot be used as a substitute for fusion analyses without prior testing of its efficacy.

Modified alkaline oxidation method

The poor extraction of the standard NaOBr method with these highly organic samples was thought to be the result, in part, of the inability of the 3 ml of NaOBr to fully oxidise the organic soil fraction; in addition, it seemed possible that difficultly-soluble phosphates were being formed during the sand bath heating stage. In consequence, three samples (selected for the particularly low proportion of Pt that had been extracted by the standard method) were re-analysed using slightly modified procedures. The modifications tested were: 1) pre-ignition of the samples for 1 h at 400° C; 2) the use of 5N instead of 1N H_2SO_4 for post-oxidation extraction; 3) the use of a lower temperature (190° C) during oxidation (the samples were kept on the sand bath until all evaporation was complete; this took 1 to 1.5 h, thus about 15 to 30 min longer than the standard method). A full factorial set of analyses was not attempted but the results of these experiments (Table A3.3) show that pre-ignition of samples, particularly highly organic ones can improve the proportion of Pt extracted by alkaline oxidation, but that the employment of a lower temperature may be counter-productive and the use of stronger extracting acid unhelpful. Although a considerable improvement in the amount extracted from peat samples was achieved, the results on mineral soil samples were less satisfactory. Pre-ignition followed by the standard NaOBr procedure might well extract a slightly higher proportion of Pt than the standard acid extraction procedure used in these studies, but the difference would not allow a clear Pf fraction to be defined.

Table A3.2 Phosphorus extraction experiments: a comparison of total phosphorus (Na_2CO_3 fusion) with the phosphorus extracted by acid after oxidation with sodium hypobromite, and by acid after ignition.(1)

	Pt	P	$\frac{P}{Pt}$.100	Pao	$\frac{Pao}{Pt}$.100	Po	$\frac{Po}{Pt}$.100	LOI
	Na_2CO_3 Fusion	NaOBr Oxidation		$2NH_2SO_4$ Extraction after Ignition		Pao-Pa		%
Surface Soils								
Oh	780	604	77		88		66	45.2
	820	624		703		528		
Oh	800	537	67	689	86	565	71	45.1
Oh	780	610						
	920	642	68-80	833	91-107	748	81-96	49.9
Oh	810	616	76	700	86	505	62	45.1
Ah	580	410	71	451	78	371	64	12.4
Ah	940	646						
	950	683	70	740	78	610	65	15.7
Sub-Surface Soils								
AhE	340	238	70	256	75	230	68	10.9
AhE	410	258						
	430	263	62	193	46	176	42	8.7
AhE	510	270	53	281	55	256	50	9.3
AhE	460	312						
	480	313	66	260	55	218	46	12.1
AB	620	372		413				
		400	62	423	67	365	59	10.6
AB	730	560	77	563	77	467	64	10.4
B_1	620							
	640	408	65	468	74	422	67	8.5
B_1	450	441						
	490	371	76	325	69	296	63	7.6
B	580	437	75	445	77	367	63	9.1

(cont)

Table A3.2 (cont'd)

	Pt NA_2CO_3 Fusion	P NaOBr Oxidation	$\frac{P}{Pt}.100$	Pao $2NH_2SO_4$ Extraction after Ignition	$\frac{Pao}{Pt}.100$	Po Pao-Pa	Pa.100	LOI %
B	580	426	73	353	61	199	34	6.5
B_2	600	404	67	357	60	261	44	6.4
B_2	480	318	70	322	67	264	55	6.5
		355						
BCux	550	331	60	271	49	147	27	5.2
BCux	450	292						
	480	302	64	215	46	95	21	3.9
$\bar{x}$ (n=20)	611.5	424.3	69.4	442.2	72.3			

(1) All phosphorus values are expressed as mg P kg^{-1} Fe

Table A3.3 Phosphorus extraction experiments: a comparison of total phosphorus (Na_2CO_3 fusion) with the phosphorus extracted by acid after ignition, and by acid after ignition and oxidation with sodium hypobromite.[1]

	P t	Pao	P extracted by oxidation with NaOBr			
	Na_2CO_3 Fusion	2 N H_2SO_4 Extraction After Ignition	Samples ignited for 1 hr at 400° C. Oxidation at 275°C	Samples ignited for 1 hr at 400° C. Oxidation at 190°C	Samples not ignited Oxidation at 275°C	Samples not ignited Oxidation at 190°C
Oh Sample	800	689 (86.1%)[3]	1N[2] 739 5N 732 x̄ 737 (92.1%)	1N 752 5N 723	1N 537 (67.1%)	
Ah/E Sample	510	281 (55.1%)		1N 348 5N 345 x̄ 347 (67.9%)	1N 270 (52.9%)	1N 204 5N 217 x̄ 211 (41.3%)
BCux Sample	550	271 (49.3%)	5N 374 x̄ 366 (66.5%)	5N 358	1N 331 (60.2%)	1N 330 5N 325 x̄ 328 (59.5%)

1) All phosphorus values are expressed as $mgPkg^{-1}Fe$.

2) Figures underlined (i.e. 1N or 5N) indicate normality of extracting acid.

3) Figures in brackets indicate the amount of P extracted expressed as a percentage of the total phosphorus extracted from a replicate sample.

Acid extraction with concentrated HCl

A modified version of the method of Beckwith and Little (1963), omitting the $HClO_4$ stage, was also tested on a small number of samples. In very brief outline, this method consisted of igniting ground fine earth samples (250 mg) for 2 h at 575° C, followed by an extraction, which involved repetitive treatment with concentrated, boiling HCl (10 ml conc. HCl was added to the ignited samples in zirconium crucibles, which were then placed on a sand bath at 100° C and evaporated to near dryness; this was then repeated two more times with, on the last stage, complete evaporation to dryness. Phosphorus was then taken up in 1N H_2SO_4 and P in solution determined using the standard colorimetric procedure described above. 100 mg of magnesium acetate was added to one set of sub-samples prior to ignition (as suggested by Beckwith and Little 1963:17) but a second set without such addition showed effectively identical results (see Table A3.4). To check whether interfering ions might have led to underestimation of P in solution, a recovery test was performed; the results (also shown in Table A3.4) suggest that no such interference was present.

The results of this experiment were disappointing; little if any more P had been extracted by boiling HCl then by cold, dilute H_2SO_4, except perhaps with the BCux samples. Certainly, the method did not offer any significant improvement over the Pao - Pa system of extraction.

Determination of pH

Both in the field and in the laboratory, pH was determined on a soil - water mixture using a combination glass/reference electrode. In the field, a heaped 5 ml spoonful of soil in field condition was added to 25 ml of distilled water and pH was determined on a Walden Precision Apparatus C 6 portable pH meter after 2 min during which the soil - water mixture was periodically stirred. In the laboratory 10 g of OD fine earth (unground) was added to 25 ml of distilled water and pH was determined in a similar fashion but in this case using a C10 laboratory pH meter. Although not comparable with each other, the field (see Table 3.32) and laboratory determined values (see Figs. 5.3, 5.28, 5.89, 5.104 and 5.140) for pH form highly consistent series in themselves.

Table A3.4 Phosphorus extraction experiments, a comparison of total phosphorus (Na_2CO_3 fusion) with the phosphorus extracted by concentrated hydrochloric acid and dilute sulphuric acid after ignition of samples.(1)

	P t	P		P		Pao	
	Fusion $Na_2\ CO_3$	Extraction after ignition Conc. HCL. 100° Without magnesium acetate		Extraction after ignition Conc. HCL. 100° With magnesium acetate		Extraction after ignition 2N H_2SO_4	
Oh Sample	860	794	(92%)(2)	806	(94%)	743	(86%)
AhE Sample	355	203	(57%)	198	(56%)	186	(52%)
B Sample	520	360	(69%)	353	(68%)	391	(75%)
BCux Sample	520	329	(63%)	336	(65%)	289	(56%)
$\bar{x}$	563.75	421.50	(74.8%)	423.25	(75.1%)	402.25	(71.4%)

Recovery Check

Without Magnesium Acetate

Sample Absorbance	Sample plus P Absorbance	Increase in Absorbance	$\bar{x}$	P Standards Absorbance	Recovery %
.2390	.3500	.1110			
.0631	.1820	.1171	.11365	.1151	98.7
.1080	.2220	.1140			
.1030	.2155	.1125			
With Magnesium Acetate					
.2355	.3465	.1110			
.0645	.1803	.1158	.11445	.1149	99.6
.1100	.2265	.1165			
.1010	.2155	.1145			
		overall $\bar{x}$	.11405	.115	99.2

(1) All phosphorus values are expressed as mg P kg^{-1}Fe.

(2) Figures in brackets indicate the amount of P extracted expressed as a percentage of the total phosphorus extracted from a replicate sample.

Appendix 4 Calculation and expression of results

MEASURED VARIABLES

Soil bulk density

$$\frac{\text{OD wt of volume soil sample (g)}}{\text{Volume of undisturbed soil sample}^{\neq}\ (\text{cm}^3)} = \text{Soil bulk density (BD) } (\text{g cm}^{-3})$$

BD was also estimated from LOI values using the regression equations listed in Table 3.5.

Apparent bulk density of fine earth (Wt of fine earth per unit volume of soil)

$$\frac{\text{OD wt of volume soil sample (g) — OD wt of all stones in volume soil sample (g)}}{\text{Volume of undisturbed soil sample}^{\neq}\ (\text{cm}^3)}$$

= Apparent bulk density of fine earth (BD-Fe) (g cm^{-3})

or, where BD has been estimated from LOI,

$$\frac{\text{OD wt of soil sample (g) — OD wt of stones in sample (g)}}{\text{OD Wt of soil sample (g)}} \times \text{estimated BD } (\text{g cm}^{-3})$$

= Apparent bulk density of fine earth (BD-Fe) (g cm^{-3})

≠Volume of undisturbed soil samples = 182.137 cm^3

Loss-on-ignition

OD wt of fine earth before ignition minus OD wt of fine earth after ignition expressed as a percentage of OD wt of fine earth before ignition = LOI (%)

Phosphorus - Pao and Pa (for Pt, see below).

$$\frac{\text{P in solution}^{\neq}\ (\text{mg ml}^{-1})\ \text{X extractant volume (ml) X Dilution factor}}{10\ \text{X Aliquot volume (ml) X OD wt of fine earth sample (g)}}\ \text{X}\ 10{,}000$$

$= \text{P (mg kg}^{-1}\ \text{Fe)}$

$\neq$ P in solution determined from absorbance values by reference to standard solutions.

FORMULAE FOR CALCULATED VARIABLES

Wt of P in the Fe of a unit volume of soil

$$\text{P } (\mu\text{g cm}^{-3}) = \text{P (mg kg}^{-1}\text{Fe) X BD-Fe (g cm}^{-3}) \text{ (within a horizon)}$$

$$\text{P } (\mu\text{g cm}^{-3}) = \frac{\sum \text{P (g m}^{-2}) \text{ in all horizons}}{\sum \text{Thickness (cm) of all horizons}}\ \text{X 100 (within a profile)}$$

Wt of P in the Fe of a horizon or profile of given thickness

$$\text{P (g m}^{-2}) = \frac{\text{P } (\mu\text{g cm}^{-3}) \text{ X thickness of the horizon (cm)}}{100} \text{ (within a horizon)}$$

$$\text{P (g m}^{-2}) = \sum \text{P (g m}^{-2}) \text{ in all horizons} \quad \text{(within a profile)}$$

Wt of P per unit wt of Fe in a profile of given thickness

$$\text{P (mg kg}^{-1}\text{Fe)} = \frac{\sum \text{P (g m}^{-2}) \text{ in all horizons}}{\sum \text{Fe (kg m}^{-2}) \text{ in all horizons}}\ \text{X 1000}$$

Wt of P per unit wt of ignited Fe in a horizon or profile

$$\text{P (mg kg}^{-1}\text{ IFe)} = \frac{\text{P (mg kg}^{-1}\text{Fe)}}{100 - \text{LOI (\%)}}\ \text{X 100 (within a horizon)}$$

$$P\ (mg\ kg^{-1} IFe) = \frac{P\ (g\ m^{-2})\ \text{in all horizons}}{IFe\ (kg\ m^{-2})\ \text{in all horizons}} \times 1000\ \text{(within a profile)}$$

<u>Calculated phosphorus fractions</u>

Po = Pao - Pa   Pf = Pao - Pt   Pi = Pt - Po

<u>Wt of Po per unit wt of Fe lost on ignition</u>

$$Po\ (mg\ kg^{-1} L\ OI) = \frac{Po\ (mg\ kg^{-1} Fe)}{LOI\ (\%)} \times 100\ \text{(within a horizon)}$$

$$Po\ (mg\ kg^{-1} LOI) = \frac{\sum Po\ (g\ m^{-2})\ \text{in all horizons}}{\sum LOI\ (kg\ m^{-2})\ \text{in all horizons}} \times 1000\ \text{(within a profile)}$$

<u>Wt of Fe lost on ignition of a unit volume of soil</u>

$$LOI\ (mg\ cm^{-3}) = LOI\ (\%) \times BD\text{-}Fe\ (g\ cm^{-3}) \times 10\ \text{(within a horizon)}$$

<u>Wt of Fe lost on ignition</u>

$$LOI\ (kg\ m^{-2}) = \frac{LOI\ (mg\ cm^{-3}) \times \text{Thickness of the horizon (cm)}}{100}\ \text{(within a horizon)}$$

$$LOI\ (kg\ m^{-2}) = \sum LOI\ (kg\ m^{-2})\ \text{in all horizons}\quad \text{(within a profile)}$$

<u>Wt of soil in a horizon</u>

$$Soil\ (kg\ m^{-2}) = BD\ (g\ cm^{-3}) \times \text{Thickness of the horizon (cm)} \times 10$$

<u>Wt of Fe in a horizon</u>

$$Fe\ (kg\ m^{-2}) = BD\text{-}Fe\ (g\ cm^{-3}) \times \text{Thickness of the horizon (cm)} \times 10$$

Wt of ignited Fe in a horizon

$$IFe\ (kg\ m^{-2}) = Fe\ (kg\ m^{-2}) - LOI\ (kg\ m^{-2})$$

Wt of stones in a horizon

$$Stones\ (kg\ m^{-2}) = Soil\ (kg\ m^{-2}) - Fe\ (kg\ m^{-2})$$

Wt of soil, Fe, ignited Fe and stones in a profile

In each case, profile weight is the sum of the weight in all the horizons.

Apparent density of Fe in a profile

$$BD\text{-}Fe\ (g\ cm^{-3}) = \frac{\sum Fe\ (kg\ m^{-2})\ \text{in all horizons}}{\sum \text{Thickness (cm)} \times 10}$$

Wt of Fe lost on ignition per unit wt of Fe in a profile

$$LOI\ (\%) = \frac{LOI\ (kg\ m^{-2})\ \text{in a profile}}{Fe\ (kg\ m^{-2})\ \text{in a profile}} \times 100$$

TOTAL PHOSPHORUS - Pt

With 6 exceptions, all Pt values used in these studies are those determined by Na_2CO_3 fusion analyses at Rothamsted Experimental Station. The Pt values for the exceptional samples have been estimated from their Pao values using the regression equations presented in Chapter 3 (section 3.3.2, Table 3.10). This procedure was adopted in order that the description of phosphorus within the palaeosols discussed in section 5.2.1 could include a complete balance sheet of Pt despite the fact that some samples from these profiles could not be submitted to Rothamsted.

Table A4.1 Pt values estimated from the regression of Pao on Pt
(All values in mg kg^{-1} Fe)

Sample and horizon	Measured Pao value	Pt value of:	Predicts Pao value of:	Pt value adopted
Oh (and Oh-Ah) samples	(uses regression equation 2 in Table 3.10)			
1. HM 78/79 B, bOh-Ah Bulk density sample	479	564	479	564
2. HM77F 6 (1)	494	579	494	579
3. HM77F 5 (1)	797	887	797	887
BCux samples	(uses regression equation 6 in Table 3.10)			
4. HM 78/79 B (11)	238	476	238	476
5. HM77F (9U)	297	534	297	535
but note (9L)	296 and measured Pt = 535			
6. HM77F 5 (9U)	287	525	287	520
but note (9L)	289 and measured Pt = 520			

Appendix 5 Replication and error

Replication experiments designed to determine the level of uncertainty in the results of chemical analysis were not pursued systematically through all stages of the process of analysis. A full investigation of uncertainty should include repetitive sampling and analysis of:

(1) A unit of land - replicate profiles;
(2) A soil profile - replicate bulk samples of horizons;
(3) A bulk sample - replicate fine earth sub-samples;
(4) A fine earth sub-sample - replicate ground fine earth sub-samples;
(5) A ground fine earth sub-sample - replicate analytical sub-samples processed within a single batch and in separate batches;
(6) An extractant solution - replicate aliquots taken for the final solution used in colorimetric analysis;
(7) A final solution - replicate aliquots taken for absorbance measurements.

Some information as to the uncertainty existing at each of these stages of processing or 'levels' of analysis is available and is presented here in reverse order.

Replication of absorbance measurements (7) - Table A5.1

Differences (D) in the absorbance of two aliquots taken for colorimetric determination from the same final solution; second reading taken 1.5 to 2 h after the initial reading.

.0877	.0831	.0820	.0807	.0800	Absorbance 1
.0850	.0832	.0810	.0792	.0798	Absorbance 2
.0027	.0001	.0010	.0015	.0002	D

Mean Difference in absorbance = .0011

Replication of the final solutions used in colorimetric analysis (6)
Table A5.2

Differences in the absorbance of two aliquots taken for colorimetric determination from replicate final solutions prepared from the same extractant solution; second set of colorimetric determinations made 10 days after initial readings.

.0961	.0950	.0605	.1040	.1952	.1444	Absorbance 1
.0953	.0954	.0585	.1039	.1920	.1440	Absorbance 2
.0008	.0004	.0020	.0001	.0032	.0004	D

Mean difference in absorbance = .0012

The relationship between the absorbance value and the amount of P in a soil sample varies as a function of the degree of dilution. In most Pao determinations, an absorbance difference of .0012 would be equivalent to a difference in soil phosphorus of about 4 mg kg^{-1}Fe: in most Pa determinations, the same absorbance difference would be equivalent to between 0.5 and 1 mg kg^{-1}Fe.

Replication of analytical sub-samples (5) - Tables A5.3 and A5.4

Differences in the values of Pao, Pa (mg kg^{-1} Fe) and LOI (%) determined by extraction and analysis (within a single batch) of replicate analytical sub-samples drawn from a single ground fine earth sub-sample.

Profile and Horizon	Batch 34 Pao	D	Batch 32 Pa	D	Batch 34 LOI	D
HM 77F	330.39		24.86		8.905	
5 (2)	334.58	4.19	24.64	0.22	8.855	0.050
HM 77F	234.99		24.94		7.785	
6 (2)	238.49	3.50	25.24	0.30	7.730	0.055
HM 77F	196.55		18.88		5.205	
6 (3)	199.18	2.63	18.88	0.00	5.185	0.020
HM 77F	288.76		32.25		7.105	
6 (5a)	287.88	0.88	32.86	0.61	7.045	0.060
HM 77F	363.41		64.72		7.925	
6 (5b)	359.21	4.2	65.15	0.43	7.945	0.020
HM 77F	426.30		49.43		12.885	
6 (5)	431.90	5.6	49.26	0.17	12.855	0.030
HM 77F	461.25		96.05		10.980	
6 (5c)	459.15	2.1	96.16	0.11	10.945	0.035
	Mean difference = 3.30		Mean difference = 0.26		Mean difference = 0.039	

Differences in the values of Pao, Pa (mg kg^{-1}Fe) and LOI (%) determined by extraction and analysis (in different batches) of replicate analytical sub-samples drawn from a single ground fine earth sub-sample.

Profile and Horizon	Batch	Pao	Batch	Pa	Batch	LOI
HM 78C (13)	52	320.35 (.0940)	51	196.76 (.2320)	52	3.790
B Cux below ditch sediments	54	297.88 (.0871)	53	197.67 (.2325)	54	3.725
	D 22.47	(.0069)	D 0.91	(.0005)	D 0.065	
HM 79B 'O' (1)	52	453.69 (.1325)	51	31.26 (.0398)	52	26.100
bOh-Ah of medieval palaeosol	54	505.17 (.1466)	53	28.72 (.0372)	54	26.035
	D 51.48	(.0141)	D 2.54	(.0026)	D 0.065	

Values in ( ) indicate sample absorbances.

Replicate sub-samples analysed in different batches appear to exhibit very much larger differences than those analysed in a single batch, though Pa differences remain very small. However, this particular type of replication was only undertaken on the two samples shown and may not be representative. Other replication work at higher levels (see immediately below) suggests that these particular analyses exaggerate the likely level of differences between samples that arise from imprecision at this level. Within-batch differences are similar to those which would arise from imprecision at levels (7) and (6); this suggests that sub-samples drawn from a single ground fine earth sample are very similar and that this stage of sampling adds little to sample variance. It should be noted that, in the between-batch comparison and in all the comparisons described below, equality of absorbance values does not imply equality in the calculated values for P in soil samples, since the latter may be affected by differences in the absorbance of standards and blanks run with a specific batch. However, these factors cannot explain the large between-batch differences discussed above, since both blanks (Batch 52 = .0015, Batch 54 = .0016) and standards were almost identical in these two batches.

Replication of ground fine earth sub-samples (4) - Table A5.5

Differences in the values of Pao, Pa (mg kg^{-1}Fe) and LOI (%) determined by extraction and analysis (in different batches) of analytical sub-samples drawn from replicate ground fine earth sub-samples of a single fine earth sub-sample.

Profile and Horizon	Batch	Pao	Batch	Pa	Batch	LOI
SP6 (2)	2	272.03 (.0834)	3	33.93 (.0810)	2	11.670
Ah/E	60	275.58 (.0833)	60	39.64 (.0973)	60	11.905
	D 3.55	(.0001)	D 5.71	(.0163)	D 0.235	
SP8 (2)	2	255.83 (.0758)	3	26.39 (.0780)	2	10.915
Ah/E	60	246.62 (.0750)	60	33.75 (.0838)	60	11.390
	D 9.21	(.0008)	D 7.36	(.0058)	D 0.475	

Values in ( ) indicate sample absorbances.

The differences between samples shown above include imprecision at levels (7), (6) and (5), as well as (4) and, moreover, may include differences arising during prolonged storage of the fine earth (in OD condition). Batch 60 was processed two years after Batches 2 and 3; the effects of prolonged storage will be considered separately below, but it can be noted here that, whereas Pa values may well increase during prolonged storage (due to mineralisation of Po), Pao values are unlikely to be significantly affected by storage. In consequence, the differences in this fraction (Pao) may have arisen in part from the sub-sampling of the fine earth sample. If so, such sub-sampling may contribute little to sample variance. The samples shown are among those which suggest that the between-batch differences evident at level (5) may be atypical.

Replication of fine earth sub-samples (3) - Table A5.6

Differences in the values of Pao, Pa (mg kg^{-1}Fe) and LOI (%) determined by extraction and analysis (in different batches) of analytical sub-samples taken from ground fine earth sub-samples, each of which was drawn from a replicate fine earth sub-sample of the single bulk sample taken in the field.

Profile and Horizon	Batch	Pao	D	Batch	Pa	D	Batch	LOI	D
SP 10 (2)	17	220.01	1.04	17	29.12	2.95	17	18.365	0.395
Ah/E	20	218.97		21	32.14		20	18.760	
GSP 9 (3)	17	245.45	3.28	17	53.88	0.12	17	6.685	0.140
B_1	22	248.73		23	53.76		22	6.825	
SP 5 (2)	2	354.38	2.57	3	43.06	0.33	2	14.950	0.000
Ah/E	81	351.81		81	42.73		81	14.950	
SP 8 (2)	2			3					
Ah/E	60	251.23†	17.70	60	30.07†	6.62		11.153†	0.302
	81	268.93		81	36.69		81	11.455	
Mean Difference all samples			6.15			2.51			0.209
Mean Difference excluding SP 8 (2)			2.30			1.13			0.178

† The mean values from two analyses (see Table A5.5 above) are used here.

The sample values shown here are affected by imprecision at all the lower stages (7 to 4) as well as (3) and may include differences due to prolonged storage in field (wet) condition. Although analysed only a few weeks apart, GSP 9 (3) and SP 10 (2) each provide instances of bulk re-sampling after a three month interval; SP 5 (2) and SP 8 (2) were re-sampled after a two year interval. (These four samples provide the only fully comparable set which can be used to judge the effects of long storage in the field condition; it does not seem that, with these very acid soil samples, such storage has any substantial effect, though a much larger check would be needed to demonstrate this conclusively). It can also be concluded, if only tentatively, that fine earth sub-samples extracted from a bulk sample are not substantially different from each other and most probably provide a representative sample of the bulk sample. These examples also support the notion that the between-batch differences noted for level (5) are atypical.

Replication of bulk samples (2) - Table A5.7

During the Holne Moor sampling, one profile was partially resampled after an interval of one year and so provides an opportunity to assess the extent to which field samples are themselves replicable and so may be regarded as representative of the profile horizons from which they originate. Although each sample was separately processed down to the stage at which an analytical sub-sample becomes available, extraction and colorimetry was done in four batches during one week and many of the comparisons avoid between-batch differences. All samples spent similar time stored in field condition, but 1978 samples were stored for a year longer in OD condition. This resampling was prompted by the need to obtain a better volume sample of the very thin, buried Oh-Ah horizon; it was felt that the use of the standard procedure during the 1978 season had resulted in some contamination of the Oh-Ah sample through incorporation of overlying and underlying mineral soil. In this instance, therefore, the differences between 1978 and 1979 samples may mainly reflect the recovery, in 1979, of a 'better' sample of this buried surface soil. All the other samples simply represent a deliberate replicate sampling.

Table A5.7 - Pao, Pa ($mg\ kg^{-1}\ Fe$), LOI (%)

Profile HM 78, 79 B, Buried soil and Overburden

Horizon	Year	Pao		D	Pa		D	LOI		D
Ah developed	1978	421.21		10.45	89.10		0.65	13.080		1.915
in overburden	1979	431.66			88.46 [1]			14.995		
Buried Oh-Ah	1978	431.18 (52)		48.25	38.06 (51)		8.07	23.030 (52)		3.038
	1979	479.43[2] (52,54)			29.99[2] (51,53)			26.068[2] (52,54)		
Buried Ah/E samples from upper half of horizon	1978	238.30		2.44	21.84		0.50	8.085		0.290
	1979	235.86			21.35[1]			8.375		
Samples from lower half of horizon	1978	280.80		17.42	35.47		2.38	8.820		0.730
	1979	263.38			33.09			8.090		
Mean (n = 4)			254.59			27.94			8.343	
Buried Ah/E Two bulk samples	1978	269.49[1]			21.11			8.113[1]		
of whole horizon	1978	250.32[1]		19.18	28.98		7.87	9.503[1]		1.390
Mean (n = 2)			259.91			25.05			8.808	
Difference of Means			5.32			2.89			0.465	

All Pao and LOI = Batch 54, all Pa = Batch 53, except where indicated in ( ).

1. = mean of two, within-batch analytical sub-sample replicates.
2. = mean of two, between-batch analytical sub-sample replicates.

Since the initial sampling of this profile had removed or seriously disturbed one face of the sampling pit, most of the 1979 samples had to be taken from the opposite face of the pit, some 75-100 cm distant from the original sampling point. In view of this, the similarity of sample values is somewhat surprising; this data suggests that, in 'wild' soils developed on uniform parent materials, soil phosphorus may be more uniformly distributed than is commonly supposed (see Beckett and Webster 1971). The differences between paired samples in this profile could have arisen entirely from imprecision of observation; even the soil in bulk samples taken in different years may have had identical concentrations of the phosphorus fractions studied.

Replication of profiles (1) - Tables A5.8 and A5.9, and Figs. A5.1 and A5.2

Many of the studies reported in detail in Chapter 5 provide information about soil variability on a scale wider than the individual profile and based upon the chemical qualities estimated for complete profiles. However, in order to pursue the question of the reproducibility of this research to the highest level in a manner comparable to foregoing replication, certain data is presented here; it illustrates the extent of variability in samples from specific horizons within small areas. Fig. A5.1 shows the location of sampled profiles within one half of zone C; these groups of samples (A and B), each provide a random sample of an area of land of ca. 500 m^{-2} . One profile in group B (SP 37) contained a 'grey stone zone' (see section 4.2.1.1) below an iron-pan; separate statistics omitting this profile are included below.

Table A5.8 Zone C, groups A and B - Pao (mg kg^{-1} Fe)

Oh horizon

Group	Range	Max D	$\bar{x}$	SD	SE	CV
A n = 4	639-736	97	681.3	46.3	23.1	6.8
B n = 4	415-700	285	613.8	135.2	67.6	22.0
B n = 3 excluding SP 37	642 -700	58	680.0	32.9	19.0	4.8
ALL n = 8	415-736	321	647.5	100.3	35.3	15.5
ALL n = 7 excluding SP 37	639-736	97	680.7	37.9	14.3	5.6

Ah/E horizon

Group	Range	Max D	$\bar{x}$	SD	SE	CV
A n = 4	220-283	63	252.0	28.3	14.2	11.2
B n = 5	215-354	139	277.3	50.2	22.5	18.1
B n = 4 excluding SP 37	260-354	94	292.9	41.8	20.9	14.3
ALL n = 9	215-354	139	266.1	41.7	13.9	15.7
ALL n = 8 excluding SP 37	220-354	134	272.4	39.6	14.0	14.5

A full evaluation of the soils in zone C is provided in section 5.4.2, where more information is presented. In this context, the aspects worth stressing include: 1) the overall homogeneity of the sampled horizons - the CV values are markedly lower than might have been expected; 2) the absence of any evidence that 1978 samples differ from those taken a year earlier; 3) the absence of any significant spatial pattern in the values; 4) the substantial increase in the size of the maximum difference between samples compared with differences observed at lower levels of replication. It seems likely that, at least at this stage, the apparent differences between samples may arise not only from imprecision of observation, but also from hetereogeneity in the materials sampled.

This zone is not unique; Fig. A5.2 and Table A5.9 show the pattern of values for comparable mineral horizons in one of the subsidiary sampling zones.

Table A5.9 - Bench Tor and West Stoke Farm

Area and soil type	Samples	Range	Max D	$\bar{x}$	SD	SE	CV	n
Bench Tor. Moorland stagnopodzols	Ah/E from zone ca. 620 m^2	217-235	18	223.60	7.47	3.34	3.34	5
Brake Field, West Stoke Farm, Humic brown podzolic soils.	Ap from zone ca. 270 m^2	1013-1539	526	1256.60	230.79	103.21	18.37	5

Within a similarly-sized area, the moorland CV values are even lower than those in zone C, though field values, affected by phosphorus fertilisers and FYM, are substantially more variable. This study is pursued further in section 5.2.2.2.

Sources of variability in observed sample values

Insufficient numbers of replicate analyses of all types are available for a proper statistical analysis, which would allow one to pin-point the different sources of variability with confidence. In addition, many of the sample comparisons may include differences arising from more than a single factor (e.g. differences in storage as well as stage of sub-sampling and analysis). However, it is apparent that differences of up to about 5 mg kg^{-1}Fe of phosphorus may merely reflect error during colorimetric determinations and this source of error may well be the principle cause of within-batch differences in replicates. It is likely that Pao replicate differences (within-batches and between-batches) are higher than Pa replicate differences as a result of the greater dilution of these samples. Not only are colorimetric errors magnified solely as a function of the arithmetic (five to ten-fold), but the process of dilution itself must add imprecision.

Between-batch differences must almost certainly be higher than within-batch differences, but the evidence available cannot provide an accurate assessment of the differences arising at this stage. In the author's view, a judgement as to the significance of individual sample values must be based on a consideration of the data from all stages of replication. On this basis, it seems probable that differences in Pao sample values greater than about 2 0 mg kg^{-1}Fe will usually reflect real differences in the sampled horizons - though one must be aware that, in some cases, even larger differences may be due solely to imprecision of observation. For Pa values, the analogous threshold may lie nearer 5 mg kg^{-1}Fe and when the samples being compared have been processed and analysed in a single batch, even this threshold may exaggerate the level of imprecision. Po values derived by calculation from the Pao and Pa values must be less precise than the Pao values.

One may conclude that the sampling, sub-sampling, preparation of samples and analytical procedures used in these studies are capable of indicating the amounts of soil phosphorus fractions present in the land sampled with as much precision as can reasonably be achieved during routine analysis of large numbers of samples (see Kaila's comments (1962) on the precision of these type of analyses).

In addition to general studies of replication, the effect on sample values of specific parts of the process of field and laboratory sampling and analysis have been studied; the effects of prolonged storage in field condition have been considered above and a small-scale check on the effects of storage in OD condition was also undertaken.

Replicate analysis of oven-dry ground fine earth samples after two years storage in self-sealing polythene bags in the laboratory - Table A5.10

An increase or decrease in Po (due to immobilisation or mineralisation) are the most probable changes in soil phosphorus during long storage of soil samples. Measurement of Po itself is, however, unlikely to reveal such changes clearly due to the low precision of such measurements. Instead, changes in the more precisely determined Pa fraction, which can be expected to vary inversely with changes in Po, can be used as a proxy. Increases in Pa should indicate nett mineralisation of Po; decreases in Pa should indicate nett immobilisation. Five highly organic surface samples, which could be expected to be affected most seriously by such processes were, therefore, re-analysed for Pa after an interval of two years.

Type	Absorbance		Absorbance-Blank		D	D	mg Pa kg^{-1} Fe ≠		D
	1st	2nd	1st	2nd	Absorbance	Abs.-Blank	1st	2nd	
Oh	.2160	.2110	.2085	.2059	-.0050	-.0026	174.67	176.29	+2.00
Oh	.1840	.1827	.1765	.1776	-.0013	+.0011	147.86	152.06	+4.20
Ah	.1285	.1340	.1210	.1289	+.0055	+.0079	101.37	110.37	+9.00
Ah	.1025	.1040	.0950	.0989	+.0015	+.0039	79.59	84.68	+5.09
Ah	.1250	.1285	.1175	.1234	+.0035	+.0059	98.44	105.66	+7.20
Means	.15204	.15120	.14694	.14370	+.00084	+.00324	120.386	125.812	+5.426

+.00084 is equivalent to 0.70 mg kg^{-1} Fe (1st standards)
or 0.72 " " " (2nd standards)
+.00324 is equivalent to 2.71 " " " (1st standards)
or 2.77 " " " (2nd standards)

Table A5.10

≠ calculated using standards run with each batch.

This data set suggests that little change occurs during long storage in an OD condition. Although several samples did give higher absorbance values in the second analysis, even the mean increase in Pa (expressed as mg kg^{-1}Fe, which, due to slight between-batch differences in standards' absorbance, may exaggerate differences in samples) is hardly greater than might occur as a result of imprecision. In only two samples (both Ah horizon) is it possible to argue that some mineralisation of Po has probably occurred. Certainly, variation in the length of OD storage is unlikely to be more than a very minor source of variability in sample values.

Changes in field sampling procedures at the end of the first season of fieldwork (see 3.3.1) might have led to some differences in the estimated P contents of B horizons and thus whole profile estimates. The sampling program in zone C, where similar numbers of profiles were sampled in each year provides the best opportunity available to check on this potential source of error and bias.

Assessment of the effects of changes in field sampling procedures in zone C - Table A5.11

In 1978 seven profiles were sampled to augment the ten examined in the previous year; of these seventeen profiles, four exhibited unusual features, which are discussed in sections 5.2.2.1 and 5.4.2, and will not be considered here. The total weight of Pao (g m^{-2} to a depth of 40 cm below the mineral soil surface) in the remaining thirteen profiles is tabulated below; the groupings used here were selected to reveal significant error or bias, if it was present. In all cases, the values have been calculated as if the lowest B horizon sample had sampled the profile to exactly 40 cm depth. In most cases, the true sampling depth lay within 2 cm of the depth used in calculation, but in two cases a depth of only 31 cm was sampled due to the abundance of stone.

Profile Group	n	$\bar{x}$	SD	SE	CV	Range
All profiles	13	159.39	15.38	4.27	9.65	131.75 - 181.83
1977 profiles	9	159.50	16.73	5.58	10.49	131.75 - 181.83
1978 profiles	4	159.14	14.13	7.07	8.88	145.54 - 172.49
Profiles sampled to 40 cm	5	160.62	12.68	5.67	7.89	145.54 - 172.4
profiles sampled to depths other than 40 cm	8	158.61	17.66	6.24	11.13	131.75 - 181.83
Sub-zones and groups within zone C (see Fig. 5.1)						
North Field (stagnopodzols)	7	157.66	17.01	6.43	10.79	131.75 - 178.59
North Lobe (brown podzolic soils)	6	161.40	14.54	5.94	9.01	145.11 - 181.83
Profiles sampled to 40 cm:						
North Field	2	157.83	17.37	12.2 8	11.01	145.54 - 170.11
North Lobe	3	162.49	12.55	7.25	7.72	148.40 - 172.49
Profiles sampled to depths other than 40 cm:						
North Field	5	157.60	18.94	8.47	12 .02	131.75 - 178.59
North Lobe	3	160.30	19.16	11.06	11.95	145.11 - 181.83
North Field profiles						
Groups A	4	160.05	16.87	8.44	10.54	145.54 - 178.59
B	3	154.48	20.37	11.76	13.19	131.75 - 154.48

The wider implications and meaning of the tabulated profile values are discussed in section 5.4.2. The main points to note here are: 1) the virtually identical mean values for 1977 and 1978 profiles, and for profiles sampled to 40 cm and those sampled to other depths; 2) the similarity in the differences between the mean values for the North Field and the North Lobe profiles, whether the mean value is based on profiles sampled to 40 cm, to other depths, or uses the entire set of profiles. Even the small subsets of profiles in the North Field (Groups A and B) produce mean values that differ insignificantly from the larger sample sets. These data demonstrate that neither 'year of sampling' nor 'depth sampled' can be regarded as factors which may have introduced significant errors; in particular, the adoption of a standard sampling depth in 1978 has not resulted in any bias which would affect, indeed invalidate, comparison between the soil in the North Field and that in the North Lobe.

Although there is no evidence that estimates of the Pao fraction in the soils of zone C have been affected either by the sampling change or by a change in laboratories, which occurred immediately prior to the processing of the 1978 samples, there is evidence that the oven-drying of the 1978 samples was not identical to that of the 1977 samples, and that, in conse uence, the proportions of Pa and Po in the 1978 samples was systematically altered as a result of extra mineralisation of Po during oven-drying. The data which suggested to the author that this might have occurred is listed in Table A5.12. Whereas a very small change in the proportion of Po and Pa in surface soils might be expected to occur as a result of seasonal and inter-annual changes in moisture and temperature (but **note** that all these samples were recovered in mid-summer - mid-July 1977 and early August 1978), changes of this order of magnitude, extending deep into the profile seem unlikely to represent real differences in the sampled materials at the time of their recovery.

At the outset of laboratory work, it had been recognised that Pa values would very likely be affected by any form of sample drying and that oven-drying, in particular, might increase Pa values at the expense of the Po fraction. For practical reasons, oven-drying of all samples was nevertheless adopted (in part because air-drying posed greater problems of sample equivalence). It was accepted that, in consequence, the Pa va lues would be, to some extent, an artifact of the process of analysis. The data in Table A5.12 prompted investigation of the extent to which the standard oven-drying (24 h at 105° C) had affected sample values.

Assessment of the effects of various drying procedures on the results of subsequent phosphorus analyses

Two experiments were run; in the first, separate ground fine earth sub-samples of a single oven-dried (24 h at 105° C) fine earth sub-sample were used (to hold sub-sampling 'error' to a minimum); in the second, fresh sub-samples were each drawn separately from a (wet) field bulk sample. Precise details of samples, the experimental conditions and the results of subsequent analyses appear in Table A5.13. Prolongation of the oven-drying period was included in the experiments to establish whether longer oven-drying could be substituted for the prior air-drying of samples that had been adopted as a standard procedure.

Table A5.12 Zone C: Po values expressed as a percentage of Pao values in soil samples recovered in 1977 and 1978.

North Lobe (Brown podzolic soils)

1977 profiles: GSP 3	SP 2	SP 3	SP 4	SP 1		1978 profiles: SP 34	SP 31	SP 32	House in North Lobe: SP 33
									58.8≠
82.4	81.1	83.4	82.3	81.7	Ah$_1$	76.5≠	76.7≠	74.0≠	75.3≠
		(82.2 ± 0.9)					(75.7 ± 1.5)		82.0≠
	87.1	88.5	87.3	84.8	Ah$_2$	82.1≠	78.9≠	79.8≠	
		(86.9 ± 1.5)					(80.3 ± 1.7)		
83.0					A/B				
	77.2	88.9	90.2	67.1	B$_1$	71.4	82.8≠	78.5≠	68.3
B 56.4		(85.4 ± 7.2)					(80.7 ± 3.0)		
	62.5	74.7	73.1	57.8	B$_2$	34.4	68.2≠	59.9≠	51.3
		(66.7 ± 8.7)					(64.1 ± 5.9)		
54.2					BCux				

North Field (Stagnopodzols)

	1978 profiles: SP 35	SP 36	S 37	1977 profiles: SP 7	SP 8	GSP 2	SP 6	SP 5
Oh	65.9≠	64.9≠	65.2≠	76.7	75.0	72.1	77.1	78.4
		(65.5 ± 0.7)				(75.9 ± 2.4)		
Ah/E	76.7≠	78.2≠	82.0≠	86.8	87.8	83.9(2)	86.9	87.3
		(79.0 ± 2.7)				(86.5 ± 1.5)		
E							89.9	92.0
								91.3
Bir	79.9≠	82.0≠	78.8≠	88.4	86.2	83.7	89.8	79.9
		(80.2 ± 1.6)				(85.6 ± 3.9)		
B$_1$	84.0≠	84.0≠	83.1≠	88.3	91.1		83.7	76.6
	(83.8 ± 0.3)		(83.4)			(85.6 ± 5.7)		88.4
			(84.8)			B 82.5		
B$_2$	75.3	71.2	83.4	81.4	82.0		79.0	59.1
			68.7				80.1	
		(74.7 ± 6.4)				(76.3 ± 9.7)		
BCux						44.2		

Summary of apparent reduction in Po percentage values in 1978 samples compared with 1977 samples

	North Lobe		North Field
Ah$_1$	6.5	Oh	10.4
Ah$_2$	6.6	Ah/E	7.5
B$_1$	4.7	Bir	5.4
B$_2$	2.6	B$_2$	No clear evidence of difference

(1) Figures in brackets indicate group $\bar{x}$ and SD.

(2) HM79Q, Ah/E horizon, sampled in 1979 from a profile close to GSP 2, also had a mean value of 83.9

≠ samples affected by data adjustment discussed in text.

Table A5. 13 Sample drying and its effects on the results of subsequent phosphorus analysis[4]

Samples	Field Bulk Sample: Fe 1: G Fe 1 Anal. 1[1]	G Fe 1 Anal. 2	G Fe 2 Anal. 3	G Fe 3 Anal. 4	G Fe 4 Anal. 5	G Fe 5 Anal. 6	G Fe 6 Anal. 7	Fe 2 G Fe 7 Anal. 8	Fe 3 G Fe 8 Anal. 9	Mean Anal. 8 and 9	Fe 4 G Fe 9 Anal. 10	Fe 5 G Fe 10 Anal. 11	Fe 6 G Fe 11 Anal. 12	Mean of all Analyses	Mean of 'standard' analyses 1, 2, 3, 10
SP6 (2) Pao	272.03		275.58	288.48	275.88	268.25	268.95							274.86	273.81
Pa	33.93	37.20	39.64	44.52	46.92	46.61	49.53							n = 6	n = 2
Pa as a % of Pao	12.47		14.38	15.43	17.03	17.38	18.42							SD 7.40 SE 3.02	36.92 n = 3 13.48
SP 8 (2) Pao	255.83		246.62	236.51	233.02	242.09	230.93	249.50	283.60	266.55	232.67	268.93	261.59	249 .21	257.13
Pa	26.39	30.14	33.75	36.71	38.20	39.20	41.03	15.11	17.57	16.34	24.60	36.69	37.81	n = 11	n = 3
Pa as a % of Pao	10.32		13.69	15.52	16.39	16.19	17.77	6.06	6.20	6.13	10.57	13.64	14.45	SD 16.90 SE 5.10	31.74 n = 4 12.34
SP5 (2) Pao	354.38							358.93	372.74	365.84	345.12	351.81	344.90	354.65	353.10
Pa	43.06	44.05						28.14	28. 32	28.23	34.71	42.73	45.32	SD 10.39 SE 4.24	n = 2 43.28
Pa as a % of Pao	12.15							7.84	7.60	7.72	10.06	12.15	13.14		n = 3 12.26
Initial drying	24 hours at 105° C							2 weeks air-drying							
Additional drying	None				24 h at 105° C		48 h at 105° C	None			24 h at 80° C	24 h at 105° C	48 h at 105° C		
Re-wetting (2)					RW		RW								
Storage before analysing: Wet	2 - 3 months							2 years							
Storage before analysing: OD	1 month	2 years (3)						Analyses 8 - 12 performed immediately after completion of drying							

(1) Initial routine analyses, all other analyses two years later.

(2) Samples re-wetted with distilled water prior to additional drying.

(3) Two years storage of OD fine earth. Analyses 4 - 7 performed 1 week after additional drying/re-wetting.

(4) All results in mg kg^{-1} Fe expressed on an oven-dry basis.

Fe = Fine earth sub-sample

GFe = Ground fine earth sub-sample

Anal = Analytical sub-sample

The main conclusions reached from an examination of this data are::

1) any form of oven-drying will increase the values of Pa beyond those which would have been recorded if the samples had been air dried. In some cases, more than twice as much Pa was extracted from OD samples than from AD samples. It is probable that even less Pa would be extracted from samples analysed in the field condition. Oven-drying at lower temperatures reduces the increase in Pa but the values remain significantly higher than those recorded for AD samples. The differences between AD samples, samples dried at 80° C and those dried at 105° C suggest that Pa values might increase still further if higher temperatures were used.

2) Since samples that had been re-wetted prior to additional oven-drying showed greater increases in Pa, it seems possible that the initial moisture state of even a fresh sample could affect the size of the increase in Pa caused by subsequent oven-drying.

3) Longer periods of drying clearly lead to even greater increases in Pa, though, particularly on the fresh samples which had been air-dried before oven-drying, the extra amount of Pa after 48 h instead of 24 h of oven-drying was not substantial.

4) The absence of any clear trends among the Pao values indicate that this fraction is not significantly affected by alterations in drying procedures of the type tested. If this is correct, these same values can be regarded as merely sample replicates, which provide further evidence for the level of precision achieved in these studies. Another implication of this conclusion is that the change in Pa values must be at the expense of the Po fraction.

More generally, conclusions 2 and 3 support the practice, which had already been adopted, of bringing all samples to a similar moisture level prior to oven-drying and argue against the adoption of lengthier oven-drying. One may note also that lengthy storage in field condition seems to have had little effect on these samples, but that storage in OD condition may have led to a small increase in Pa.

Finally, it is evident from conclusions 1 and 4 that the significance of Pa (and thus Po) values for samples that have been dried prior to analysis requires further investigation. Both the data provided by previous studies and that presented in chapter 5, leave little doubt that the Pa - Po division of soil phosphorus is more than a mere artifact of analytical procedures, but it is probable that any form of sample drying reduces the apparent amount of Po, probably most markedly in samples from organic-rich surface soils.

Adjustment of Pa and Po values for profiles in zone C

The differences in the proportion of Po in the 1977 and 1978 samples from this zone (listed in Table A5.12) are in many cases greater than those induced in the experiments described above; they are also remarkably systematic. Both features suggest that minor differences in moisture content prior to oven-drying are unlikely to be responsible for this pattern of sample values. Since all samples were oven-dried using the same standard procedures (24 h at 105° C), there seem to be only three possible explanations. First, it is possible that the pattern is 'real', and reflects changes in the sampled soils; this seems extremely unlikely, especially in view of the analysis of a sample taken in 1979, which had precisely the same proportion of Po as had been recorded for a 1977 sample from a profile lying less than 4m from the new sampling point. Secondly, it may be that the (new) oven used to dry the 1978 samples, although set at the same temperature, did not in fact dry these samples at the desired temperature or, thirdly, produced drying conditions that differed in some other manner from those used in 1977. No other sample set available from other areas provides a clear indication of the sort of problem encountered with the zone C samples, but it is also true that no other area provides such a clear set of comparable samples in a small area. However, differences of the magnitude evident in zone C do not occur between the 1977 and later samples in other areas. It is also the case that the 1978 samples from zone C were the first samples to be dried in the new oven.

Taking all of this into consideration, the author concluded that the most probable cause of the higher Pa values in the 1978 samples from zone C was oven-drying at a temperature higher than that indicated by the oven control mechanisms. Unfortunately this hypothesis was not specifically tested in the experimental work described above and time forbade further investigation. In all later oven-drying, temperatures were checked with an independent (mercury) thermometer.

Although a definite cause has not been established, the author felt that it was necessary to find some way to adjust the measured sample values so that subsequent calculations used to assess the soils in zone C should not be biased by an artificial element of variability. A very simple procedure was used; all 1978 sample values for Po, which showed clear evidence of having been affected, were raised by an amount equal to the difference between the mean values of Po (%) for the 1977 and 1978 samples from the particular horizon. Thus, for example, the percentage values of Po in the Ah_1 horizon samples from profiles SP 31, 32 and 34 (see Table A5.12) were raised by 6.5% (SP ¯4 from 76.5 to 83.0%, SP 31 from 76.7 to 83.2% and so on). In doing this, the original sample variability is preserved but the marked difference between 1977 and 1978 samples is eliminated. The samples affected by these adjustments are indicated on Table A5.12.

Some profiles close to a prehistoric house in the North Lobe (SP1 and SP34) contained abnormally high quantities of Pa in the B horizons (as did the house itself - SP 33). Since these samples differed so substantially from all others, there was no way of determining the extent to which these samples had been affected and no adjustment was possible. Although the samples from the lower B horizons in the North Field may have been very slightly affected, the variability in values is so great that adjustment seems unjustified and would in any case have made very little difference to the values used.

It must be stressed that these adjustments to the measured sample values in no way affect Pao values for samples; the procedure takes the Pao value as a 'constant' and simply adjusts the Pa and Po values such that they conform more closely to the pattern found among the 1977 samples. Even the differences between 1978 samples in respect of the Pa - Po relationship are preserved.

TABLES for Chapter 5

Table 5.1 Particle size characteristics of soil samples from the medieval palaeosol and its overburden (HM78B, HM79B) and a nearby (HM79Q) profile (particle sizes in mm).

	% of fine earth (soil < 2.00) in size category indicated.						% of soil < 8.0	% of soil
	< 0.002	0.002/0.063	0.063/2.0	0.063/0.25	0.25/0.5	0.5/2.0	2.0/8.0	> 2.0
	Hydrometer			Dry Sieving				
Overburden profile								
1. Ah_1	6.7	34.2	59.1 (53.2)[(1)]	12.2	14.5	26.5	17.70	19.27
2. Ah_2	4.2	44.1	51.7 (46.0)	10.8	12.0	23.2	17.32	20.70
3. A/B	ND	ND	ND	ND	ND	ND	23.33	28.58
Redeposited make-up of overburden								
4. Oh-Ah	4.2	47.9	47.9 (39.8)	10.8	12.0	17.0	6.79	7.26
5. BS_2	10.0	37.9	52.1 (46.0)	10.2	13.0	22.8	17.02	30.50
6. Ah/E	6.7	43.7	49.6 (43.2)	10.2	13.3	19.7	5.94	7.05
Buried Palaeosol (1978 samples)								
7. Oh-Ah	5.8	48.8	45.4 (38.5)	12.2	10.7	15.7	3.55	3.55
8. Ah/E	11.7	43.7	44.6 (37.3)	8.3	9.7	19.3	7.10	11.94
9. BS_1	10.8	42.5	46.7 (32.8)	8.3	9.7	14.8	8.59	9.54
10. BS_2	6.7	41.2	52.1 (47.2)	10.8	13.0	23.3	18.94	23.22
11. BCux	5.0	39.2	55.8 (55.0)	16.3	15.2	23.5	14.95	21.98

(cont)

Table 5.1 (cont'd)

	% of fine earth (soil < 2.00) in size category indicated.						% of soil < 8.0	% of soil
	< 0.002	0.002/0.063	0.063/2.0	0.063/0.25	0.25/0.5	0.5/2.0	2.0/8.0	> 2.0
		Hydrometer			dry sieving			
Buried Palaeosol (1979 samples)								
Ah/E Upper	4.2	46.7	49.1 (45.2)	10.8	10.0	24.3	12.63	19.16
Lower	12.5	40.8	46.7 (41.2)	10.2	11.0	20.0	12.26	14.21
HM79Q								
Ah/E Upper	5.0	39.2	55.8 (49.5)	11.2	12.8	25.5	12.78	12.78
Lower	11.7	37.5	50.8 (45.7)	9.8	12.2	23.7	12.72	15.34

(1) Figures in ( ) represent Σ of sieved sand-fractions.

Table 5.2 Measured and predicted soil bulk density and loss-on-ignition values in Ah/E horizon samples from the medieval palaeosol (HM79B) and a nearby stagnopodzol (HM79Q).

	Contemporary Iron Pan Stagnopodzol			Buried Stagnopodzol	
	Measured soil bulk density (gcm^{-3})		LOI (%)	Measured soil bulk density (gcm^{-3})	LOI (%)
Ah/E horizon					
(a) Upper sample	1.1331		10.52	1.1185	8.23
(b) Lower sample	1.0284		11.36	1.0068	8.46
(c) Whole horizon calculated(1)	1.0866		10.86	1.0748	8.30
Predicted(2)	1.1080			1.2004	
difference	- 0.0214	lower than predicted		- 0.1256 lower than predicted	
	= 1.97% of calculated SBD			= 11.69% of calculated SBD	

(1) SBD and LOI calculated from values recorded for both samples, taking into account the variation in thickness of sampled layers.

(2) SBD predicted from the calculated whole horizon LOI value based on two samples, using the Ah/E regression equation for SBD/LOI (see Table 3.5, section 3.3.2)

Table 5.3 Measured and predicted soil bulk density in B horizon samples from the medieval palaeosol (HM78B)

HM78B

	Measured SBD	LOI (%)	Predicted[1] SBD	Difference
B_1	0.8711	8.92	1.0708	0.1997
B_2	1.0764	6.66	1.1595	0.0831
			$\bar{x}$ Difference	0.1414 lower than predicted

Table 5.4 Measured and predicted soil bulk density in an Oh-Ah horizon sample from the medieval palaeosol (HM79B)

HM79B

	Measured SBD	LOI (%)	Predicted[1] SBD	Difference
Oh-Ah	0.7405	26.07	0.7087	0.0318 higher than predicted

(1) SBD predicted from the LOI value using the appropriate regression equation for SBD/LOI (see Table 3.5, Section 3.3.2)

Table 5.5 Models of the initial state of the buried Oh-Ah horizon in the medieval palaeosol.

	Buried Oh-Ah Horizon - HM78/9 B		1a	1b	2a	2b	Oh horizon in North Field stagnopodzols
	measured values	adjusted to allow for compression	assumes loss of 29.66 % of initial quantity of organic matter (i.e. similar to loss in Ah/E)		assumes loss of 45.00% of initial quantity of organic matter		Group A $\bar{x}$ values (n = 4)
LOI $mgcm^{-3}$	192.000	184.751	204.389	215.050	216.271	225.466	232.922
LOI kgm^{-2}	12.480	-	17.742		22.691		27.988
IFe kgm^{-2}	35.393	-	35.393	28.428	35.393	28.428	28.428
Fe kgm^{-2}	47.873		53.135	46.170	58.084	51.119	56.415
LOI %	26.07	-	33.39	38.43	39.07	44.40	49.56
Soil bulk density gcm^{-3}	0.7405	-	-	-	-	-	0.4701
Predicted soil bulk density gcm^{-3}	0.7087	-	0.6121	0.5596	0.5536	0.5079	0.4705
Thickness cm	6.5	6.76	8.68	8.25	10.49	10.06	12 (excluding L & F)
Loss of organic matter after burial							
kgm^{-2}	-	-	5.262		10.211		-
$mgcm^{-3}$ incorporates allowance for compression	-	-	19.638	30.299	31.520	40.715	-
			Assumes IFe content similar to present buried soils	Assumes IFe content similar to present surface soils	Assumes IFe content similar to present buried soils	Assumes IFe content similar to present surface soils	

Table 5.6 Summary of quantitative estimates of organic matter changes in the medieval palaeosol[1]

Horizon	Stagnopodzols Zone C, group A $\bar{x}$ values (n = 4)	Palaeosol prior to burial	Palaeosol at time of sampling (2)	Estimated nett post-burial losses (3)	Difference between stagnopodzols and palaeosol at time of sampling
			kg LOI m^{-2}		
Oh or Oh-Ah	27.99	17.74	12.48	5.26	15.51
Thickness cm	12	8.25	6.5 (6.76)	(29.7%)	
Ah/E	8.25	12.44	8.75	3.69	0.51
Thickness cm	7.5	11.5	11.5	(29.7%)	
B (to 40 cm)	20.80	18.24	17.80	0.44	3.00
Thickness cm	32.5	28.5	28.5	(2.4%)	
Mineral soil	29.05 (4)	30.68	26.55	4.13 (13.5%)	2.50
Whole profile	57.03	48.43	39.03	9.40	18.00
Thickness cm	52	48.25	46.5 (46.76)	(19.4%)	
			mg LOI cm^{-3}		
Oh or Oh-Ah	232.9	215.1	192.0 (184.8)	23.1 (30.3)	40.9
Ah/E	108.2	108.2	76.1	32.1	32.1
B (to 40 cm)	64.0	64.0	62.4	1.6	1.6
Mineral soil	72.6	76.7	66.4	10.3	6.2
Whole profile	109.7	100.4	83.9	16.4	25.7
			LOI %		
Oh Oh-Ah	49.6	38.4	26.1	ND	ND
Ah/E	11.2	11.2	8.3	ND	ND
B (to 40 cm)	ND	ND	ND	ND	ND
Mineral soil	8.2	8.7	7.6	ND	ND
Whole profile	13.8	11.9	9.8	ND	ND

(1) All calculations to 40 cm below mineral soil surface.

(2) Figures in brackets make an allowance for compression.

(3) Figures in brackets indicate loss of organic matter as a percentage of initial amound of organic matter.

(4) Note that $\bar{x}$ for all zone C stagnopodzols (n = 8) was 30.27 kgm^{-2}.

Table 5.7 The fractional composition of phosphorus in the mineral horizons of the medieval palaeosol and nearby stagnopodzols[1]

P Fraction	Medieval Palaeosol	Difference between medieval palaeosol and Pt profiles	Pt profiles (n = 2)	Pao profiles (n = 4)
Pt	176.4	+ 4.1	172.4	ND
Pao	137.8	+ 16.2	121.6	122.0
Pf	38.6	- 12.2	50.8	ND
Pa	30.9	+ 11.3	19.6	20.6
Pi	69.5	- 0.8	70.3	ND
Po	106.9	+ 4.9	102.0	101.4

(1) All values in gPm^{-2} calculated to a depth of 40 cm below the mineral soil surface.

Table 5.8 The fractional composition of phosphorus in BCux samples from the medieval palaeosol and a nearby stagnopodzol

	Pt	Pi	Pa	Pf	Po
HM 78/79B medieval palaeosol					
$mgP\ kg^{-1}$ IFe	493	413	166	247	80
% Pt		83.7	33.7	50.0	
% Pi			40.3	59.7	
GSP2 iron-pan stagnopodzol					
$mgP\ kg^{-1}$ IFe	484	385	125	260	99
% Pt		79.5	25.8	53.7	
% Pi			32.5	67.5	

Table 5.9 Particle size characteristics of soil samples from the prehistoric palaeosol and its overburden (HM77F6) and from adjacent (HM77F5) and nearby (HM77F11) profiles (particle sizes in mm).

Horizon and sample	% of fine earth (soil <2.00) in size category indicated						% of soil <8.0	% of soil
	<0.002	0.002/0.063	0.063/2.00	0.063/0.250	0.250/0.500	0.500/2.00	2.00/8.00	>2.0
		Hydrometer			dry sieving			
HM77F6 Overburden								
1. Oh	ND	ND	ND	ND	ND	ND	ND	ND
2. Ah/E	2.5	30.8	66.7 (60.0)(1)	11.5	11.2	37.3	15.22	16.66
3. E_1	3.3	35.0	61.7 (53.8)	8.7	10.7	34.5	14.69	24.48
4. E_2	3.3	34.2	62.5 (54.2)	9.3	11.3	33.5	12.39	13.37
Buried Palaeosol								
5c. bAh (or Bhs)	5.0	30.8	64.2 (64.2)	17.3	11.0	35.8	10.53	11.90
7. bAB (or Bs(h))	1.7	34.6	63.7 (57.7)	17.3	9.8	30.5	17.27	19.31
8. Bs	5.0	45.8	49.2 (50.2)	17.0	7.5	25.7	19.21	31.55
9L. BCux	1.7	34.2	64.2 (61.5)	19.2	12.5	29.8	21.58	33.73
5. bAh (2nd sample)	4.2	30.4	65.4 (60.3)	12.8	9.2	38.3	11.03	20.18

(cont)

Table 5.9 (cont'd).

Horizon and sample	% of fine earth (soil <2.00) in size category indicated						% of soil <8.0	% of soil
	<0.002	0.002/0,063	0.063/2.00	0.063/0.250	0.250/0.500	0.500/2.00	2.00/8.00	>2.0
		Hydrometer			dry sieving			
HM77F5 Adjacent Iron-Pan stagnopodzol								
1. Oh	ND	ND	ND	ND	ND	ND	ND	ND
2. Ah/E	1.7	35.8	62.5 (54.8)	12.5	12.2	30.2	11.79	11.79
3. E	5.0	44.6	50.4 (44.0)	12.3	8.3	23.3	11.23	11.23
6. Bs_1	8.3	52.5	39.2 (39.8)	13.3	6.8	19.7	15.66	24.85
8. Bs_2	5.0	41.7	53.3 (47.3)	12.3	8.0	27.0	23.24	35.45
9L. BCux	2.5	32.1	65.4 (60.5)	15.2	11.8	33.5	25.94	38.25
HM77F 11 Iron-pan Stagnopodzol in sub-zone B								
1. Oh	ND	ND	ND	ND	ND	ND	ND	ND
2. Ah/E	1.7	32.5	65.8 (57.5)	13.5	10.0	34.0	11.24	12.14
3. Bhs (g)	10.0	35.8	54.2 (49.7)	10.7	11.3	27.7	15.88	32.37
4. Bs (g)	8.3	38.3	53.3 (49.8)	12.2	11.3	26.3	19.49	27.12
7. BCux	3.3	26.7	70.0 (66.8)	12.5	12.3	42.0	36.77	50.35

(1) Figures in ( ) represent Σ of sieved sand fractions.

Table 5.10 Concentration of organic matter in Bh and Bhs horizons of selected stagnopodzol profiles in zone A.

Sub zone	Profile	$mgLOIcm^{-3}$
A	SP26	94.2
B	SP27	89.7
C	C 3	114.1
D	SP23	111.1
E	GSP6	106.9
F	SP12	112.8
G	GSP4	115.9

Table 5.11 Organic matter content of the prehistoric palaeosol, its overburden and other profiles on Holne Moor[(1)].

Profile	$kgLOI\ m^{-2}$	LOI %
HM77F6		
Overburden	33.59	7.75
Palaeosol	27.89	8.61
Σ	61.48	8.12
HM77F5		
Adjacent stagnopodzol	44.49	11.12
Zone A, sub-zone B		
Stagnopodzols $\bar{x}$ (n = 5)	52.86	13.05
HM78B		
Overburden	32.36	10.42
Palaeosol	39.03	9.80
Σ	71.29	10.07
Zone C - North Field, Group A		
Stagnopodzols $\bar{x}$ (n = 4)	57.03	13.82
- North Lobe		
Humic Brown Podzolic soils $\bar{x}$ (n = 6)	32.98	9.82

(1) All calculations to standard depth of 40 cm below the mineral soil surface.

Table 5.12 Phosphorus and organic matter characteristics of the buried surface horizon of the prehistoric palaeosol and of contemporary Bh and Ah horizons in zones A and C

Profile and Horizon		Phosphorus (mg kg^{-1} Fe)					LOI		Po
	Pt	Pao	Pf	Pa	Pi	Po	%	mg cm^{-3}	(mg kg^{-1} LOI)
HM77F6 - buried soil bAh or Bhs 5	495	429	66	49	115	380	12.87	94.32	2953
5c	610	460	150	96	246	364	10.96	104.95	3321
Bh horizons in stagnopodzols (S - I series)									
SP 12	ND	458	ND	37	ND	421	15.66	112.77	2688
S14	ND	439	ND	60	ND	379	13.17	101.44	2878
SP 18	ND	431	ND	93	ND	338	11.59	88.39	2916
SP 23	ND	491	ND	122	ND	369	14.55	111.13	2536
SP 26	ND	489	ND	133	ND	356	12.09	94.21	2945
Ah horizons in humic brown podzolic soils (S - IV)									
SP 31	ND	395	ND	66	ND	329	9.31	87.84	3538
SP 4	580	451	129	80	209	371	12.41	113.29	2992
SP 32	ND	546	ND	106	ND	440	10.35	97.87	4272
SP 3	ND	595	ND	99	ND	496	13.98	126.17	3543
SP 2	ND	736	ND	139	ND	597	15.8	133.57	3778
GSP 3	945	740	205	130	335	610	15.71	129.28	3885

Table 5.13 Whole profile values for Pt and Pao in the prehistoric palaeosol, its overburden and nearby soils.(1)

	Pt		Pao	
	mgkgIFe	gm^{-2}	mgkgIFe	gm^{-2}
HM77F6				
Overburden	369	147.5	250	100.1
Buried soil	625	185.1	441	130.5
HM77F5				
Stagnopodzol	627	223.1	451	160.5
Zone A soils				
Sub-zone B $\bar{x}$ and SD (n = 5)	ND	ND	420 ± 32	148.0 ± 3.7
Sub-zone F $\bar{x}$ and SD (n = 6)	ND	ND	379 ± 40	137.3 ± 11.2

(1) All calculations to standard depth of 40 cm below mineral soil surface.

Table 5.14 Estimates of changes in the phosphorus content of the prehistoric palaeosol its overburden and adjacent soils.[1]

Profile	Now	A[2]	Change	B[3]	Change
HM77F 5					
Stagnopodzol	160.477 (451.3)	140.078	+ 20.399	154.872	+ 5.605
HM77F 6					
Overburden	100.053 (250.3)	157.447	− 57.394 (loss rate: 0.191 kg $ha^{-1}year^{-1}$)	174.075	− 74.022 (loss rate: 0.247 kg $ha^{-1}year^{-1}$)
Buried soil	130.519 (440.7)	116.648	+ 13.871	128.968	+ 1.551
			nett change − 43.523 (loss rate: 0.145 kg ha^{-1} year)		nett change − 72.471 (loss rate: 0.242 kg $ha^{-1}year^{-1}$)

(1) Values are for the Pao fraction − gm^{-2} and (in brackets) mg kg^{-1}IFe; all calculations assume no change in content of ignited fine earth in profiles.

(2) A: assumes initial concentration value of 393.9 mg kg IFe (= estimated value in subzone F − see text.)

(3) B: assumes initial concentration value of 435.5 mg kg IFe (= estimated value in subzone B − see text.)

Table 5.15 Weight of ignited fine earth[1] in the prehistoric palaeosol and other soils on Holne Moor.

HM77F6		
Palaeosol	296.14	
Zone C Humic Brown Podzolic soils		
North Lobe	$\bar{x}$ 300.47	SD 8.32 (n = 8)
HM77F 5		
Stagnopodzol	355.62	
Zone A Stagnopodzols		
Sub-zone B	$\bar{x}$ 353.54	SD 21.97 (n = 5)
Sub-zone F	$\bar{x}$ 363.66	SD 18.86 (n = 6)

(1) kg m^{-2} to a depth of 40 cm below the mineral soil surface.

Table 5.16 The concentration of phosphorus in the soil organic matter fraction and the concentration of organic matter in individual horizons of the prehistoric palaeosol (HM77F6) and a nearby soil profile. (SP 29, zone A, sub-zone B).

HM77F6		Po	LOI	SP29	Po	LOI
		mg kg^{-1} LOI	mg cm^{-3}		mg kg^{-1} LOI	mg cm^{-3}
Oh		1629	181.90	Oh	1303	250.43
AhE		2732	73.25	Ah/E	2553	78.57
E_1		3442	47.99	Eg	3261	70.32
E_2		4125	34.04			
bAh-Bhs	5c	3321	104.95	Bhs	2943	86.72
	5	2953	94.34			
bA/B - Bs(h)		3290	87.90	Bs_1	2909	74.76
Bs		3410	51.22	Bs_2	2892	56.05
$BCux_1$		2829	47.46	$BCux_1$	ND	ND
$BCux_2$		1540	41.57	$BCux_2$	ND	ND

Table 5.17 Phosphorus and organic matter content of some B horizon samples from site F and from selected profiles in zone A.

	Profile Code number		LOI %	Pao	Pa $\mu g\ cm^{-3}$	Po
Site F	M1		18.29	437	45	392
	M2		22.65	365	62	303
Zone A	C3	sub-zone C	20.16	313	29	284
	GSP 4	sub-zone G	17.80	312	17	294
	SP 12	sub-zone F	15.66	330	27	303

Table 5.18 Phosphorus and organic matter content of Oh and Ah/E samples from profiles in zone A where two peat layers were identified and sampled.

Profile and samples(1)		Pao	Pa $\mu g\ cm^{-3}$	Po	LOI %
SP 26	1	401	62	339	55.03
	2	321	36	285	53.70
	3	244	13	231	7.28
SP 27	1	379	93	286	56.44
	2	326	39	286	35.69
	3	215	18	197	8.60
GSP 5	1	401	73	328	40.63
	2	354	58	295	26.35
	3	195	22	173	8.05
E 3	1	328	91	237	52.46
	2	304	59	245	34.25
	3	339	42	297	11.70
C 1	1	208	54	154	87.29
	2	193	34	160	33.64
	3	154	26	129	11.86

(1) 1 = Oh, 2 = Oh_2, 3 = AhE.

Table 5.19 Coefficients of correlation for linear regression analyses, PHA transect, zone A, subzone D [1]

AhE x	Oh y	n = 10		n = 8	statistical significance
Pa	Pao	0.83969	≠≠	0.93615	≠≠≠
Pao	Pao	0.63966	≠	0.95203	≠≠≠
Po	Pao	0.60314	NS	0.94136	≠≠≠
Pa	Po	0.72453	≠	0.85601	≠≠
Pao	Po	0.52387	NS	0.93667	≠≠≠
Po	Po	0.48997	NS	0.93410	≠≠≠
Pa	Pa	0.79473	≠≠	0.80310	≠
Pao	Pa	0.68469	≠	0.72227	≠
Po	Pa	0.65692	≠	0.70279	NS

(1) All phosphorus values used in these calculations were expressed as $\mu g\ P\ cm^{-3}$.

(2) NS = $P > .05$

≠ = $P < .05$

≠≠ = $P < .01$

≠≠≠ = $P < .001$

Table 5.20 Phosphorus and organic matter content of a profile (SP33) in a large prehistoric house in zone C[1]

	Thickness	Pao	Pa	Po	Po	LOI
		$\mu g cm^{-3}$			$mg\ kg^{-1}$ LOI	%
Litter	3.5	ND	ND	ND	ND	ND
Oh	2	422	130	292	1130	74.4
		(320)	(76)	(244)	(1046)	(49.6)
Ah/E	12.5	367	63	304	2454	14.1
		(245	(34)	(210)	(1935)	(11.3)
Ah/Bh	16	510	54	456	4212	15.1
(B_1)		(264)	(30)	(234)	(3705)	(7.0)
Bs_1	10	648	205	442	5578	10.2
(B_2)		(334)	(56)	(278)	(4333)	(7.6)
Bs_2	4	680	331	349	5174	9.2
(B_3)		(306)	(81)	(225)	(3813)	(6.5)

(1) Figures in brackets indicate $\bar{x}$ values for 4 stagnopodzol profiles in North Field (Group A).

(cont)

Table 5.20 (cont'd)

Total calculated to 40 cms below mineral soil surface	Pao	Pa $g\ m^{-2}$	Po	Pao $mg\ kg^{-1}$ IFe	$\frac{Po}{Pao}.100$	Po $mg\ kg^{-1}$ LOI
SP 33	211.0	44.6	166.3	772	78.8	3544
$\bar{x}$ of 4 stagnopodzol profiles in North Field (Group A)	160.0	29.6	130.5	451	81.6	2287
$\bar{x}$ of 6 Humic brown podzolic profiles in North Lobe	161.4	31.1	130.3	533	80.7	3954
Total to base of Ah/E horizon SP 33 (2 cm of peat and 12.6 cm mineral soil)	54.4	10.5	43.9	565	80.8	2123
$\bar{x}$ of 4 stagnopodzol profiles in North Field (Group A) (12 cms of peat and 7.5 cm m'reral soil)	56.8	11.6	45.2	611	79.6	1254

Table 5.21 Phosphorus and organic matter content of two humic brown podzolic soil profiles in zone C (North Lobe)(1)

	SP 34 6 m from house entrance						SP 1 16 m from house entrance					
	Pao	Pa	Po	Po	LOI	Thickness	Pao	Pa	Po	Po	LOI	Thickness
Horizon		$\mu g\ cm^{-3}$		$mg\ kg^{-1}$ LOI	%	cm		$\mu g\ cm^{-3}$		$mg\ kg^{-1}$ LOI	%	cm
Ah_1	591	101	490	5243	11.5	10	499 (511)	91 (92)	408 (420)	3931 (3668)	11.6 (12.8)	10
A/B	507	57	450	5835	9.7	11.5	385 (351)	58 (46)	327 (305)	4214 (3774)	9.8 (10.5)	10
B_1	611	175	436	5195	11.3	10	637 (410)	209 (62)	428 (349)	5252 (4546)	10.7 (9.6)	15
B_2	724	475	249	4417	6.0	8.5	572 (324)	241 (108)	331 (215)	5154 (3711)	7.8 (6.5)	15
					Pao $mg\ kg^{-1}$ IFe	$\frac{Po}{Pao}\cdot 100$		gm^{-2}			Pao $mg\ kg^{-1}$ IFe	$\frac{Po}{Pao}\cdot 100$
Total calculated to 40 cm below mineral soil	240.0	74.6	165.4	5275	814	68.9	212.5 (161.4)	58.4 (31.1)	154.1 (130.3)	4594 (3954)	732 (533)	72.5 80.7

(1) Figures in brackets indicate $\bar{x}$ values for 6 other Humic brown podzolic profiles in the North Lobe.

Table 5.22 Estimates of the level of phosphorus enrichment of a soil profile in a prehistoric house in zone C and in nearby profiles.(1)

Increase above $\bar{x}$ level of:	A(2) House SP 33	A(2) SP 34	A(2) SP 1	B(3) House SP 33	B(3) SP 34	B(3) SP 1
North Lobe Humic Brown Podzolic soils n = 6	49.6	78.6	51.1	65.2	82.7	57.8
North Field (Group A) Stagnopodzols n = 4	51.0	80.0	52.5	87.8	107.1	81.8
Sub-zone F (zone A)	73.7	102.8	75.3	107.5	128.3	102.6
Difference between North Lobe and North Field soils			1.3	24.9		
Difference between North Field and Sub-zone F soils			22.8	25.4		

(1) All estimates are expressed as gPao m^{-2} to a depth of 40 cm below the mineral soil surface.

(2) A = observed differences in gPao m^{-2} without allowance for differences in content of ignited fine earth.

(3) B = increases in gPao m^{-2} calculated from present profile weights of IFe, but assuming an initial concentration of Pao (mg kg^{-1} IFe) of either 378.6 (sub-zone F) or 450.5 (North Field) or 533.2 (North Lobe). see section 5.4.1 and Table 5.33 for a full description of methods of calculation.

Table 5.23 Phosphorus content of samples from the Oh and AhE horizons of soils within and adjacent to a stone row on Holne Moor.[1]

		ST Series		SRW and SRE series
		Outside Row		Inside Row
		n = 10	n = 5[2]	n = 12
Oh	$\bar{x}$	780.2	718.6	712.1
	SD	230.0	140.0	58.9
	SE	72.7	62.6	17.0
	CV	29.5	19.5	8.3
Ah/E	$\bar{x}$	230.1	244.8	223.8
	SD	68.8	79.9	43.4
	SE	21.8	35.7	12.5
	CV	29.9	32.6	19.4

(1) All phosphorus values are expressed as mgPaoKg^{-1}Fe

(2) Samples outside the stone row for which analyses of the B horizon are available.

Tablee 5.24 Weight of phosphorus in soil profiles on Holne Moor, Vag Hill and permanent pasture at Rowbrook farm[1]

	Brown Podzolic Soils					Podzol
	Holne Moor - Zone C[2]		Rowbrook Farm	Vag Hill		
	SP34	SP1	RF1	RV2	RV6	RV1
$gPao\ m^{-x}$	240.0	212.5	232.5	138.7	149.3	144.6
$mgPao\ kg^{-1}IFe$	814	732	776	513	622	622
$mgPokg^{-1}LOI$	5275	4594	5841	2942	3458	2861

(1) All values are calculated for complete profiles to a depth of 40 cm below the mineral soil surface.

(2) See section 5.2.2.1 and Table 5.21.

Table 5.25 Fractional composition of phosphorus in oven-dried samples of animal faeces from Holne Moor, Vag Hill and Rowbrook Farm (1)

Samples		Pao	Pa	Po	$\frac{Po}{Pao} \cdot 100$	LOI
		mg g^{-1} dry matter				%
	Horses					
XRFH	Rowbrook Farm	12.099	9.487	2.613	21.6	77.9
XRVH	Vag Hill	2.648	1.770	0.877	33.1	93.6
XHMH	Holne Moor 1	2.135	1.654	0.482	22.5	94.3
	Sheep (Scottish Blackface)					
XRFS	Rowbrook Farm	5.498	3.752	1.745	31.7	87.6
XRVS	Vag Hill	5.097	3.272	1.825	35.8	85.8
XHMS	Holne Moor 1	2.937	1.223	1.714	58.4	93.3
XMAS	Holne Moor 2	2.902	1.348	1.554	53.6	93.4
	Cattle (Galloway)					
XHMC	Holne Moor 1	3.125	1.365	1.760	56.3	93.4

(1) XRV samples taken from Vagg Hill, immediately west of Rowbrook Farm, XRF samples taken from Upper and Lower Western Fields at Rowbrook Farm, XHM samples taken from the Outer South Field on Holne Moor, XMA samples taken from the North Lobe on Holne Moor. All samples analysed were sub-samples from a composite bulk sample representing at least 5 separate faeces deposits, and were taken during July and August from freshly-deposited faeces.

Table 5.26 Phosphorus content of soil samples from Brake Field, Stoke Farm [1]

	GSP11	SP46	SP47	SP48	SP49
Ap_1	1539	1086	1457	1188	1013
	47.4	60.3	52.4	56.2	60.8
	4614	4788	4726	4790	4571
Ap_2	1163	ND	ND	ND	ND
	55.0				
	4493				
B_1	864	553	448	539	439
	41.3	62.4	64.5	67.3	64.7
	3800	4395	4170	4221	3411
B_2	801				
	40.4				
	3526				
B_3	790				
	39.1				
	3482				
BCux	355				
	31.3				
	2817				

(1) Values shown: (a) mg Pao kg^{-1} Fe
(b) $\frac{Po}{Pao}$. 100
(c) mg Po kg^{-1} LOI

Table 5.27 Weight of phosphorus fractions in soil profiles at the West Stoke and Rowbrook Farms, and on Bench Tor, Vag Hill and Holne Moor (Zone C)

Location		Po	Pa	Po	$\frac{Po}{Pao}$.100
			$g\ m^{-2}$		
Rowbrook Farm	RF1	232.5	59.9	172.6	74.2
Vagg Hill					
- Podzol	RV1	144.6	20.6	124.0	85.8
- Humic brown	RV2	138.7	27.6	111.1	80.1
Podzolics	RV6	149.3	34.9	114.3	76.6
West Stoke Farm GSP11 + satellites		275.4	116.4	159.0	57.7
Bench Tor Stagnopodzol GSP10		120.3	33.1	87.2	72.5
Holne Moor Zone C	$\bar{x}$	160.0	29.6	130.5	81.6
Group A					
Stagnopodzols	MAX	178.6	32.3	146.3	81.9
(n = 4)	MIN	145.5	29.3	116.2	79.9
Holne Moor	$\bar{x}$	161.4	31.1	130.3	80.7
Zone C					
Humic Brown	MAX	181.8	40.7	141.2	77.6
Podzolics(1)					
(n = 6)	MIN	145.1	23.2	121.9	84.0

(1) These profiles do not include the high phosphorus profiles (SP1, SP34) discussed in section 5.2.2.1 (see also section 5.4.2).

Table 5.28 Phosphorus and organic matter content of profiles and selected horizons in soils on Holne Moor and Bench Tor.

Profiles	gPao m^{-2}	a – b	a – c	mgPao kg^{-1} TFe profile	mgPao kg^{-1} TFe mineral soil only	kgLOIm^{-2}	a – b	a – c
All horizons to 40 cm below mineral soil surface								
GSP 10 (a)	120.3			440.8	417.7	39.39		
Zone C(1) (b)	160.0	-39.7		450.5	373.8	57.03	-17.64	
Zone A(2) (c)	137.3		-17.0	378.6	302.9	52.21		-12.82
Oh horizon only								
GSP 10 (a)	8.8					9.92		
Zone C (b)	38.1	-29.3				27.99	-18.07	
Zone A(2) (c)	37.8		-29.0			23.91		-13.99
Oh + Ah/E horizon only								
GSP 10 (a)	29.5					20.45		
Zone C (b)	56.8	-27.4				36.23	-15.78	
Zone A(2)(3) (c)	56.2		-26.7			32.00		-11.55

(1) $\bar{x}$ value Group A (n = 4)

(2) $\bar{x}$ value sub-zone F (n = 6)

(3) includes E horizon, where present.

Table 5.29 Coefficients of variation for soil samples from Bench Tor and Brake Field.[1]

	Bench Tor Stagnopodzols			Brake Field Humic brown podzolic soils	
Oh horizon n = 4			**Ap horizon n = 5**		
Pao	7.9	(9.0)	Pao	18.4	(18.0)
Pa	10.0	(9.9)	Pa	31.0	(31.2)
Po	8.7	(8.9)	Po	8.6	(7.5)
Ah/E horizon n = 5					
Pao	3.4	(4.7)			
Pa	10.1	(13.3)			
Po	3.5	(3.7)			
B horizon n = 4			**B horizon n = 4**		
Pao	24.4	(18.3)	Pao	12.0	(16.2)
Pa	45.1	(38.4)	Pa	13.8	(20.2)
Po	16.4	(12.7)	Po	12.4	(14.7)

(1) Figures in brackets are calculated from concentration by volume data; figures without brackets are from concentration by weight data.

Table 5.30 Zone B - test for outlier among samples from soil profiles lying outside the medieval droveway.[1]

Dixon's discordancy test (N7) for a single upper outlier, $x_{(n)}$, in a normal sample (Barnett and Lewis 1978)

Test statistic $\dfrac{x_{(n)} - x_{(n-1)}}{x_{(n)} - x_{(1)}}$ Outlier PTS-X, 711 $= x_{(n)}$

Critical values (n = 8) 5% 0.468 1% 0.590

$\dfrac{711 - 435}{711 - 338} = .7399 \quad P < 0.01$

(1) phosphorus values are expressed as mgPao kg^{-1}IFe

Table 5.31 Zone B - Phosphorus content of profiles in the medieval droveway and surrounding land (PP and PT series)[1]

	n	$\bar{x}$	S	SE	CV
Inside droveway	9	469.8	56.4	18.8	12.0
Outside droveway	7	392.4	39.5	14.9	10.1

Student's t test of differences between profiles inside and outside of the droveway.
Observed t = 3.0782 with 14 df. $P < 0.005$ (one-tailed)

(1) Phosphorus values expressed as mgPaokg^{-1}IFe in profiles sampled to 30 cm below the mineral soil surface.

Table 5.32 Zone B - linear regression equations, and coefficients of correlation and determination for phosphorus values expressed as concentration by weight of ignited fine earth and as concentration by volume[1]

x = mg Pao kg^{-1} IFe y = g Pao m^{-2}

All profiles	n	$r^{(2)}$	CD
$y = 0.1152x + 53.04$	17	0.7847	61.6

Omitting profiles PTS - X, PTS - 0, PTD - 2, PTD - 7.5, PTN X

	n	$r^{(2)}$	CD
$y = 0.1910x + 24.59$	12	0.9256	85.7

(1) All phosphorus values are calculated for soil, profiles sampled to a depth of 30 cm below the mineral soil surface.

(2) Both correlation coefficients are statistically significant with $P < 0.001$ in both cases.

Table 5.33 Zone B - estimates of changes in the phosphorus content of soil profiles in the medieval droveway and in nearby land(1)

PP Profiles	A(2)	B(3)	C(4)	D(5)	Comment
16	95.474	-0.126	106.366	-10.892	
17	96.683	+1.083	100.232	-3.549	
19	108.795	+13.195	102.808	+5.987	
12	107.485	+11.885	92.911	+14.574	near gate
18	122.236	+26.636	102.487	+19.749	near boundary
10	177.664	+22.064	94.135	+23.529	near boundary
PT Profiles					
S-0	95.424	-0.176	85.548	+9.876	
S-4	94.864	-0.736	94.242	+0.622	
S-X	126.925	+31.325	70.020	+56.905	boundary wall
D-S	118.196	+22.596	94.409	+23.787	
D-2	120.199	+24.599	81.469	+38.730	
D-5	101.519	+5.919	96.731	+4.788	
D-7.5	100.351	+4.751	79.438	+20.913	
D-N	107.211	+11.611	91.786	+15.425	boundary wall
N-X	78.048	-17.552	81.957	-3.909	
N-3	88.159	-7.441	102.504	-14.345	
N-10	109.281	+13.681	98.567	+10.714	flint flake

(1) All phosphorus values are expressed as gPao m^{-2} to 30 cm below mineral soil surface.

(2) A = observed value.

(3) B = difference between A and the mean value of profiles outside the droveway (95.6 gPao m^{-2}) calculated after exclusion of PTS-X.

(4) C = value calculated by multiplying the observed weight of ignited fine earth in each profile by the mean concentration of phosphorus in profiles outside the droveway (392.4 mgPao kg^{-1} IFe) calculated after exclusion of PTS-X; this provides an estimate of the initial phosphorus content of each profile.

(5) D = difference between C and A; this provides an estimate of residual phosphorus inputs or apparent deficiencies.

Table 5.34 Zone C - LOI values (%) in Oh horizon samples from stagnopodzols.

	$\bar{x}$	SD	SE	CV	Range
West of reave (Group A) (n = 4)	49.6	3.7	1.9	7.5	45.2-54.2
East of reave (Group B) (n = 4)	46.8	4.5	2.3	9.7	43.5-53.5
All samples n = 8	48.2	4.1	1.5	8.5	43.5-54.2

Table 5.35 Zone C - thickness (cm, excluding litter) of Oh horizons in stagnopodzols

	$\bar{x}$	SD	SE	CV	Range
West of reave (Group A) (n = 4)	12.0	2.2	1.1	18.0	10 - 15
and including litter	16.3				15 - 19
East of Reave (Group B) (n = 4)	6.6	1.4	0.7	20.8	5 - 8
and including litter	11.6				10 - 13

Student's t-test of observed differences between groups A and B.
Observed t = 4.1964 with 6 df; $P < 0.01$ (two-tailed).

Table 5.36 Zone C - depth of auger penetration (cm) below mineral soil surface in soil pits sampled in 1977.

	$\bar{x}$	SD	SE	CV	Range
North Lobe (n = 5)	52.4	9.4	4.2	18.0	42 - 62
North Field (n = 5)	57.2	12.9	5.8	22.6	37 - 73

Table 5.37 Zone C - tests for outliers among North Lobe profiles[1]

Dixon's discordancy test for an upper outlier-pair, $x_{(n-1)}$, $x_{(n)}$ in a normal sample. (Barnett & Lewis 1978)

Test Statistic

$$\frac{x_{(n)} - x_{(n-2)}}{x_{(n)} - x_{(1)}}$$

Outlier pair

SP 34 240.00 = $x_{(n)}$

SP 1 212.52 = $x_{(n-1)}$

North Lobe sample (n = 8)

Critical values: 5% 0.607 1% 0.710

$$\frac{240.00 - 181.83}{240.00 - 145.11} = 0.613$$

$P < 0.05 > 0.01$

Zone C sample (n = 16)

Critical values: 5% 0.418 1% 0.508

$$\frac{240.00 - 181.83}{240.00 - 120.42} = 0.486$$

$P < 0.05 > 0.01$

Zone C sample, excluding SP 37 (n = 15)

Interpolated Critical Values: 5% 0.432 1% 0.523

$$\frac{240.00 - 181.83}{240.00 - 131.75} = 0.537$$

$p < 0.01$

Zone C sample, excluding group B stagnopodzols (n = 12)

Critical values: 5% 0.481 1% 0.579

$$\frac{240.00 - 181.83}{240.00 - 145.11} = 0.613$$

$P < 0.01$

(1) Phosphorus values are expressed as g Pao m^{-2} to a depth of 40 cm below the mineral soil surface.

Table 5.38 Zone C - organic matter content of profiles in the North Lobe and the North Field, and in the medieval palaeosol beneath the boundary that separates these fields.

	North field group A (n = 4)	Palaeosol at AD 1000[1]	North Lobe (n = 6)		North field group A (n = 4)	Palaeosol at AD 1000	North Lobe (n = 6)
		kg LOI m^{-2}				mg LOI cm^{-3}	
Litter		No data				No data	
Oh	27.99	17.74			232.9	215.1	
Thickness (cm)	12	8.25					
Ah/E	8.25	12.44	11.28	Ah	108.2	108.2	115.1
Thickness (cm)	7.5	11.5	9.8	Thickness			
Oh + AhE	36.23	30.18			185.8 (483.1)[2]	152.8 (262.4)[2]	
B	20.80	18.24	21.70	B and A/B	64.0	64.0	71.9
Thickness (cm)	32.5	28.5	30.2				
Mineral soil only to 40 cm	29.05	30.68	32.98		72.6	76.7	82.5
Whole Profile	57.03	48.43	32.98		109.7 (142.6)[3]	100.4 (121.1)[3]	82.5

(1) These estimates are taken from Tables 5.5 and 5.6 and are discussed in section 5.2.1.1.
(2) Concentration of organic matter if Oh + Ah/E content of organic matter were incorporated into AhE without volume change.
(3) Concentration of organic matter if profile content of organic matter were incorporated into mineral soil without volume change.

Table 5.39 Zone C - physical properties of soils in the North Lobe and the North Field (1)

	North Lobe n = 6		North Field n = 4			
			Without Oh		With Oh	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Fine earth	336.07	7.21	356.28 ≠≠ (2)	9.12	412.70 ≠≠≠	1.13
LOI	32.98	1.81	29.05 ≠≠	1.74	57.03 ≠≠≠	5.38
Ignited fine earth	303.09	7.86	327.24 ≠≠	8.31	355.67 ≠≠≠	4.71
Stones	86.33	3.75	93.70 ≠	5.84	93.70 ≠	5.84
Soil	422.40	8.25	449.98 ≠≠	9.27	506.40 ≠≠≠	4.84

(1) All values are expressed as kg m^{-2} to 40 cm below the mineral soil surface.

(2) Significant differences between the North Lobe and North Field values were assessed by Student's t-test (≠ = $P < 0.05$, ≠≠ = $P < 0.01$, ≠≠≠ = $P < 0.001$).

	North Lobe n = 6	North Field n = 4 without Oh	North Field n = 4 with Oh
$\frac{FE}{soil}$.100	79.56	79.18	81.50
$\frac{LOI}{soil}$.100	7.81	6.46	11.26
$\frac{IFE}{soil}$.100	71.75	72.72	70.23
$\frac{stones}{soil}$.100	20.44	20.82	18.50
$\frac{LOI}{1FE}$. 100	10.88	8.88	16.03
$\frac{stones}{1FE}$. 100	28.48	28.63	26.34

Table 5.40 Zone C – mean concentration of phosphorus fractions in entire profiles[1]

	North Field Stagnopodzols						North Lobe Podzolic Soils				
	n = 4 Group A				n=2 (GSP2, SP8)		n = 6		$A^{(4)}$	n=2 (GSP3, SP4)	$B^{(4)}$
	with Oh		without Oh		with Oh	without Oh					
mg P kg^{-1} IFe	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	$\bar{x}$	$\bar{x}$	SD		$\bar{x}$	
Pao	451≠ (2)	53	374≠≠	47	447 (73.4)[3]	382	533	53	18.2	542 (72.0)[3]	21.3
Pa	83 ns	10	63≠≠	10	81 (13.4)	62	103	27	24.1	106 (14.1)	30.9
Po	367≠	45	310≠≠≠	38	366 (60.1)	321	430	29	17.2	436 (57.9)	19.1
Pt					609	542				753	23.6
Pf					164 (27.0)	160				212 (28.1)	29.3
Pi					245 (40.2)	222				318 (42.2)	29.8
mg Po kg^{-1} LOI	2288≠≠≠	131	3500 ns	411	2458	3332	3954	218		3926	
			Group A (n=3) excluding SP7								
			3318	236							
			Group A+B (n = 8)								
			3362≠≠	345							
			Group A+B excluding SP7 (n=7)								
			3264≠≠≠	225							

(1) All values are calculated for profiles sampled to a depth of 40 cm below the mineral soil surface.

(2) Statistical significance of differences between equivalent values in the North Field and North Lobe soils were assessed by Student's t-test. ns = $P > 0.05$ ≠ = $P < 0.05$ ≠≠ = $P < 0.01$ ≠≠≠ = $P < 0.001$

(3) Figures in brackets indicate the phosphorus fractional composition as a percentage of P t.

(4) **A** = difference between values in North Lobe and North Field expressed as a % of value in North Field (uses values for ten profiles); indicates % increase in P values.
B is similar to **A**, but uses only values for the four profiles for which Pt estimates are available.

Table 5.41 Zone C - test for outlier among stagnopodzol profiles[1]

Dixon's discordancy test (N7) for a single upper outlier, $x_{(n)}$ in a normal sample (Barnett & Lewis 1978).

Test statistic

$$\frac{x_{(n)} - x_{(n-1)}}{x_{(n)} - x_{(1)}}$$

Outlier SP7
4045 $mgPokg^{-1}LOI$
n = 8

Critical Values
5% 0.468 1% 0.590

$$\frac{4045 - 3550}{4045 - 30277} = 0.486 \qquad P < 0.05$$

(1) Phosphorus values expressed as $mgPokg^{-1}LOI$.

Table 5.42 Phosphorus content of profiles in zone C and sub-zones B and F in zone A[1]

	g Pao m^{-2}		mg Pao kg^{-1}IFe		
	$\bar{x}$	SD	$\bar{x}$	SD	n
Zone A					
Sub-zone F (virgin land)	137.25	11.18	378.6	39.5	6
Sub-zone B (prehistoric field adjacent to house on site F)	147.95	3.67	420.0	32.4	5
Zone C					
North field	160.05	16.87	450.5	53.3	6
North Lobe	161.39	14.54	533.2	53.5	4
SP 33, 34, 1	221.16	16.33	772.7	41.0	3

(1) All phosphorus values are calculated for soil profiles sampled to a depth of 40 cm below the mineral soil surface.

Table 5.43 Zone C - models of farming inputs in North Lobe soils to explain residue of 34.6 g P m^{-2} (= 346 kg P ha^{-1}).

Assume recovery of applied P was:	Then FYM input was(1) (t ha^{-1})	Long-term input rate (over 450 years) was: (t ha^{-1} $year^{-1}$)	If applied in 150 dressings, application rate was: (t ha^{-1})	Phosphorus removed by crops was: (kg ha^{-1})	Number of harvests if 3.5 or 5 kg P ha^{-1} removed in each harvest.	
75%	1456	3.2	9.7	1037	296	207
50%	728	1.6	4.9	346	99	69
33%	546	1.2	3.6	173	49	35
25%	485	1.1	3.2	115	33	23

(1) assumes 1 t FYM $\equiv$ 0.95 kg P

Table 5.44 Zone A - Adjustments to observed peat depth values to allow for peat cutting losses[1]

				$\bar{x}$ peat depth[2] for:			
sub-zone	Profiles	Changes to observed values		A	n=	B	n=
A	-	No adjusted values		14.00	5	13.67	12
B	-	No adjusted values		14.00	5	13.50	14
D	GSP 8	Raised from 9 to 11	Segment XI	13.80	5	13.79	14
C	C 4	Raised from 10 to 14	Segment VI	14.80	10	14.78	9
	C 6	Raised from 7 to 14					
E	SP 16	Raised from 10 to 13	Segment X	13.67	7	13.67	9
	SP 17	Raised from 11 to 14					
	SP 18	Raised from 9 to 13					
	SP 19	Raised from 11 to 16	Segment V	15.50	2	15.50	2
F and	GSP 5	Raised from 11 to 16	Segment I				
	SP 14	Raised from 12 to 17					
	SP 15	Raised from 10 to 14		16.50	8	16.50	16
	GSP 4	Raised from 12 to 18	Segment III[3]				
	SP 10	Raised from 8 to 19					

(1) All peat depths in the table include depth of litter; all values are in cm; all calculations exclude profiles in corners and edges of enclosures.

(2) A = $\bar{x}$ peat depth of profiles for which chemical analyses are available (after adjustments to observed values as indicated in the table).
B = $\bar{x}$ peat depth of all sampled profiles in relevant subzone or segment (after omission of peat cut profiles - see section 4.3.11 and Table 4.3).

(3) All profiles in Segment III were peat cut. Values for these profiles, which lay on flatter land than those in Segment I, were raised to match the value for Segment IV (18.75 cm) on the plateau top, but the mean value for all profiles in virgin land sub-zones F and G was matched to the equivalent value for segment I.

Table 5.45 Zone A - phosphorus content of BCux samples from Holne Moor[1]

Zone	Subzone	Profile	Value	Comment	
A	G	GSP 4	253	Virgin	
	F	GSP 5	252	Land	
	E	GSP 6	259		
	C	GSP 7	297		
	D	GSP 8	354	Thick E horizon	
	A	GSP 9	223	$\bar{x}$ 253.5	
	A	HM 77C 4	284		
	B	HM 77F 5	302		Shallow
	B	HM 77F 6	313	Palaeosol	Profiles
	All sub-zones	All profiles (n = 9)	$\bar{x}$ 281.9	SD 39.6 CV 14.0%	SE 13.2
C	North field	GSP 2	224	Stagnopodzol	
	North lobe	GSP 3	286	Brown Podzolic	
		HM 78 B	247	Palaeosol	
	All	All profiles (n = 3)	$\bar{x}$ 252.3	SD 31.3 CV 12.4%	SE 18.1
A + C	All	All profiles (n = 12)	$\bar{x}$ 274.5	SD 38.7 CV 14.1%	SE 11.2

(1) All phosphorus values are expressed as mg Pao kg^{-1} JFe.

Table 5.46 Zone A - analysis of variance: bulk density of Ah/E horizon sample(1)

Total cases n = 43 in 6 groups.
Overall F value = 11.37076 ### with 5 and 37 df.

Contrasts

Group = sub-zone	$\bar{x}$	SD	A	B	C	D	E	FG	n=
A	1.1740	0.0278		#	NS	#	##	###	5
B	1.0942	0.0432			###	###	###	###	7
C	1.2378	0.0663				NS	NS	#	10
D	1.2572	0.0638					NS	NS	5
E	1.2747	0.0692						NS	8
FG	1.3070	0.0703							8

(1) Soil bulk density values are expressed as g cm^{-3}.
$P < 0.001$ ### $P < 0.01$ ## $P < 0.05$ # Anovar calculated as described by Campbell (1974: 177-205)

Table 5.47 Zone A - analysis of variance: LOI of Ah/E horizon samples(1)

Total cases n = 43 in 6 groups

Overall F value = 3.98320// with 5 and 37 df.

Contrasts

Group = sub-zone	$\bar{x}$	SD	A	B	C	D	E	FG	n=
A	7.72	0.91		NS	NS	NS	NS	NS	5
B	8.70	0.71			NS	NS	/	/	7
C	9.18	2.33				NS	///	//	10
D	7.77	0.57					NS	NS	5
E	6.92	0.74						NS	8
FG	7.02	0.80							8

(1) LOI values are expressed as % of OD fine earth.
$P < 0.001$ /// $P < 0.01$ // $P < 0.05$ / Anovar calculated as described by Campbell (1974:177-205).

Table 5.48 Zone A - statistical summary of soil phosphorus measurements: Part 1 (1)

		D n = 5		A n = 5		B n = 5		E (east) n = 4		E (west) n = 5		F n = 6		C n = 8 (south)		G n = 2	
Pao (2) µg cm^{-3}	1	328	23	379	25	396	39	302	12	323	35	347	39	350	107	212	18
	2	230	32	255	48	259	42	314	53	183	45	177	24	186	35	163	8
	3	350	57	272	65	268	41	388	56	303	83	286	84	237	55	304	13
	4	295	40	246	27	285	29	278	17	259	43	267	27	217	34	224	26
Pa µg cm^{-3}	1	72	11	61	25	71	7	76	16	70	6	63	11	68	21	47	16
	2	29	6	25	13	22	4	33	7	20	7	18	4	21	7	16	8
	3	107	31	62	25	55	20	124	48	78	29	46	37	38	16	61	45
	4	106	20	90	15	122	24	98	20	102	18	103	20	76	25	75	19
Po µg cm^{-3}	1	256	28	318	29	324	45	226	13	254	36	284	44	282	90	164	1
	2	201	29	230	41	236	39	281	49	164	40	160	21	165	32	147	0
	3	243	26	210	41	213	31	264	25	225	68	240	70	198	48	243	33
	4	189	20	156	15	163	15	180	12	156	27	164	25	141	27	149	45

(cont)

Table 5.48 (cont'd)

		D n = 5		A n = 5		B n = 5		E (east) n = 4		E (west) n = 5		F n = 6		C n = 8 (south)		G n = 2	
Pao gm^{-2}	5	64.5	13.2	67.3	13.2	74.0	8.0	63.5	7.7	55.6	7.6	56.2	11.2	60.9	12.0	49.9	7.2
	6	77.7	14.0	68.6	12.4	74.0	9.2	94.8	13.3	74.7	15.1	81.0	10.5	59.6	10.8	71.8	8.7
Profile(3) gm^{-2}	Pao	142.3	16.1	135.9	20.2	148.0	3.7	158.2	7.2	130.3	14.8	137.3	11.2	120.5	7.2	121.7	1.6
	Pa	35.5	5.3	26.9	6.6	30.6	6.5	42.9	6.6	33.6	3.9	32.0	4.9	25.4	5.6	28.5	4.2
	Po	106.8	12.0	109.1	16.0	117.4	6.6	115.4	5.1	96.7	11.1	105.3	11.1	95.1	7.5	93.2	2.6
P a %	Pao	25.0		19.8		20.6		27.1		25.8		23.3		21.1		23.4	

(1) $\bar{x}$ and SD is shown for each sub-zone within zone A.

(2) 1 = Oh 2 = Ah/E + E 3 = B_1 4 = B_2 5 = Oh + Ah/E + E 6 = $B_1 + B_2$

(3) Profile = values calculated to a depth of 40 cm below the mineral soil surface.

Table 5.49 Zone A - statistical summary of soil phosphorus measurements: Part 2[1].

		X n = 5		A n = 5		B n = 5		E (east) n = 4		E (west) n = 5		F n = 6		G n = 8 (south)		G n = 2	
Po[2]	1	1289	86	1355	152	1359	143	988	59	1263	267	1287	193	1193	454	629	4
$mgkg^{-1}$ LOI	2	2291	223	2598	466	2797	534	2796	304	2404	620	2037	196	1906	530	1488	672
	3	3008	507	2865	113	3032	469	3354	235	2813	415	2847	320	2694	233	2645	348
	4	2741	326	2732	206	2972	435	3196	272	2661	271	2632	288	2380	252	2226	64
Pao $mgkg^{-1}$ IFe	5	354.5	92.0	471.6	85.6	548.9	67.6	533.3	249.7	340.0	32.0	436.0	46.4	416.2	82.6	440.8	63.9
	3	452.2	46.1	307.1	84.7	342.4	59.8	409.7	72.8	356.4	88.4	353.3	58.1	289.9	107.1	372.4	3.8
Profile[3] IFe kgm^{-2}		364.1	27.5	370.9	26.0	353.5	22.0	373.9	17.3	377.8	36.0	363.7	18.9	364.0	40.7	305.9	21.5
Pao $mgkg^{-1}$ IFe		393.3	57.0	369.4	72.8	420.0	32.4	423.3	2.1	346.8	44.4	378.6	39.5	334.3	37.0	398.7	23.0
Po $mgkg^{-1}$ LOI		2233	249	2180	247	2238	302	2228	129	2069	265	2014	153	1818	300	1388	32

(1) $\bar{x}$ and SD is shown for each sub-zone within zone A.

(2) 1 = Oh 2 = Ah/E 3 = $B_1 + B_2$ 4 = mineral soil to a depth of 40 cm. 5 = Oh X Ah/E + E

(3) Profile = values calculated to a depth of 40 cm below the mineral soil surface.

Table 5.50 Zone A - phosphorus enrichment or deficiencies in the sub-zones of zone A taking the virgin land sub-zone F as a baseline for calculations[1]

Sub-zone or Profile	n	Phosphorus loss (-) or gain (+)[2]		
		A	B	Mean of A and B
G	2	-16	+6	-5.0
A	5	-1	+1	0.0
D	5	+5	+4	+4.5
E west	5	-7	-13	-10.0
E east	4	+21	+17	+19.0
B	5	+11	+14	+12.5
C north	2	+14	+31	+22.5
C south	8	-17	-18	-17.5
ED 8	1	-26	-9	-17.5
ED 3	1	+16	+7	+11.5
CC 1	1	+8	+37	+22.5
CC 2	1	+75	+91	+83.0
CC 3	1	+20	+19	+19.5

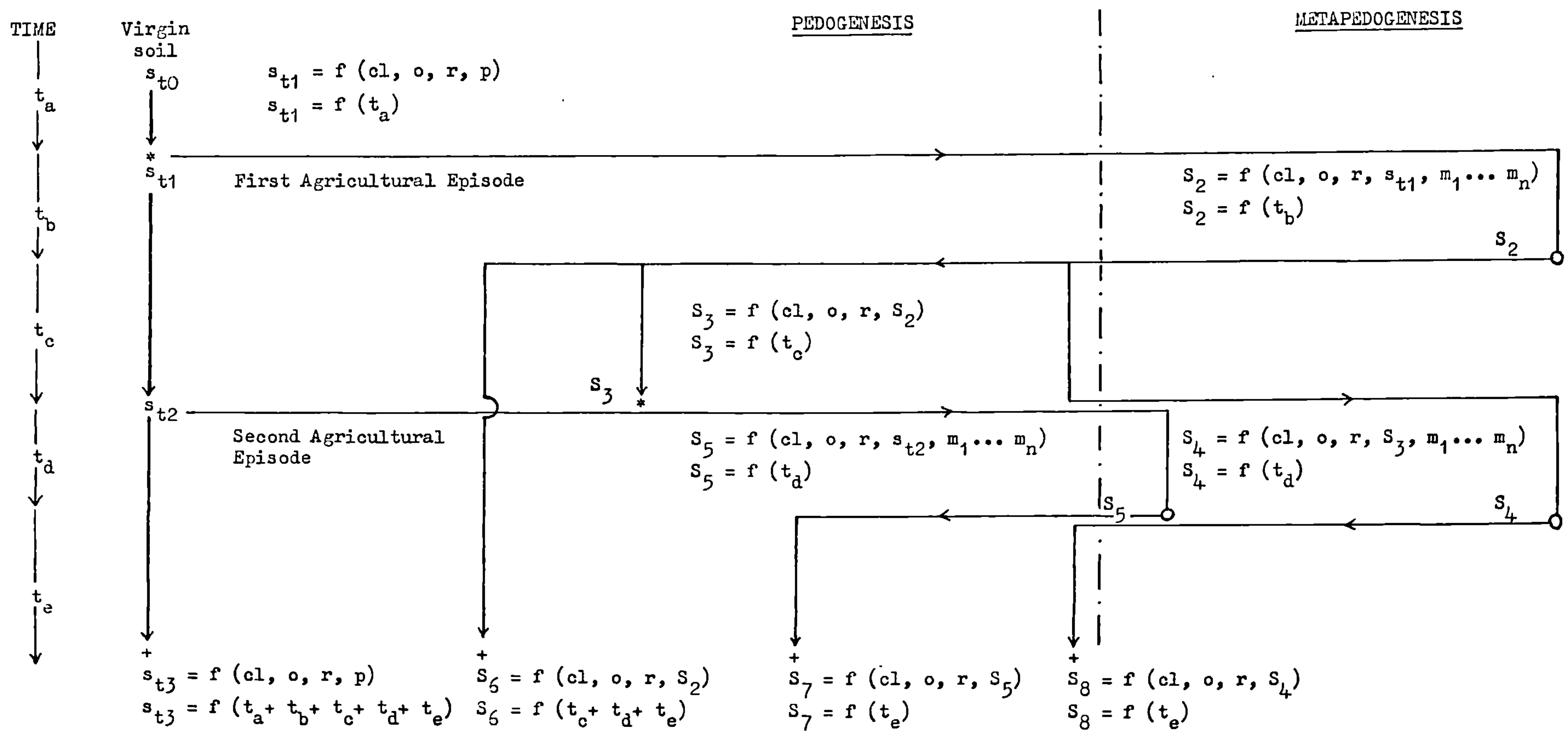
(1) All phosphorus values are expressed as g Pao m^{-2} calculated to a depth of 40 cm below the mineral soil surface.

(2) A = difference between the observed weight of phosphorus in each sub-zone ($\bar{x}$ g Pao m^{-2}) or profile and that in sub-zone F ($\bar{x}$ 137.25 g Pao m^{-2}); this is equivalent to the values in column B of Table 5.33, which were discussed in section 5.4.1.
B = difference between the observed weight of phosphorus in each sub-zone ($\bar{x}$ g Pao m^{-2}) or profile and an 'initial state' estimated by multiplying the observed weight of ignited fine earth in each sub-zone or profile by the mean concentration of phosphorus in sub-zone F (378.6 mg Pao kg^{-1}IFe); this is equivalent to the values in column D in Table 5.33, which were discussed in section 5.4.1.
The calculations for both methods A and B were performed on the values for individual profiles; subsequently mean values for sub-zones w ere calculated from the profile data.

FIGURES

FIGURES - note on conventions and lay-out

In general, all figures appear in consecutive number order starting from Fig. 2.1 (chapter 2) and concluding with Fig. A5.2 (appendix 5); exceptionally, Fig. 5.50 appears between Figs. 5.48 and 5.49, and Fig. 5.140 appears between Figs. 5.138 and 5.139. In most cases the keys provided with figures cover all newly introduced information, but in some instances symbols and conventions are repeated from figure to figure and are only keyed in the figure in which the information is most relevant. A conventional depth scale has been used for the many diagrams illustrating the vertical distribution of values for soil variables; it is marked at 10 cm intervals and the '0' included in it indicates the level of the mineral soil surface. Values above the '0' refer to Oh horizon samples and those immediately below it to Ah/E horizon samples. Diagrams showing cumulative weight of soil variables with depth (abbreviated to 'cum.') usually indicate cumulative weight both to 40 cm and, where appropriate, to deeper, sampled depths.



\+ Surface soils visible today
* Soils buried by boundaries at the start of agricultural episodes

s = soils created solely by pedogenetic factors
S = soils affected by metapedogenetic factors

Fig. 2.1 Soil development trajectories and equations illustrating the factors affecting soils created by pedogenesis and metapedogenesis.

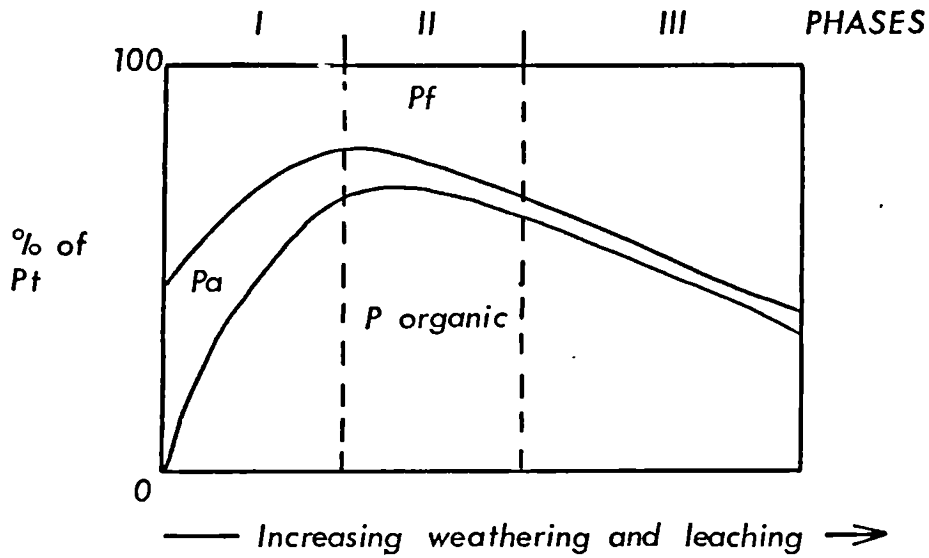


Fig. 2.2 Changes in the proportion of soil phosphorus fractions during pedogenesis (from Floate 1962: Fig. 8.4)

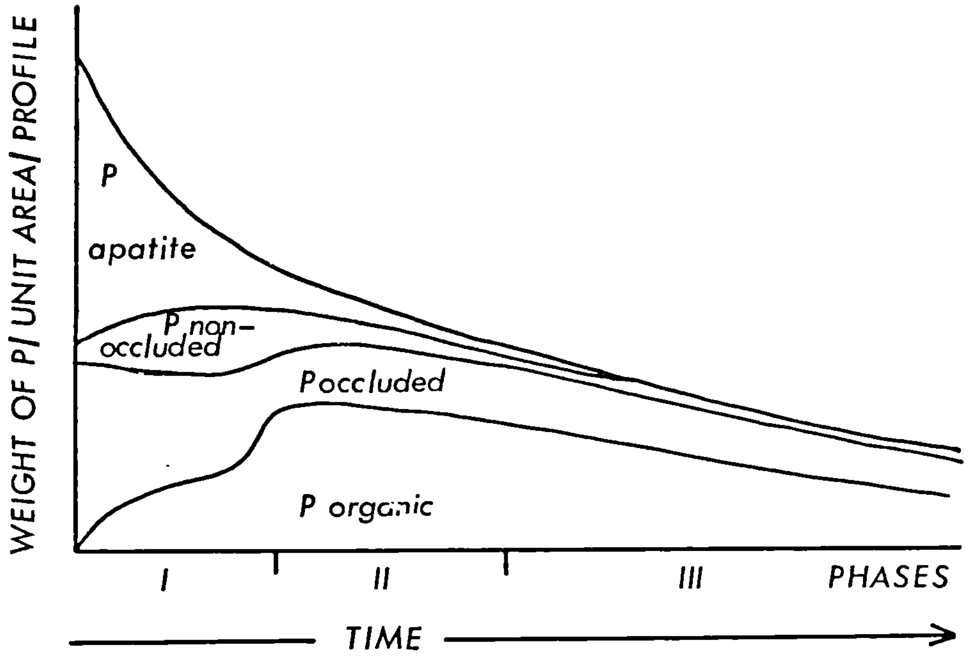


Fig. 2.3 Changes in the forms and amounts of soil phosphorus with time (after Floate 1962: Fig. 8.4 and Walker and Syers 1976: Fig. 1)

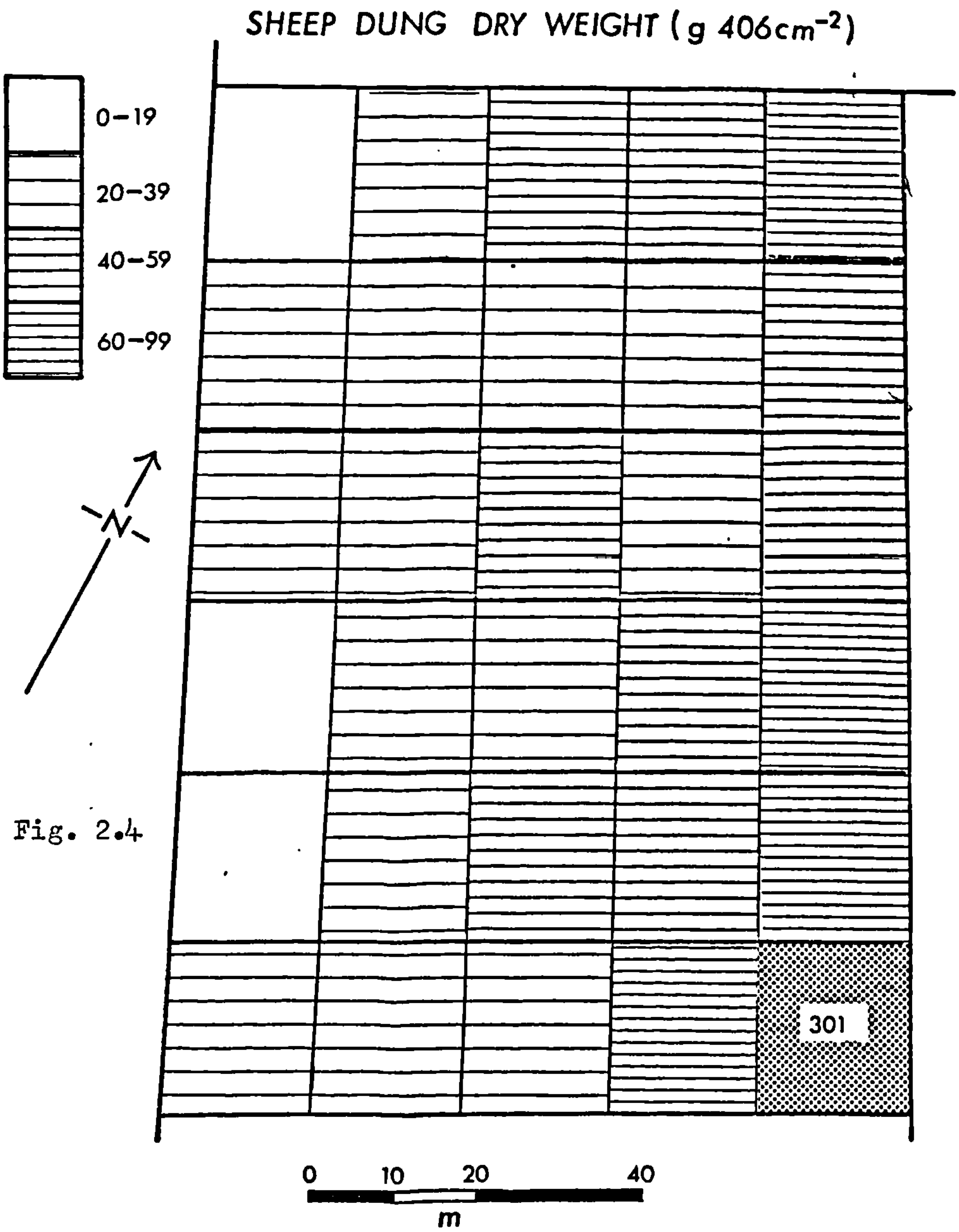


Fig. 2.4

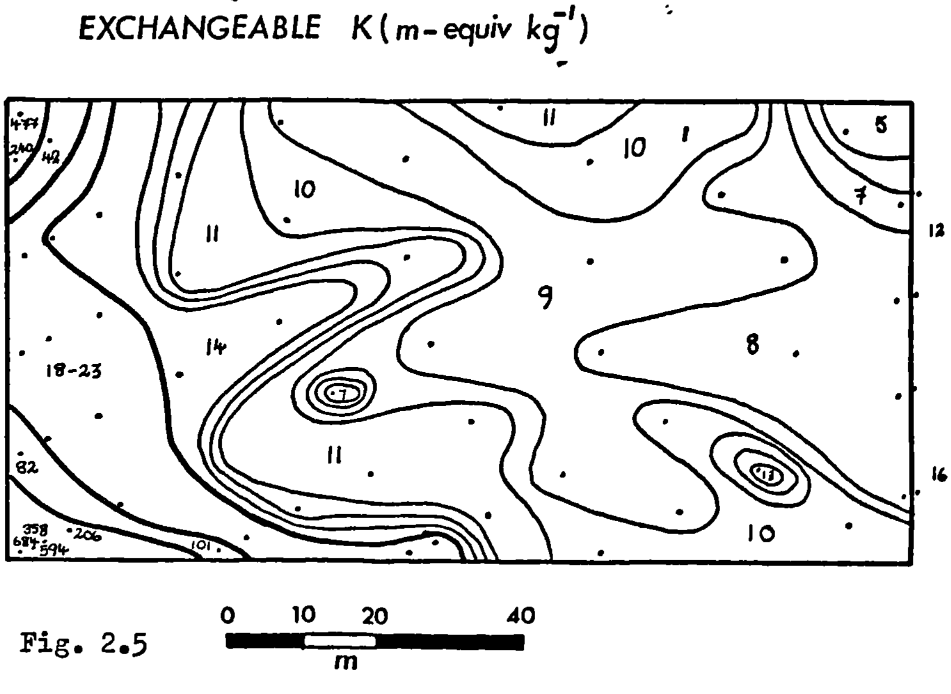


Fig. 2.5

Figs. 2.4 and 2.5 Distribution of dung and exchangeable potassium in Australian paddocks grazed by Merino sheep (after Hilder 1964: Fig. 1 and Fig. 2)

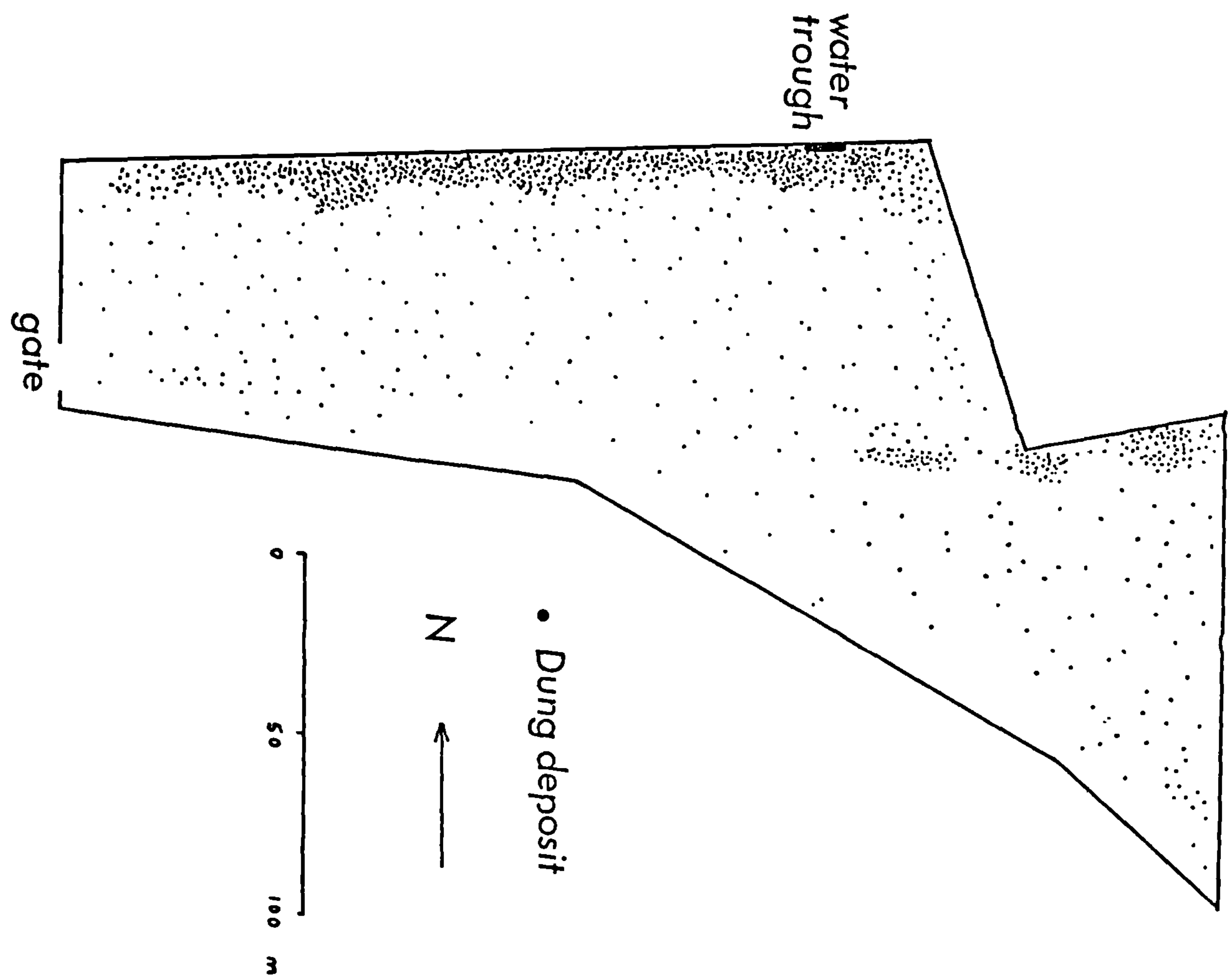


Fig. 2.6 Distribution of dung in a Dorset grass ley grazed by Fresian cattle (from Salmon 1980: Fig. 3)

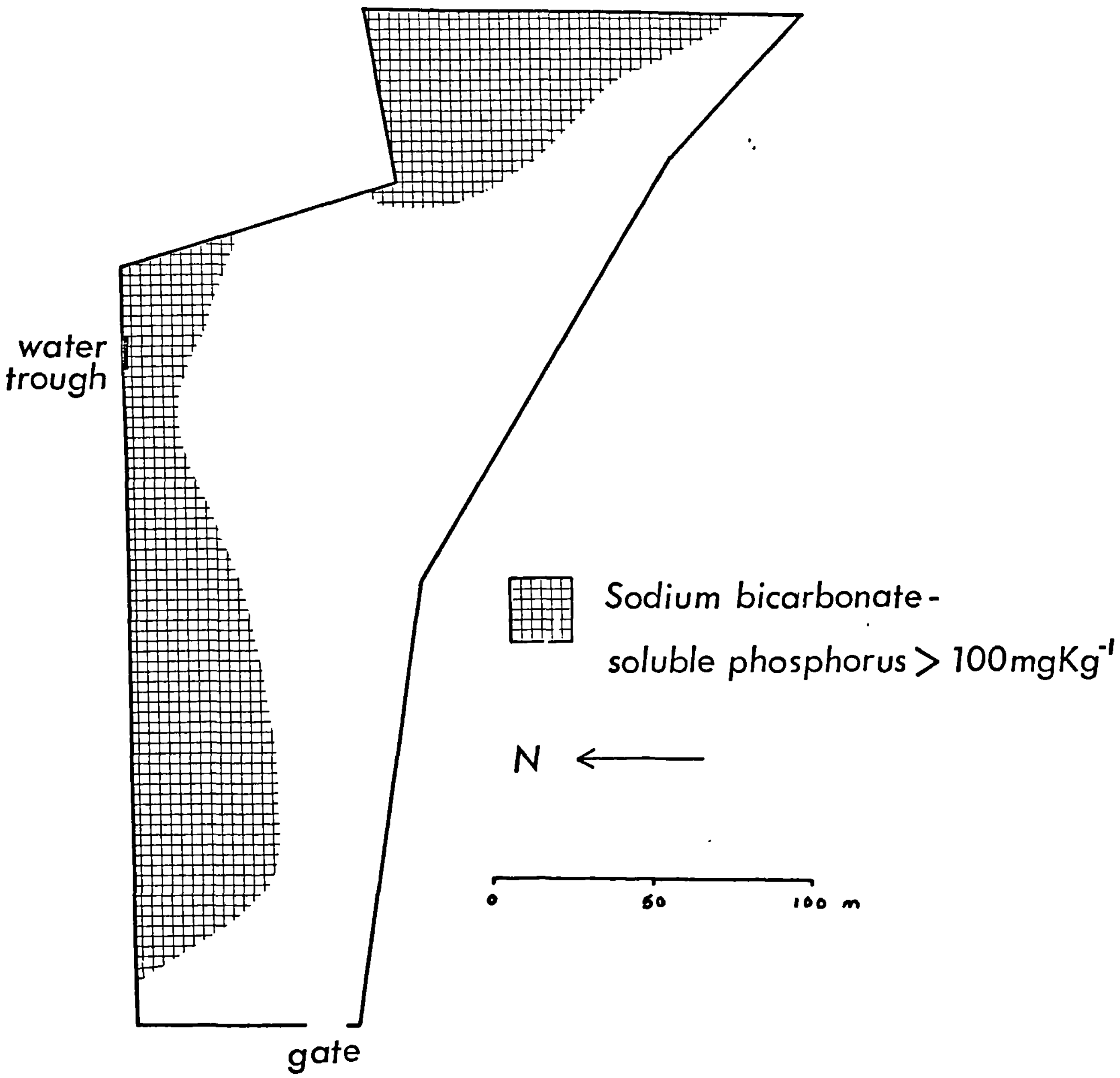


Fig. 2.7 Distribution of sodium bicarbonate-soluble phosphorus in a Dorset grass ley grazed by Fresian cattle (from Salmon 1980: Fig. 11)

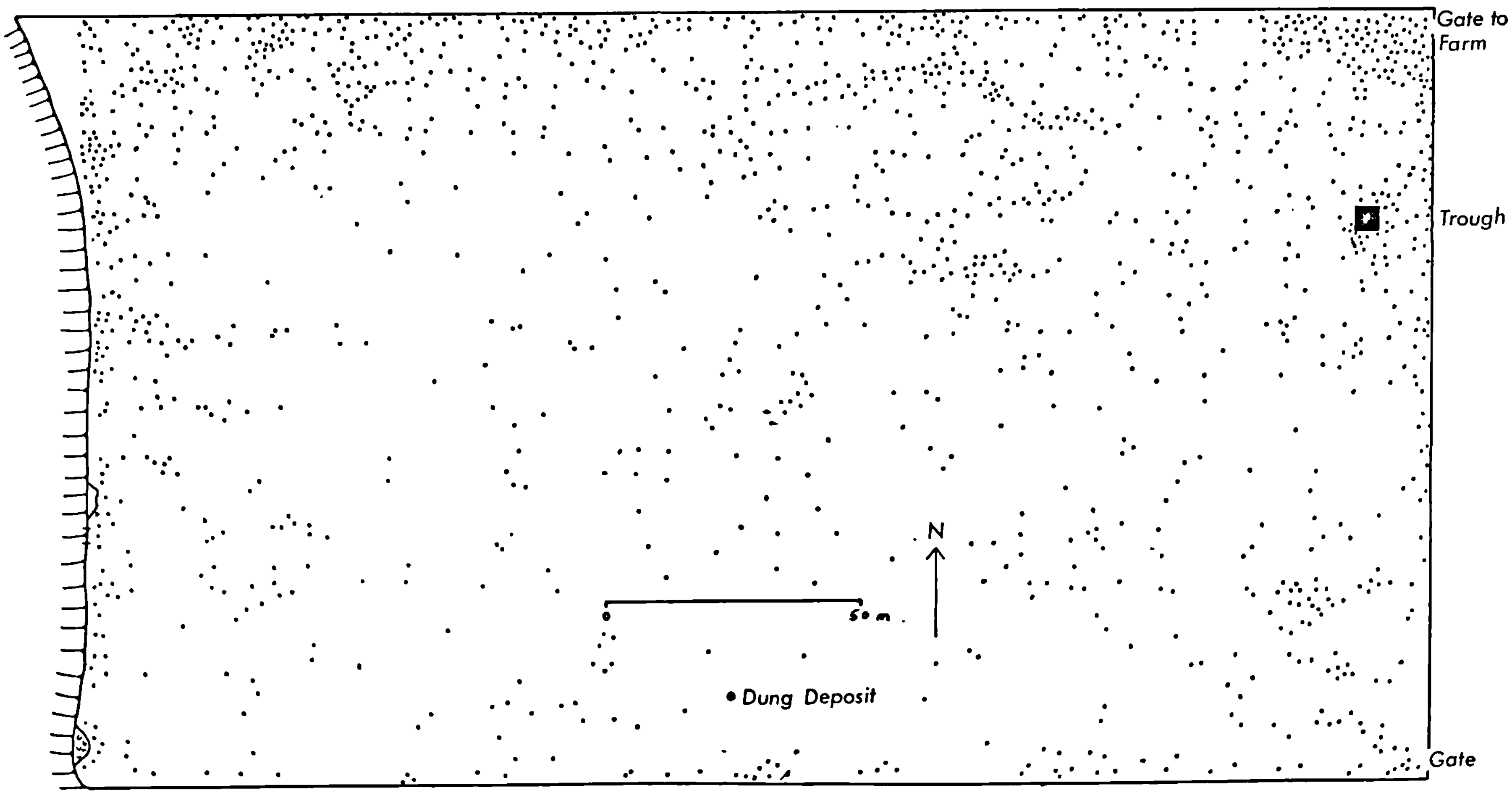


Fig. 2.8 Distribution of dung in a cattle pasture in western Ireland
(after Briggs: unpublished data)

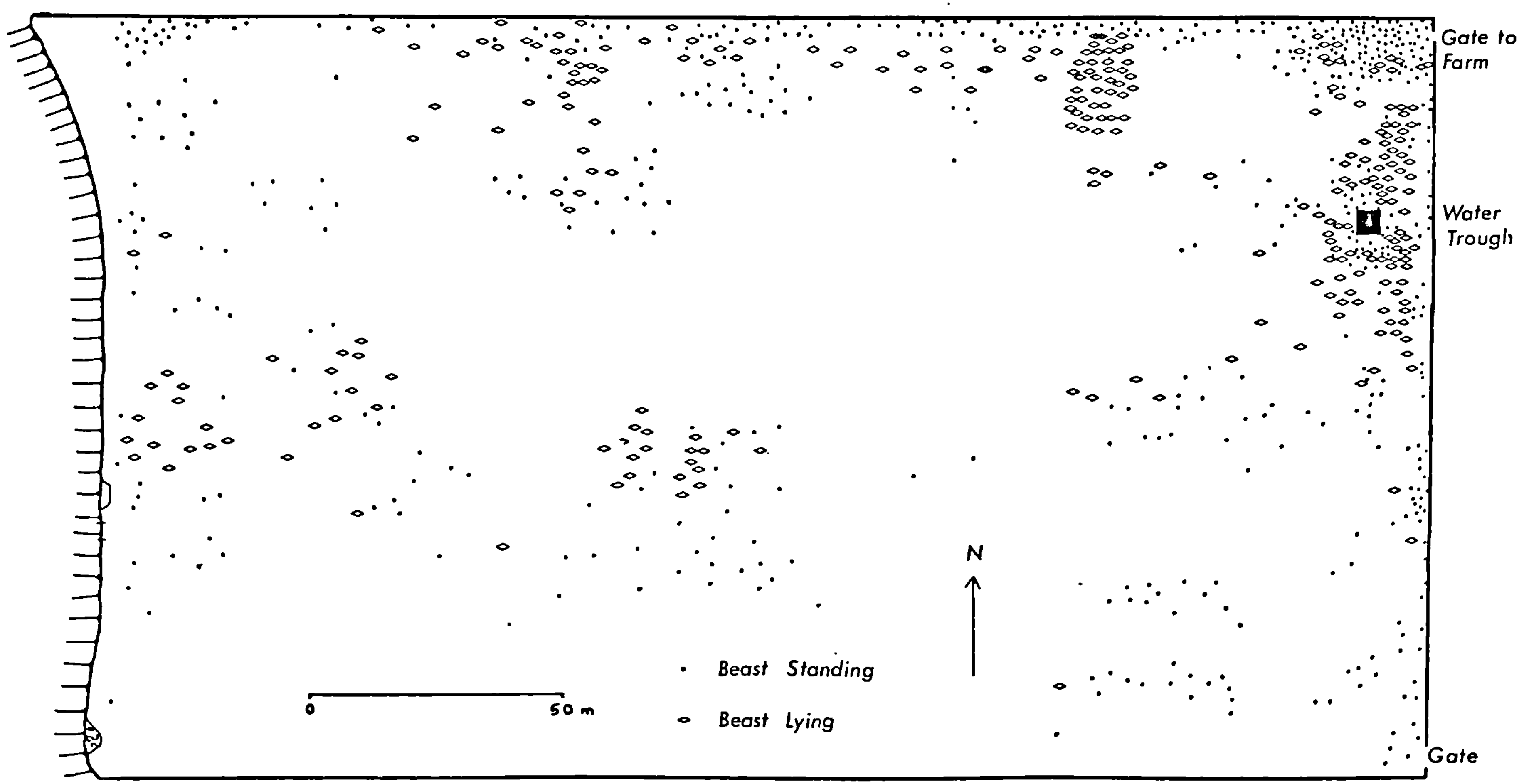
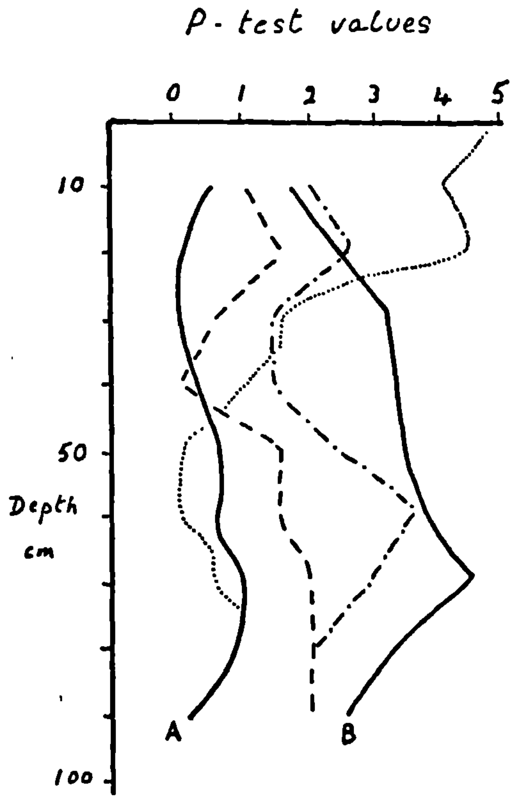


Fig. 2.9 Distribution of cattle in a pasture in Western Ireland
(after Briggs: unpublished data)



A ——— Heather-grass, Salthelleven

- - - - - Intensively-used pasture, Salthelleven

B ——— Mesolithic settlement, Salthelleven

.... Modern arable (fertilised), Sunde

—·—·— Arable in recent and iron-age times (700-1100 AD), Străpa-Sandsa

Fig 2.10 Vertical distribution of phosphorus-test values in Scandanavian soils (after Bakkevig 1980: Figs. 10, 13 and 16)

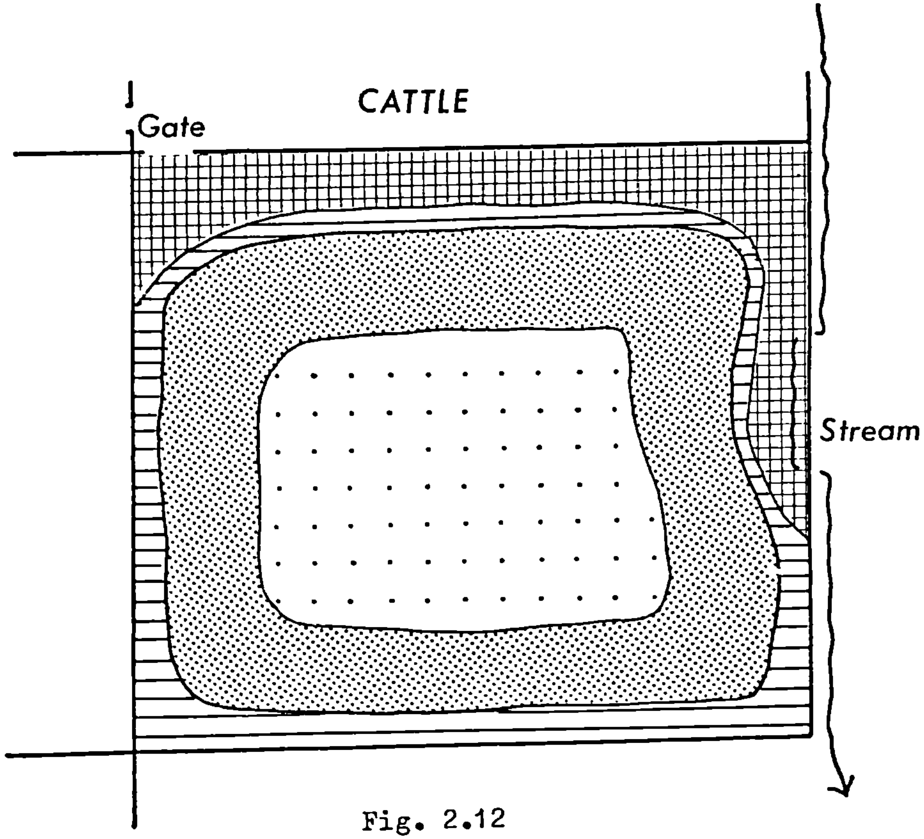


Fig. 2.12

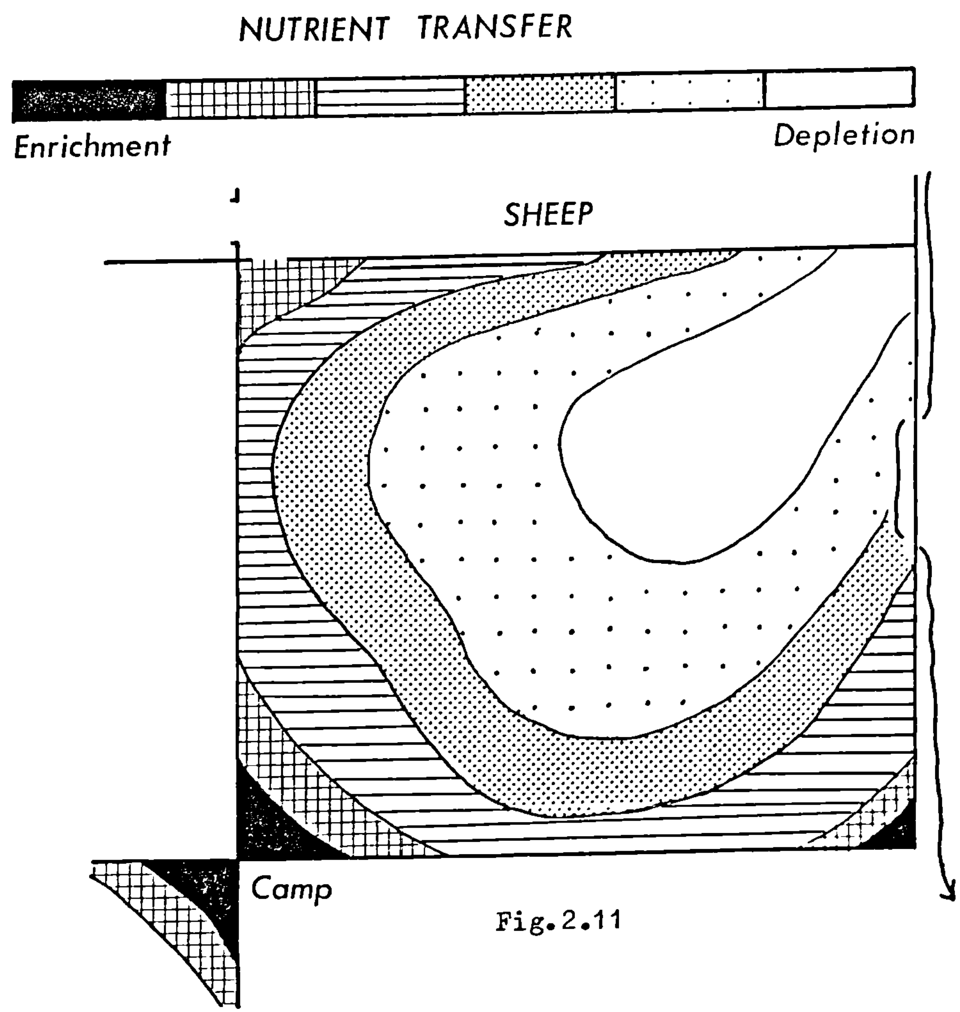


Fig.2.11

Figs. 2.11 and 2.12 Nutrient enrichment and depletion in pastures grazed by sheep and cattle.

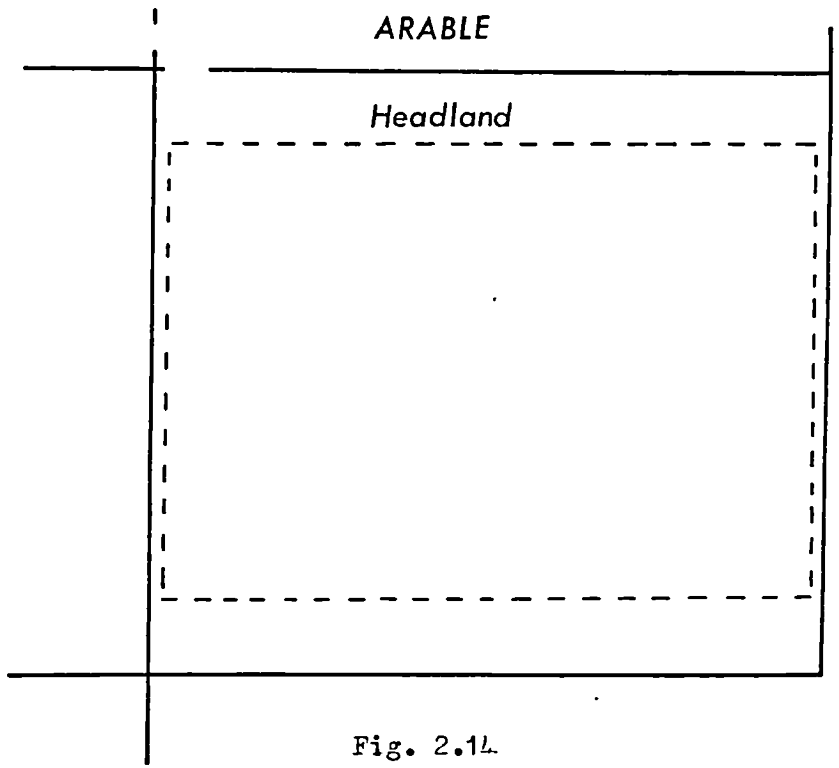


Fig. 2.14

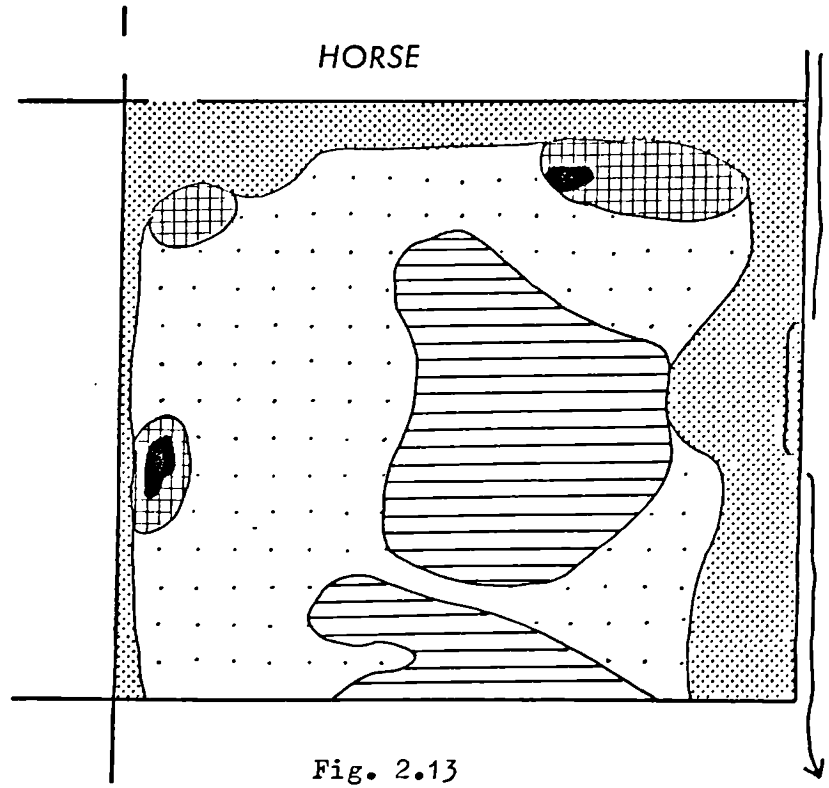


Fig. 2.13

Fig. 2.13 Nutrient enrichment and depletion in pastures grazed by horses (for key see Figs. 2.11 and 2.12)

Fig. 2.14 The major zones within arable fields.

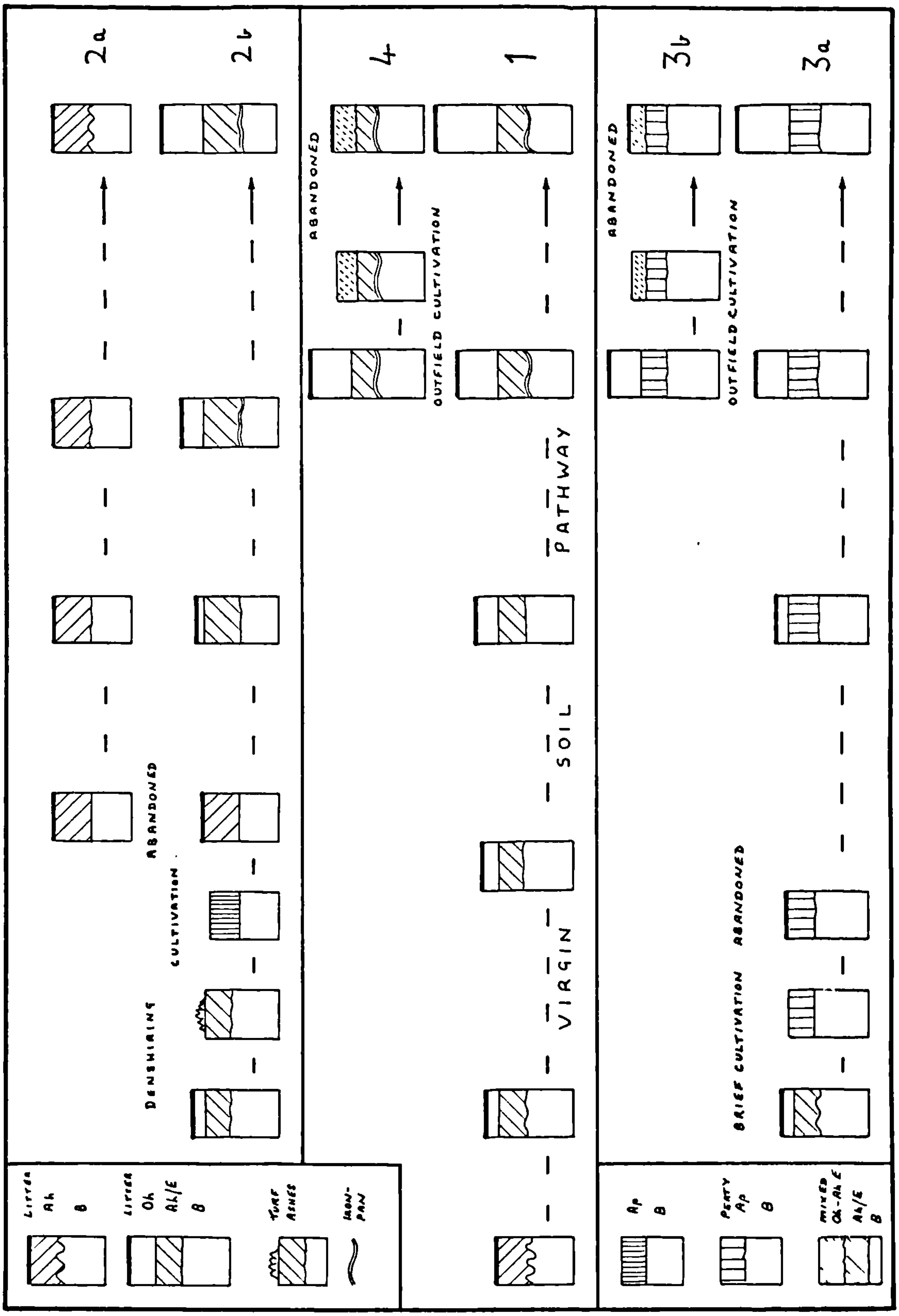


Fig. 2.15 Models of the changes in soil development and profile morphology caused by cultivation of stagnopodzol soils.

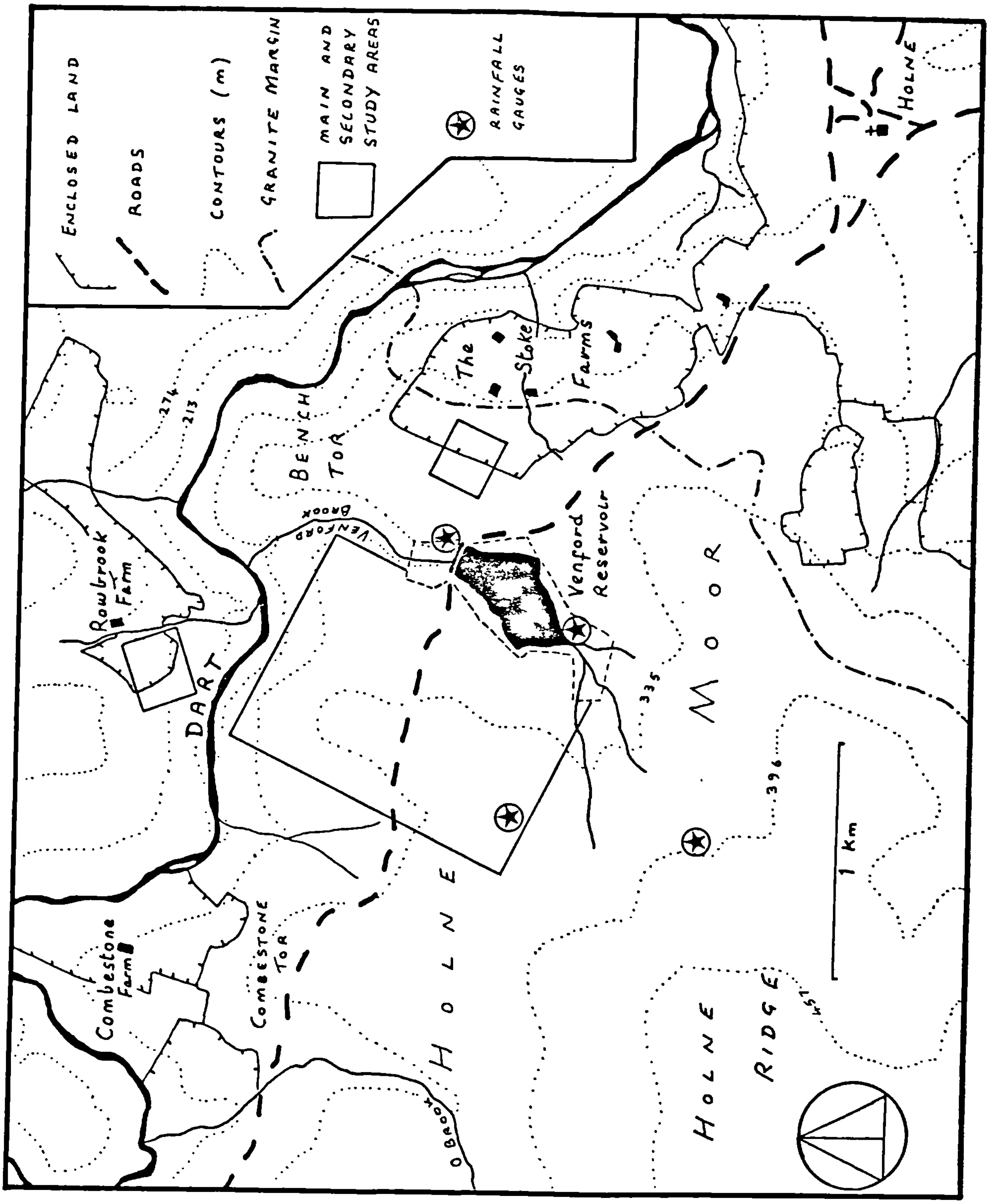


Fig. 3.1 The location of the main study area on Holne Moor and the secondary study areas at Rowbrook and West Stoke farms.

Fig. 3.2 Distribution of vegetation in the Holne Moor study area in 1969 and location of soil pollen sampling sites.

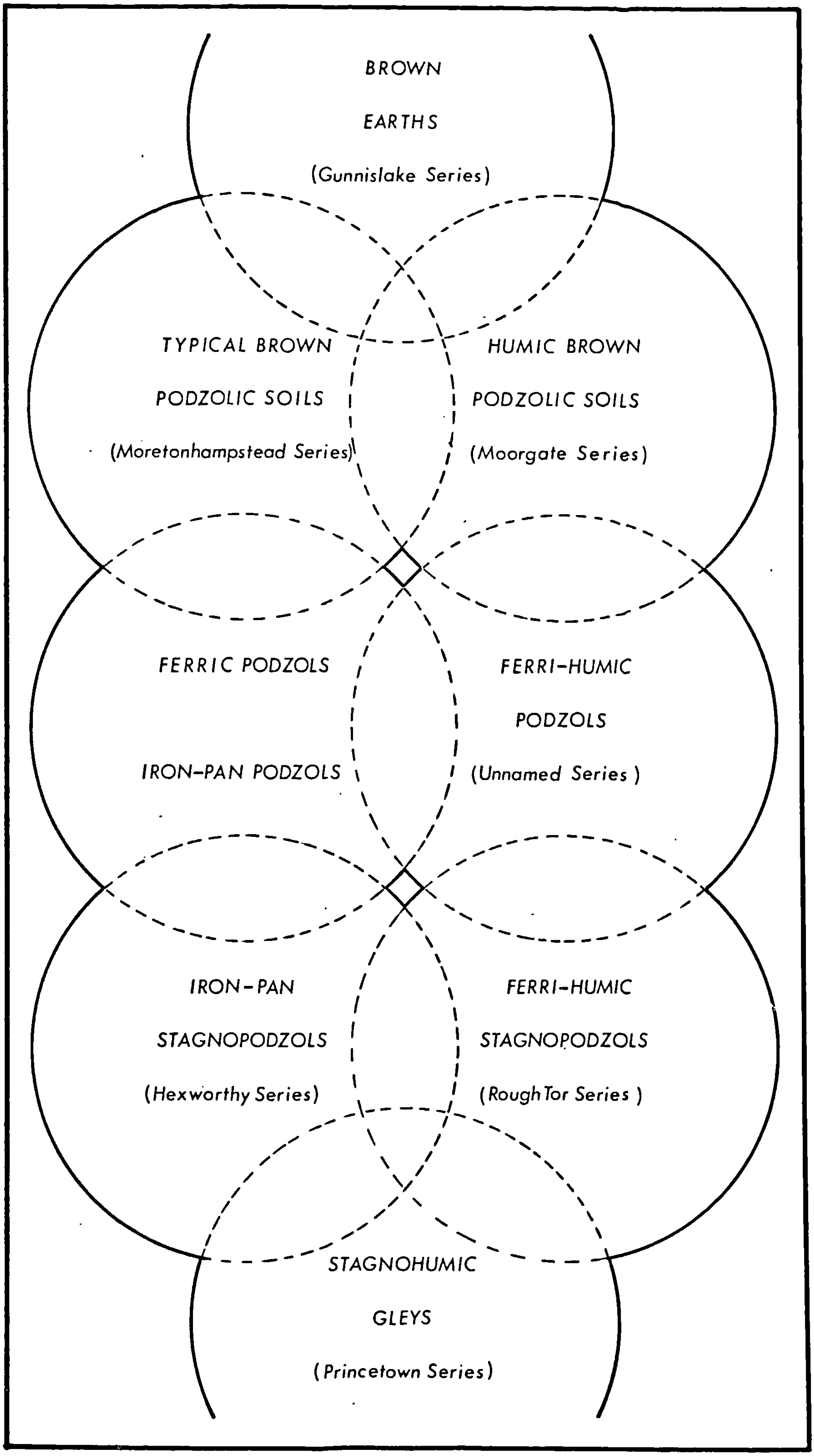


Fig. 3.3 Diagram illustrating the present classification of Dartmoor soils and the relationship between classification units.

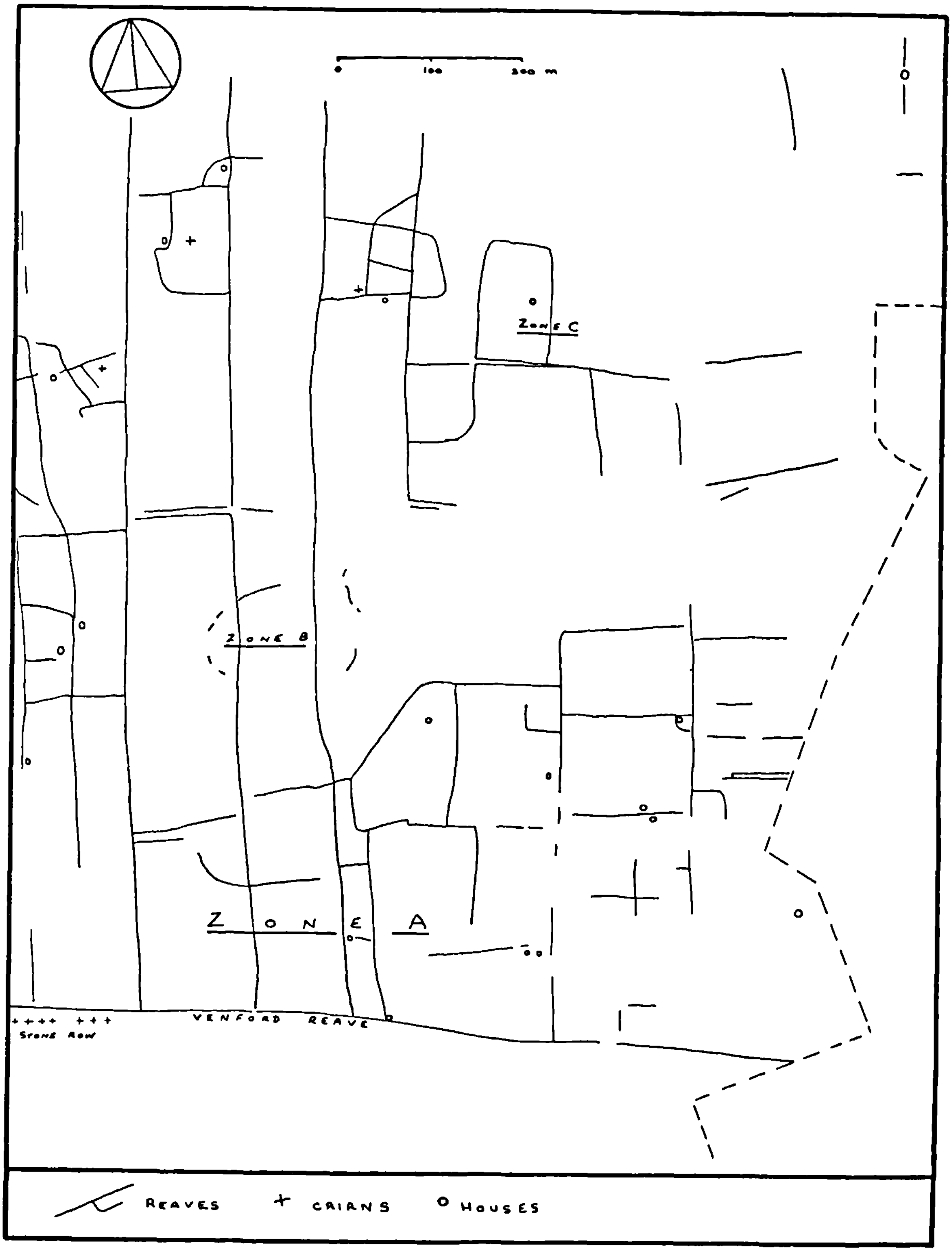


Fig. 3.4 Prehistoric land boundaries (reaves), ceremonial monuments (cairns and a stone row) and houses in the Holne Moor study area.

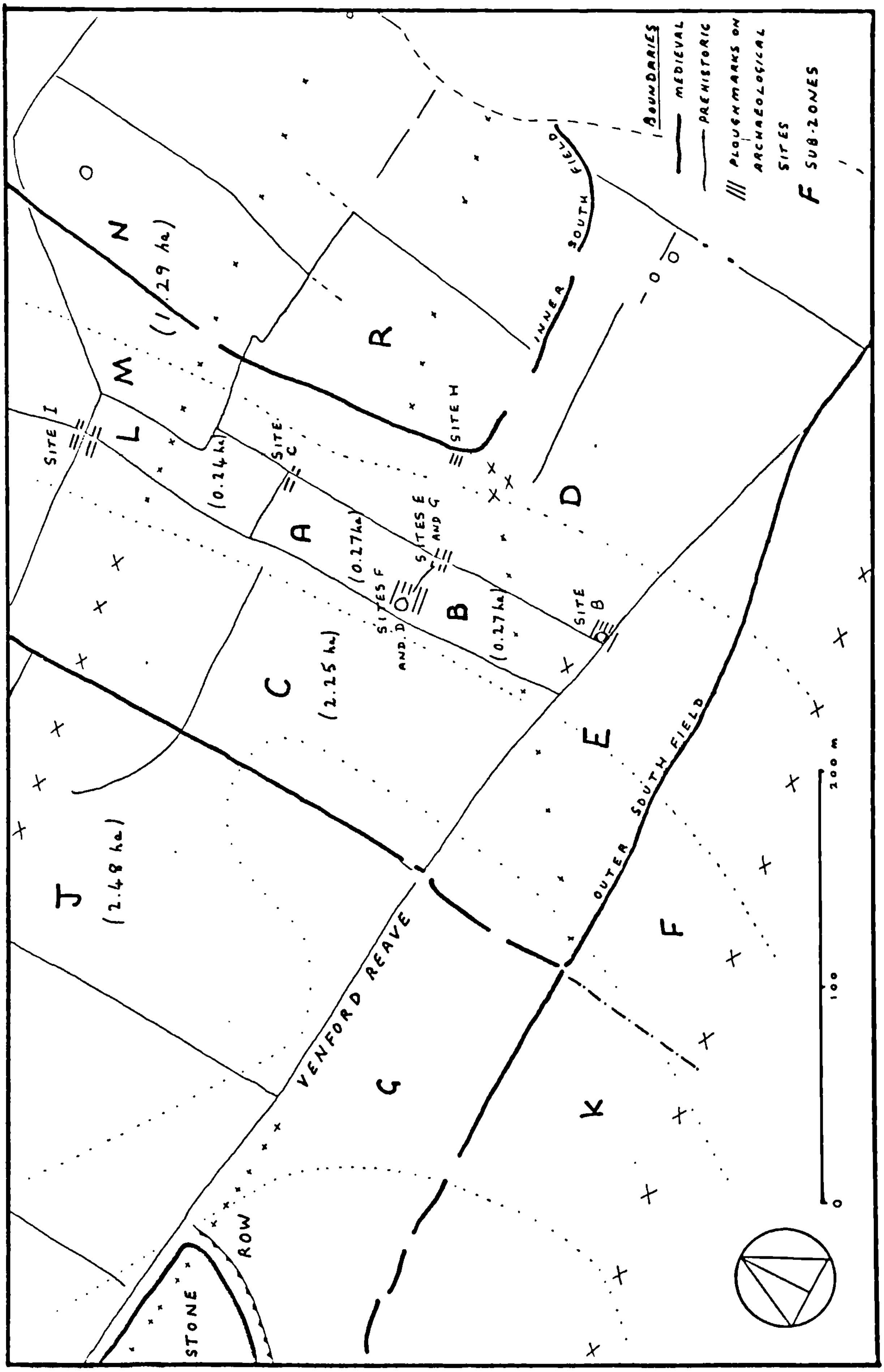


Fig. 3.5 Zone A - prehistoric and medieval land boundaries, archaeological excavation sites and sub-zone divisions.

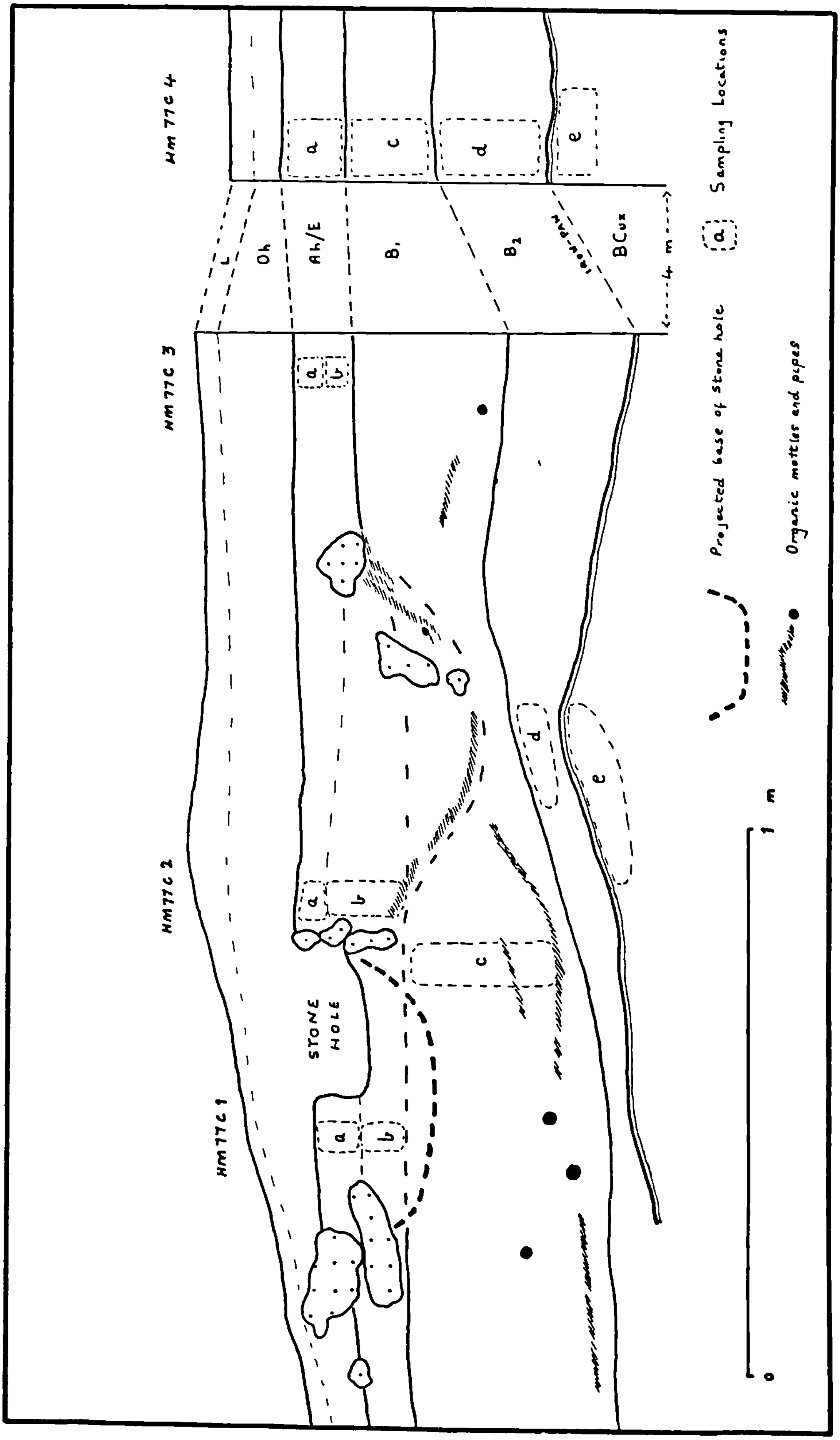


Fig. 3.6 Archaeological site C - south face of excavation showing section through stone reave boundary and bank/lynchet, and soil sampling locations.

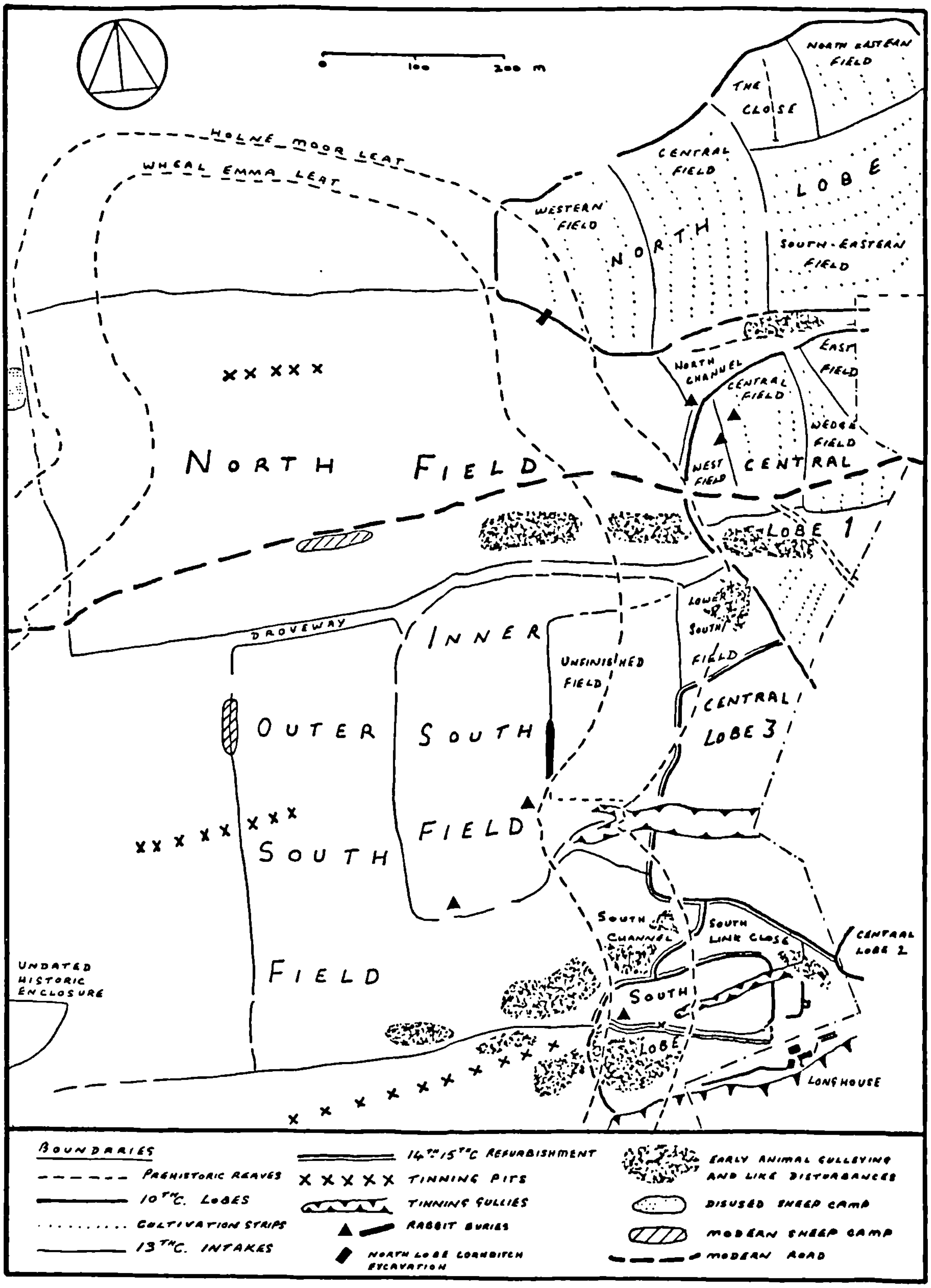


Fig. 3.7 Medieval land boundaries, fields, rabbit buries and tinning works in the Holne Moor study area (after Fleming and Ralph: in press)

Fig. 3.8 Soil mapping sample locations and the main study zones in the Holne Moor study area.

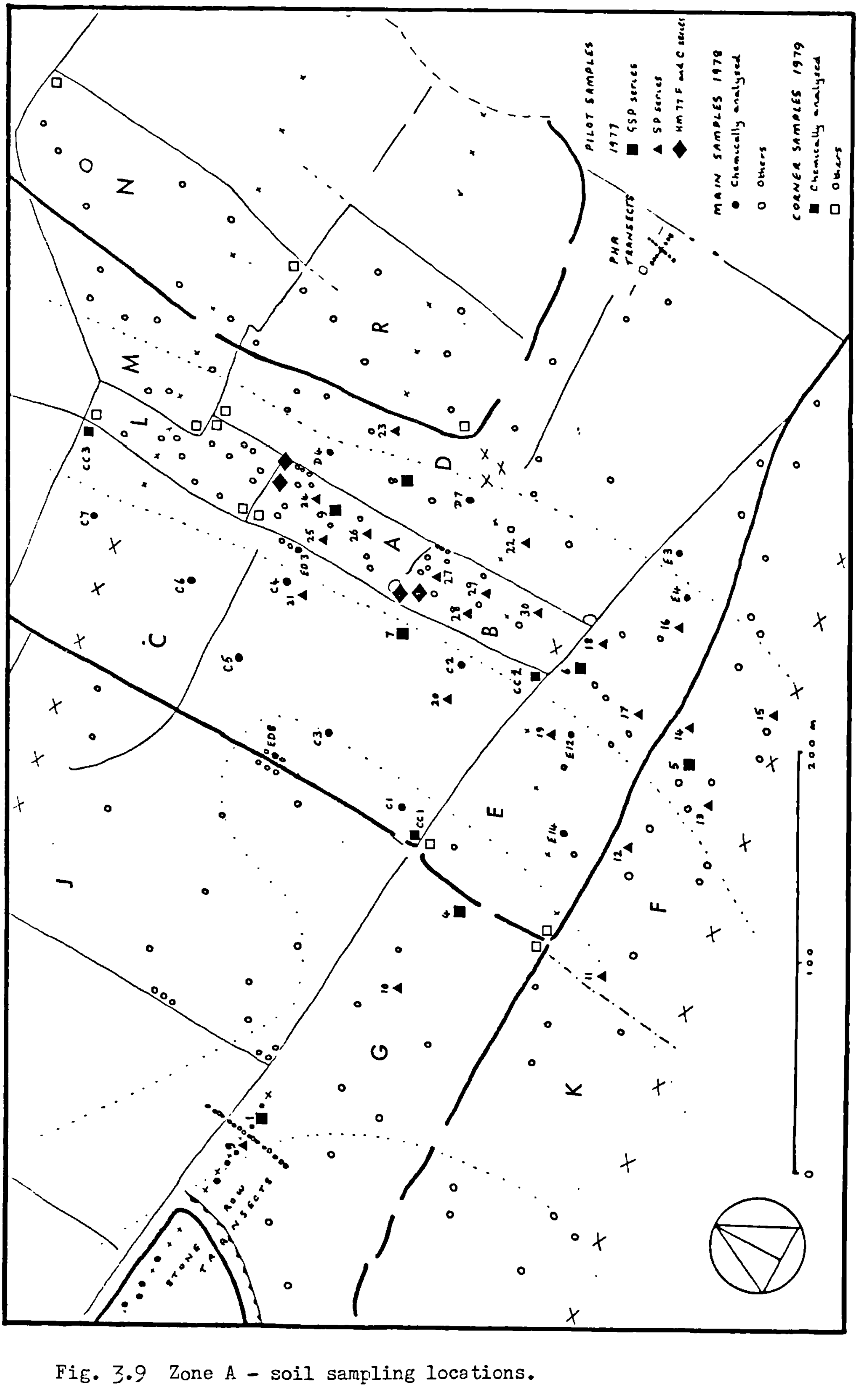


Fig. 3.9 Zone A - soil sampling locations.

Fig. 3.10

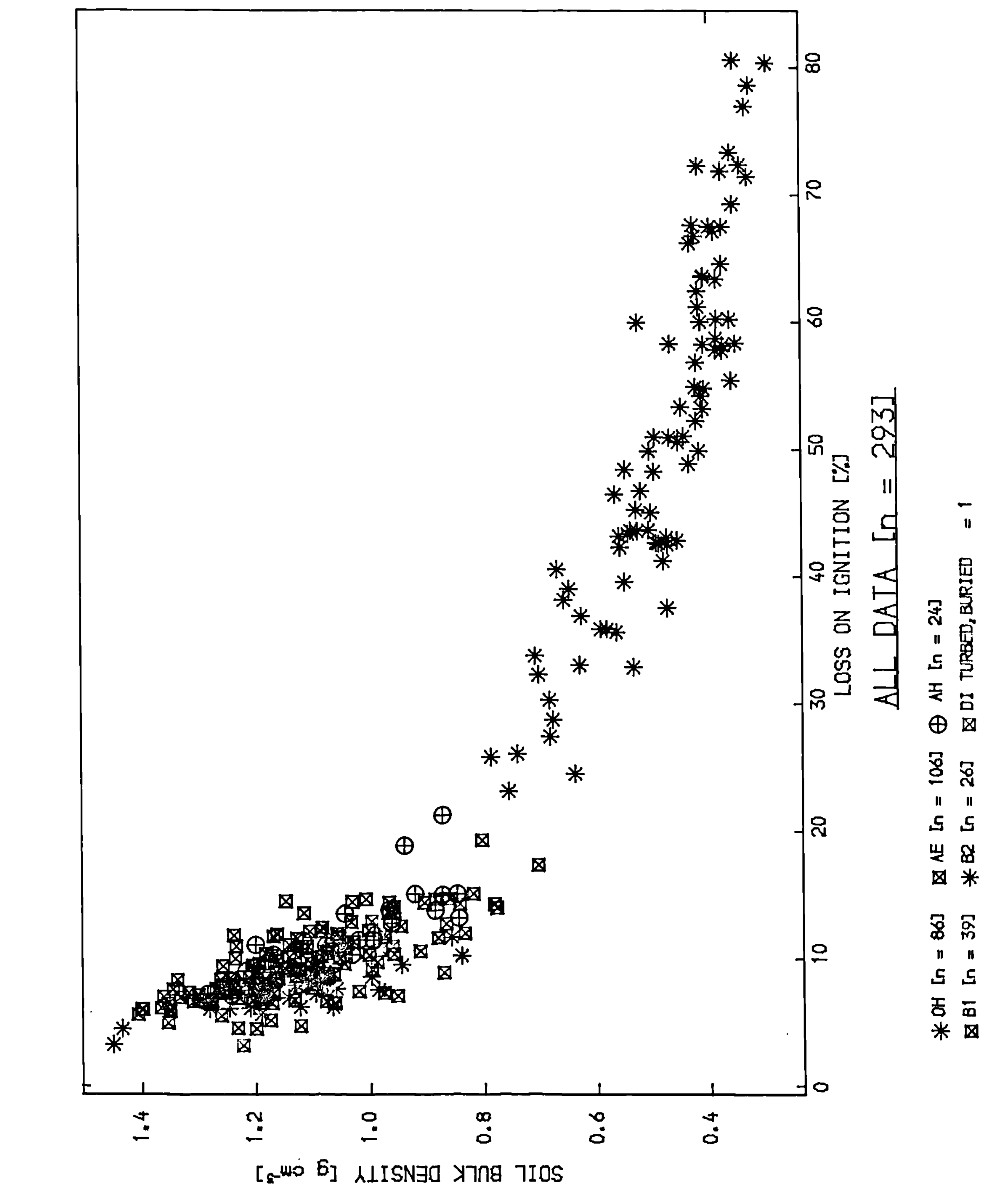

SOIL BULK DENSITY [g cm^{-3}]
1.4
1.2
1.0
0.8
0.6
0.4
LOSS ON IGNITION [%]
0
10
20
30
40
50
60
70
80
ALL DATA [n = 293]
* OH [n = 86]   ⊠ AE [n = 106]   ⊕ AH [n = 24]
⊠ B1 [n = 39]   * B2 [n = 26]   ⊠ DI TURBED, BURIED = 1

Fig. 3.11

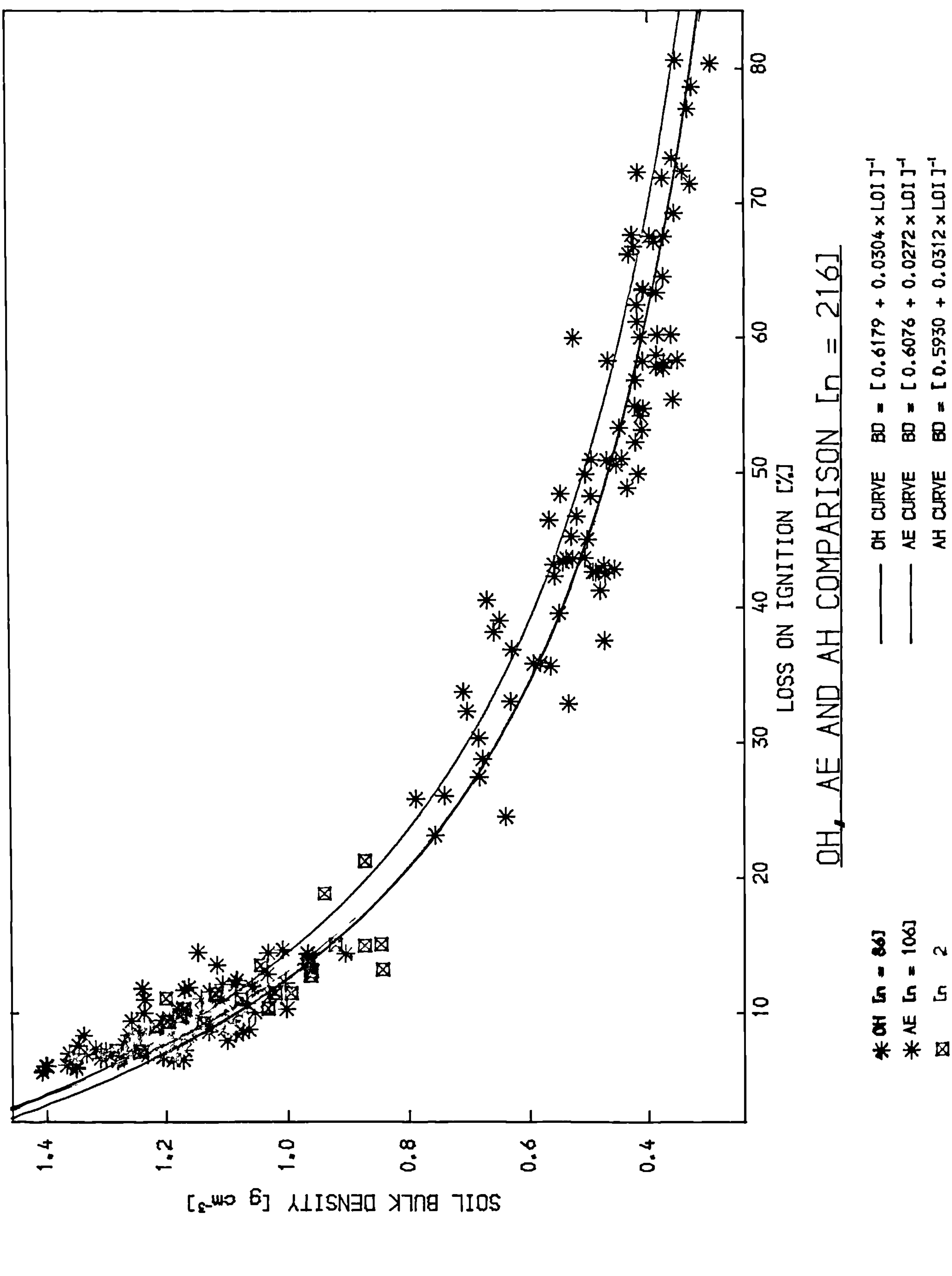

OH, AE AND AH COMPARISON [n = 216]
SOIL BULK DENSITY [g cm-3]
LOSS ON IGNITION [%]
1.4
1.2
1.0
0.8
0.6
0.4
10
20
30
40
50
60
70
80
OH CURVE BD = [0.6179 + 0.0304 x LOI]-1
AE CURVE BD = [0.6076 + 0.0272 x LOI]-1
AH CURVE BD = [0.5930 + 0.0312 x LOI]-1
AE [n = 106]
[n 2

Fig. 3.12

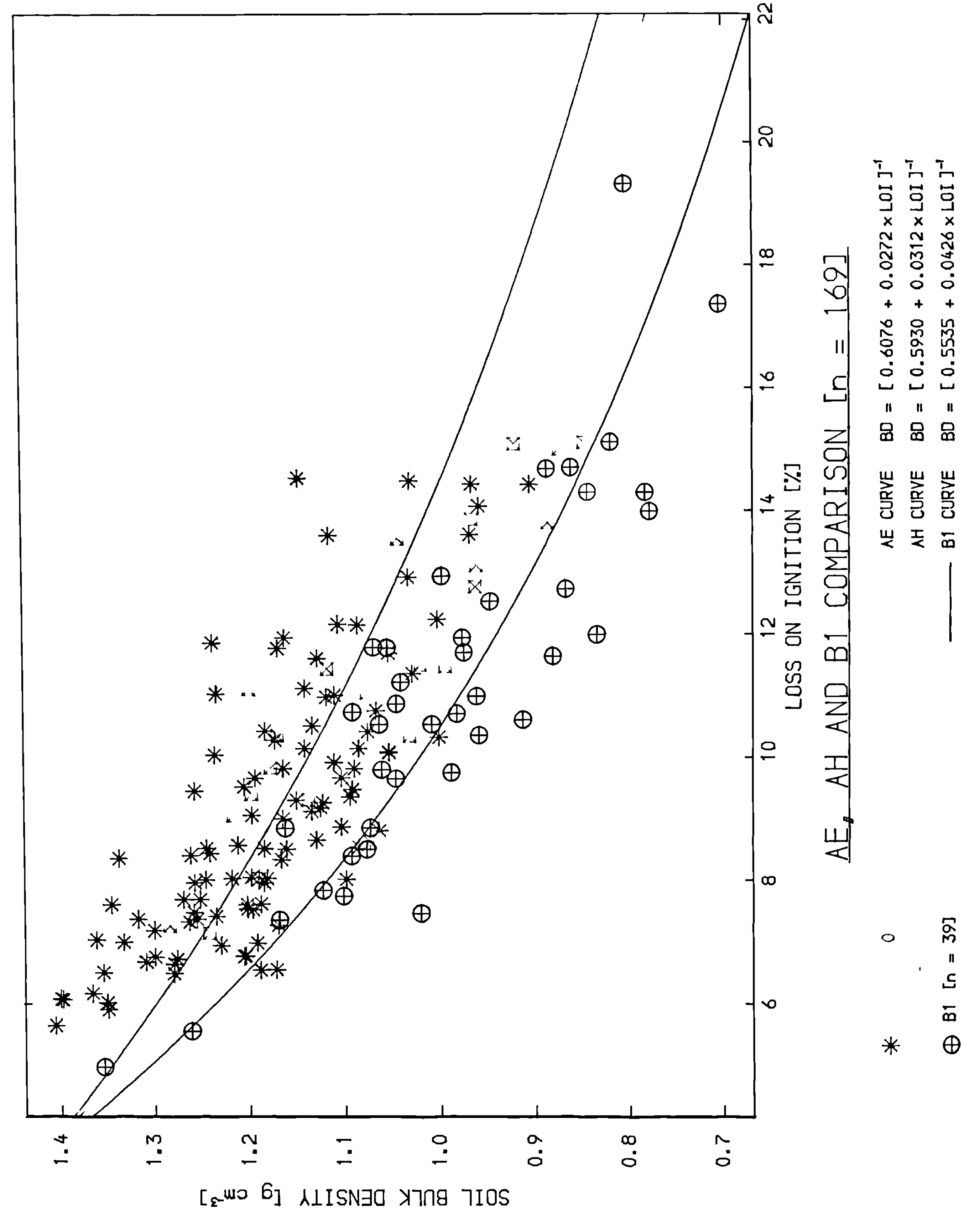

AE, AH AND B1 COMPARISON [n = 169]
LOSS ON IGNITION [%]
SOIL BULK DENSITY [g cm-3]
AE CURVE BD = [0.6076 + 0.0272 x LOI]-1
AH CURVE BD = [0.5930 + 0.0312 x LOI]-1
B1 CURVE BD = [0.5535 + 0.0426 x LOI]-1
B1 [n = 39]
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
6
8
10
12
14
16
18
20
22

Fig. 3.13

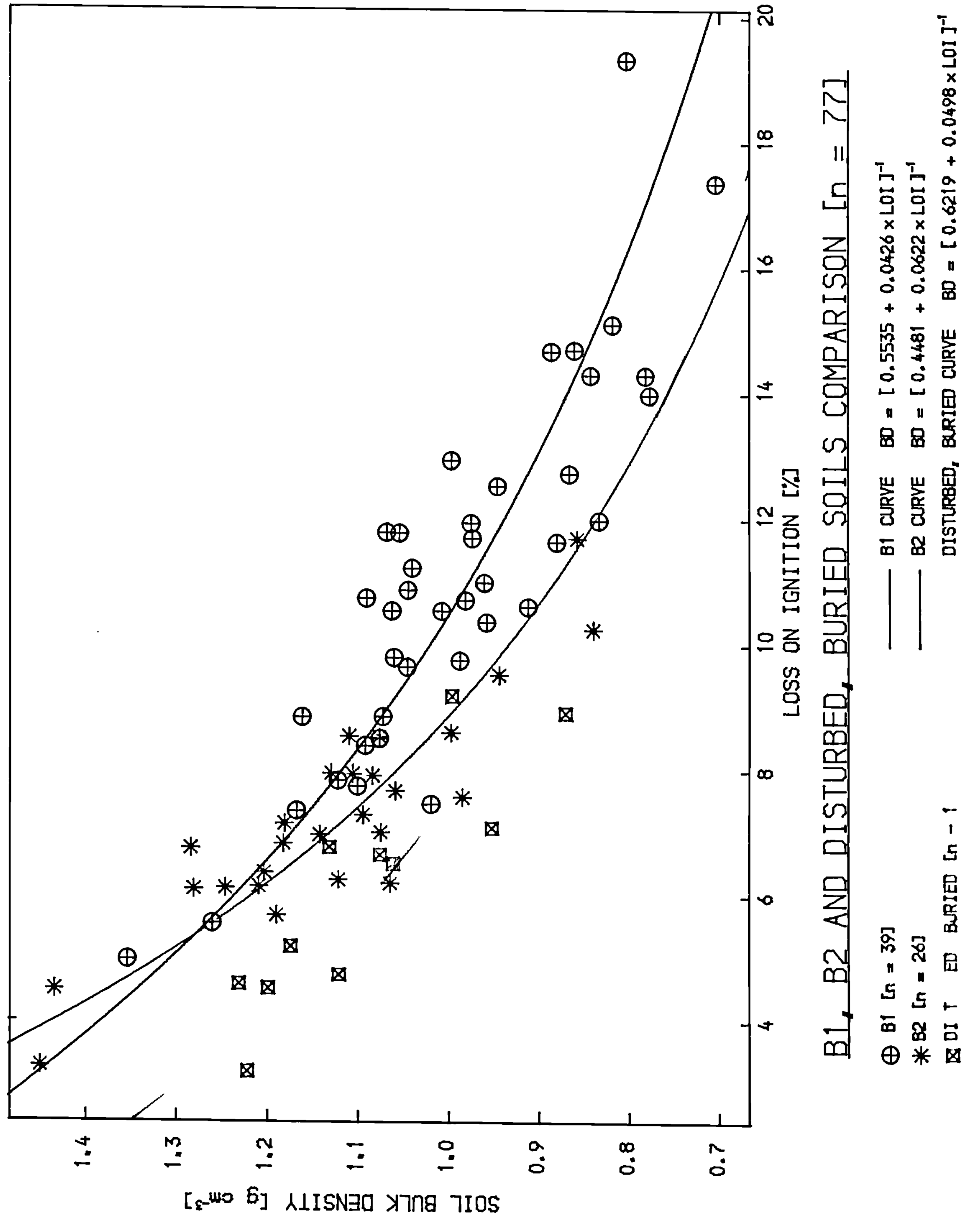

B1, B2 AND DISTURBED, BURIED SOILS COMPARISON [n = 77]
LOSS ON IGNITION [%]
SOIL BULK DENSITY [g cm-3]
4
6
8
10
12
14
16
18
20
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
⊕ B1 [n = 39]
✱ B2 [n = 26]
⊠ DI T ED BURIED [n - 1
B1 CURVE BD = [0.5535 + 0.0426 x LOI]-1
B2 CURVE BD = [0.4481 + 0.0622 x LOI]-1
DISTURBED, BURIED CURVE BD = [0.6219 + 0.0498 x LOI]-1

Fig. 3.14

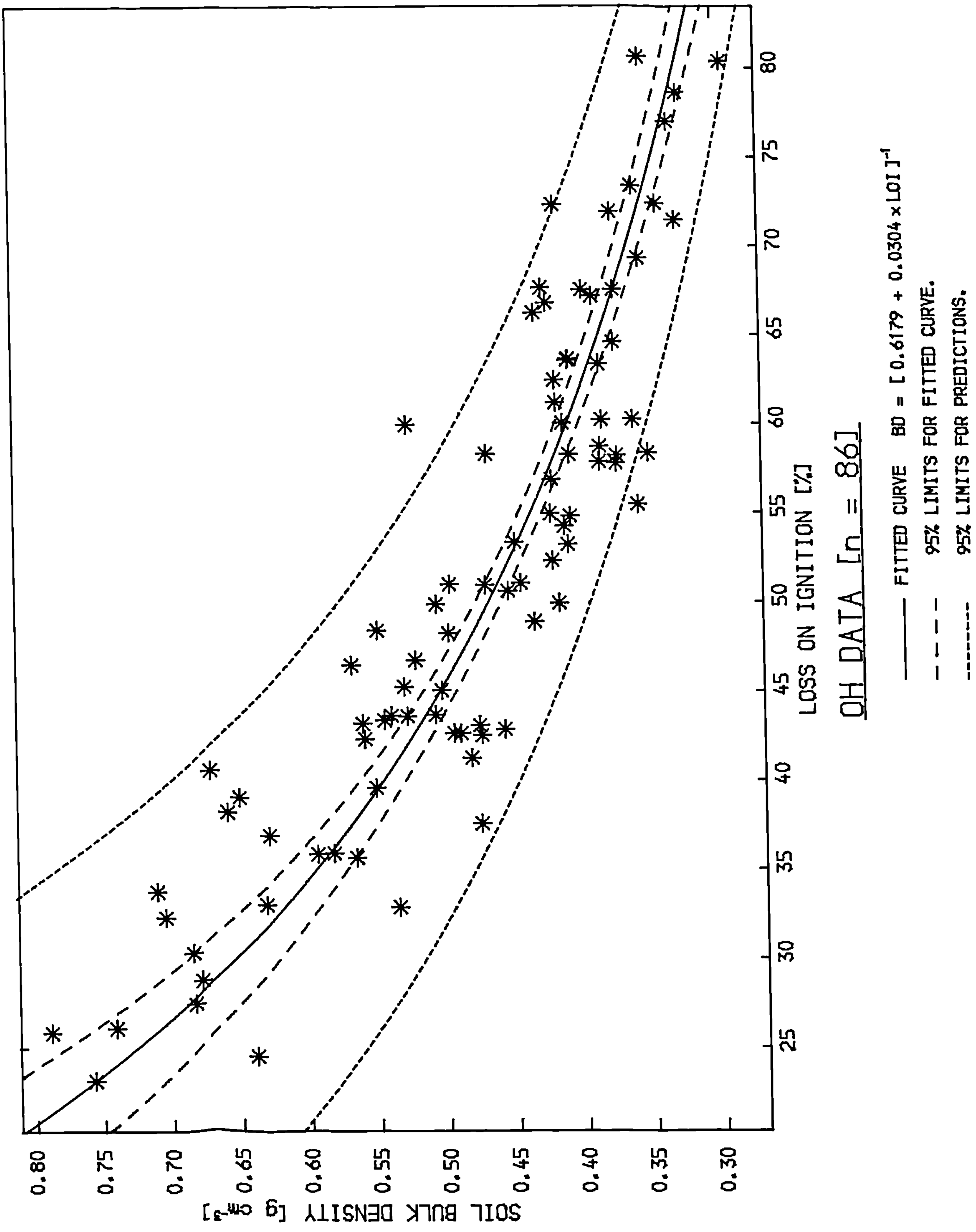

SOIL BULK DENSITY [g cm-3]
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
LOSS ON IGNITION [%]
25
30
35
40
45
50
55
60
65
70
75
80
OH DATA [n = 86]
FITTED CURVE BD = [0.6179 + 0.0304 x LOI]-1
95% LIMITS FOR FITTED CURVE.
95% LIMITS FOR PREDICTIONS.

Fig. 3.15

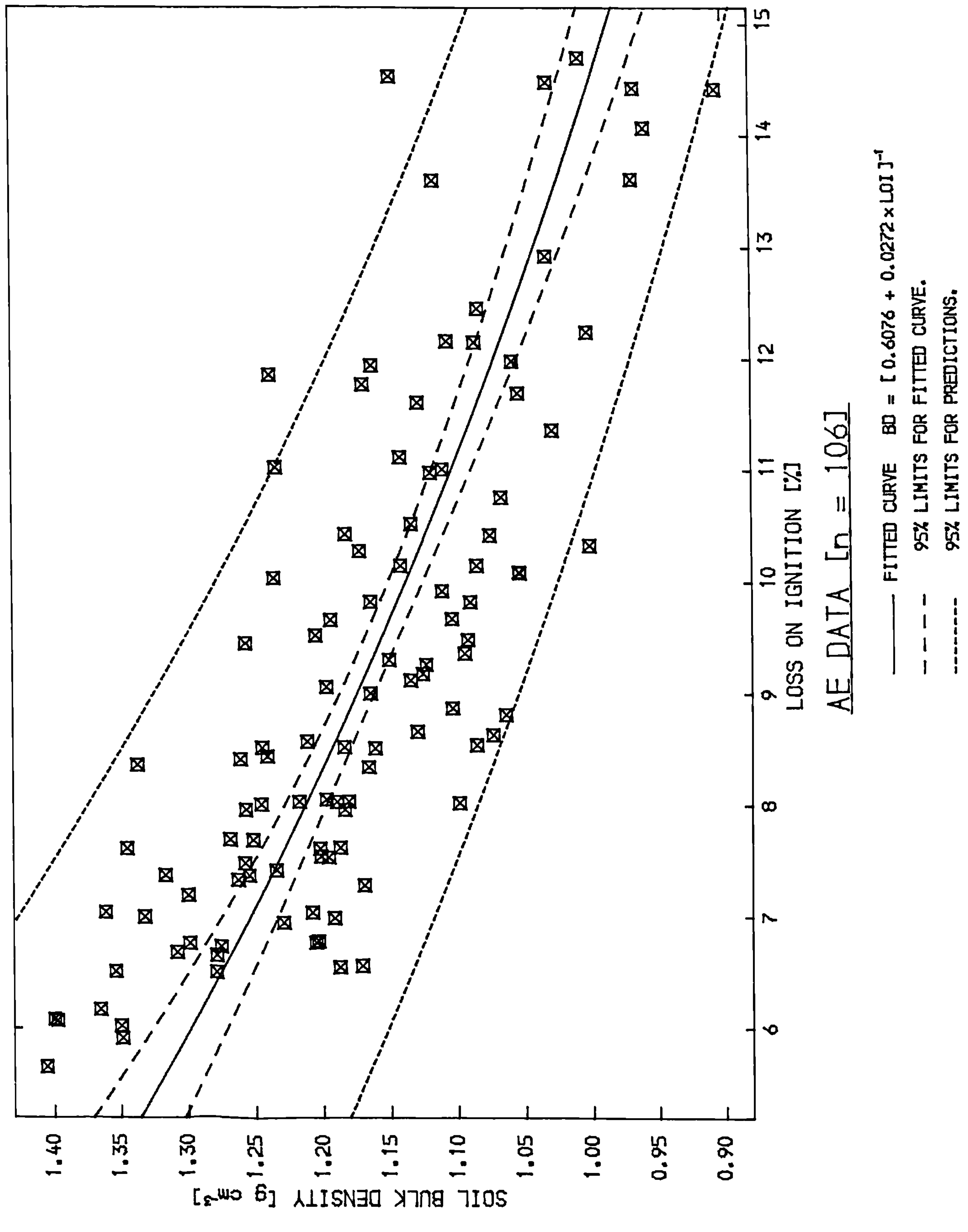
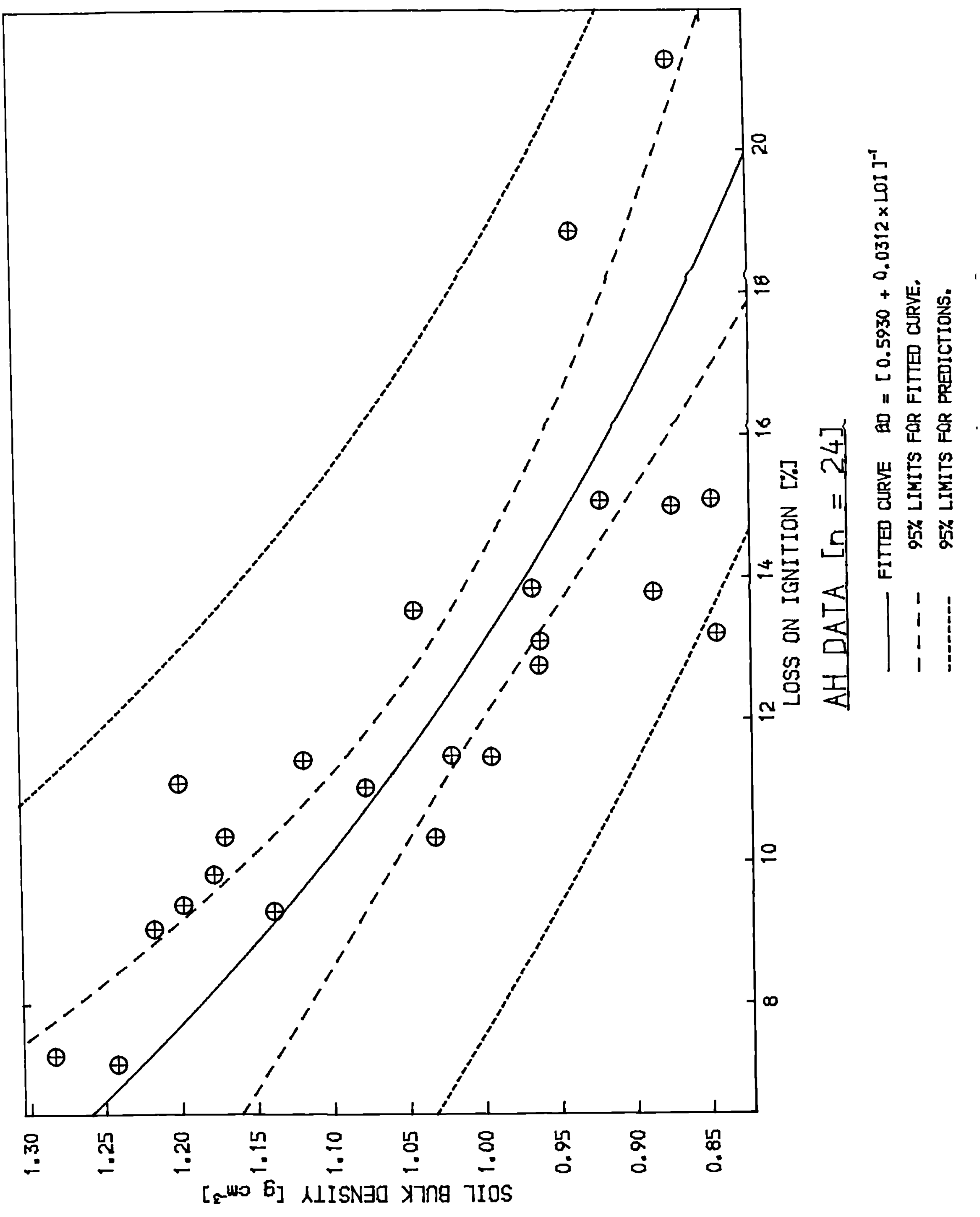

SOIL BULK DENSITY [g cm-3]
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
6
7
8
9
10
11
12
13
14
15
LOSS ON IGNITION [%]
AE DATA [n = 106]
FITTED CURVE BD = [0.6076 + 0.0272 x LOI]-1
95% LIMITS FOR FITTED CURVE.
95% LIMITS FOR PREDICTIONS.

Fig. 3.16



SOIL BULK DENSITY [g cm⁻³]
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
8
10
12
14
16
18
20
LOSS ON IGNITION [%]
AH DATA [n = 24]
FITTED CURVE BD = [0.5930 + 0.0312 × LOI]⁻¹
95% LIMITS FOR FITTED CURVE.
95% LIMITS FOR PREDICTIONS.

Fig. 3.17

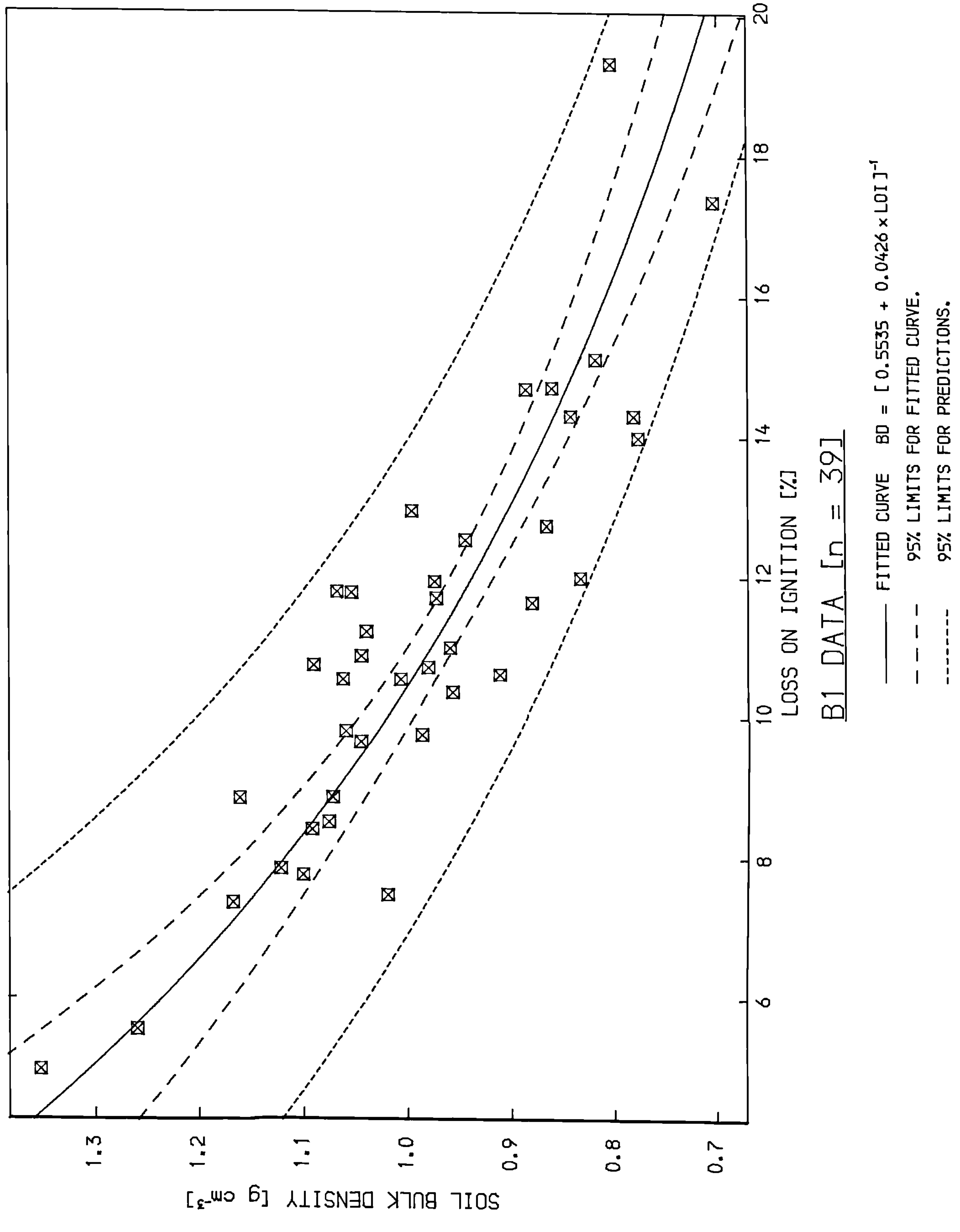

SOIL BULK DENSITY [g cm-3]
1.3
1.2
1.1
1.0
0.9
0.8
0.7
6
8
10
12
14
16
18
20
LOSS ON IGNITION [%]
B1 DATA [n = 39]
FITTED CURVE BD = [0.5535 + 0.0426 x LOI]-1
95% LIMITS FOR FITTED CURVE.
95% LIMITS FOR PREDICTIONS.

Fig. 3.18

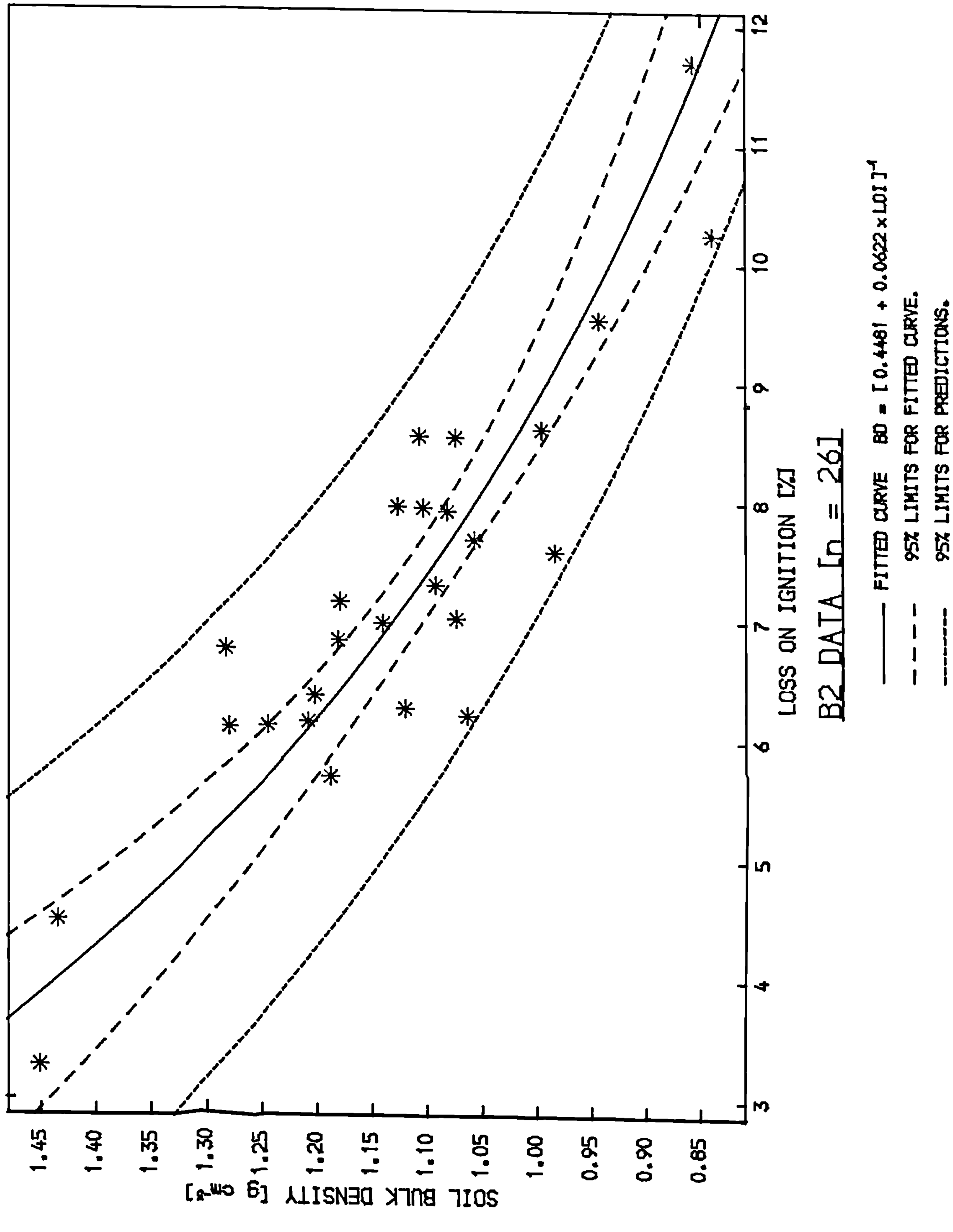

B2 DATA [n = 26]
LOSS ON IGNITION [%]
SOIL BULK DENSITY [g cm-3]
FITTED CURVE BD = [0.4481 + 0.0622 x LOI]-1
95% LIMITS FOR FITTED CURVE.
95% LIMITS FOR PREDICTIONS.
3
4
5
6
7
8
9
10
11
12
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85

Fig. 3.19

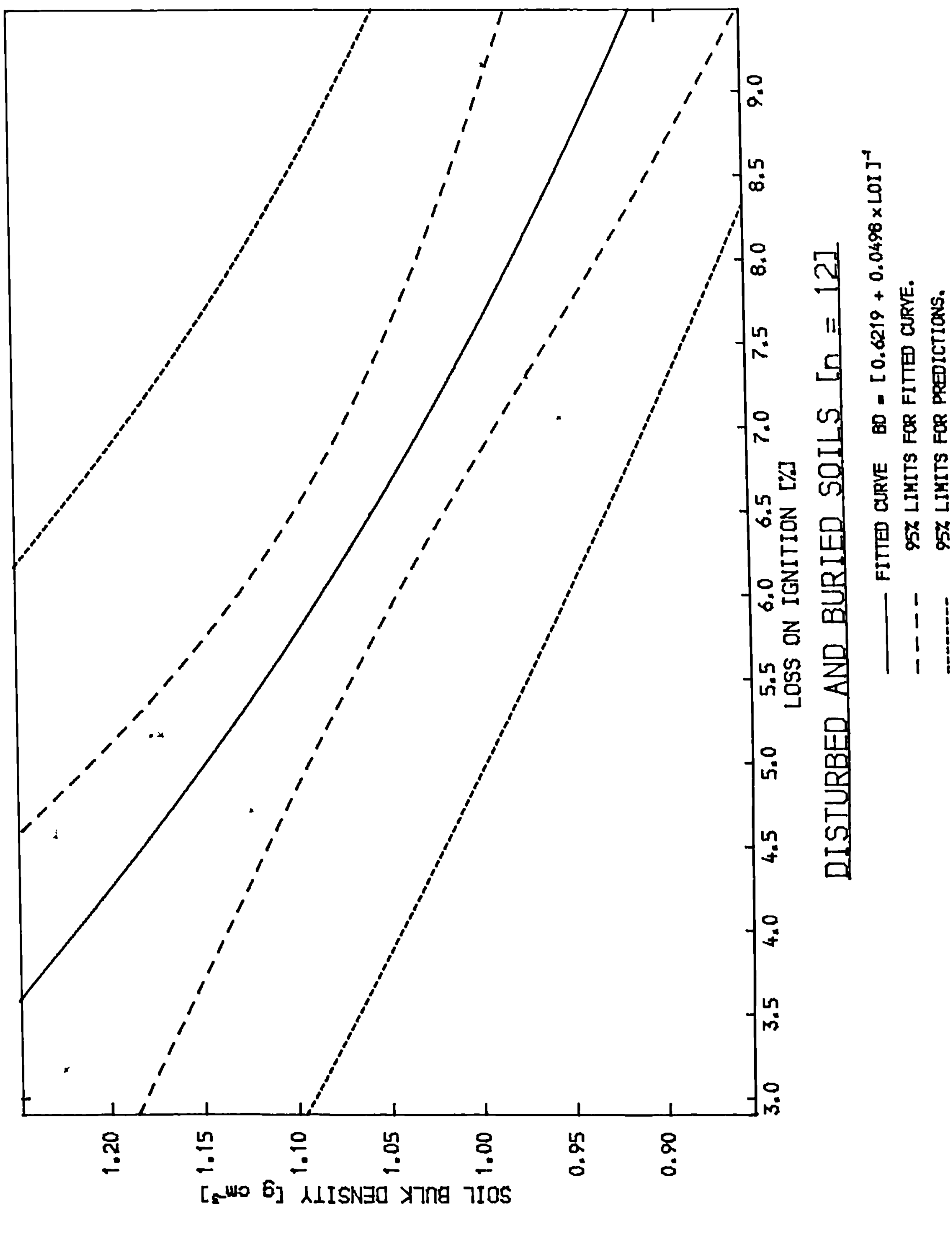
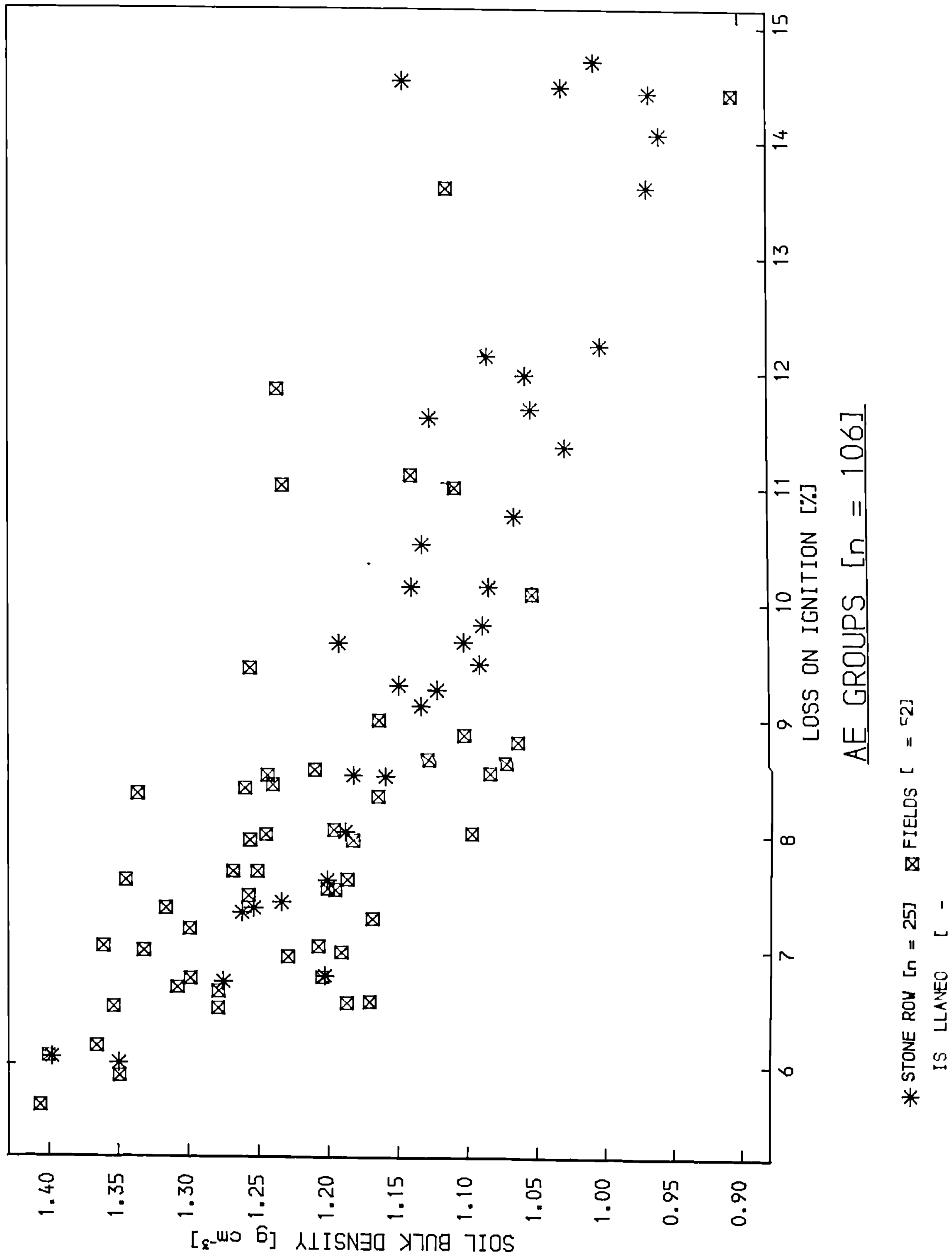
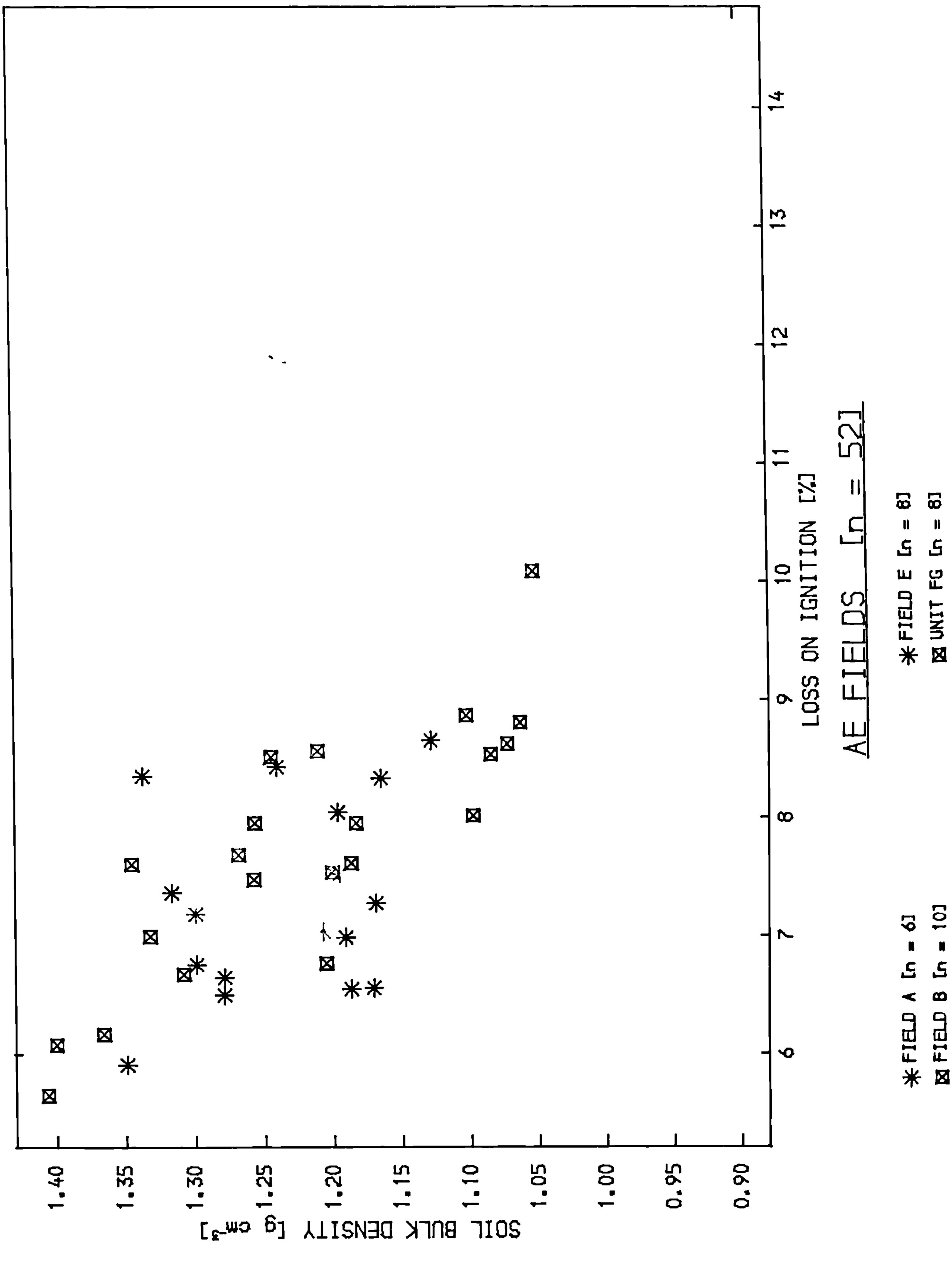

DISTURBED AND BURIED SOILS [n = 12]
FITTED CURVE BD = [0.6219 + 0.0498 x LOI]^-1
95% LIMITS FOR FITTED CURVE.
95% LIMITS FOR PREDICTIONS.
LOSS ON IGNITION [%]
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
SOIL BULK DENSITY [g cm^-3]
1.20
1.15
1.10
1.05
1.00
0.95
0.90

Fig. 3.20



SOIL BULK DENSITY [g cm-3]
LOSS ON IGNITION [%]
AE GROUPS [n = 106]
STONE ROW [n = 25]
FIELDS [= 52]
IS LLANEO [-

Fig. 3.21


AE FIELDS [n = 52]
LOSS ON IGNITION [%]
6
7
8
9
10
11
12
13
14
SOIL BULK DENSITY [g cm-3]
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
FIELD A [n = 6]
FIELD B [n = 10]
FIELD E [n = 8]
UNIT FG [n = 8]

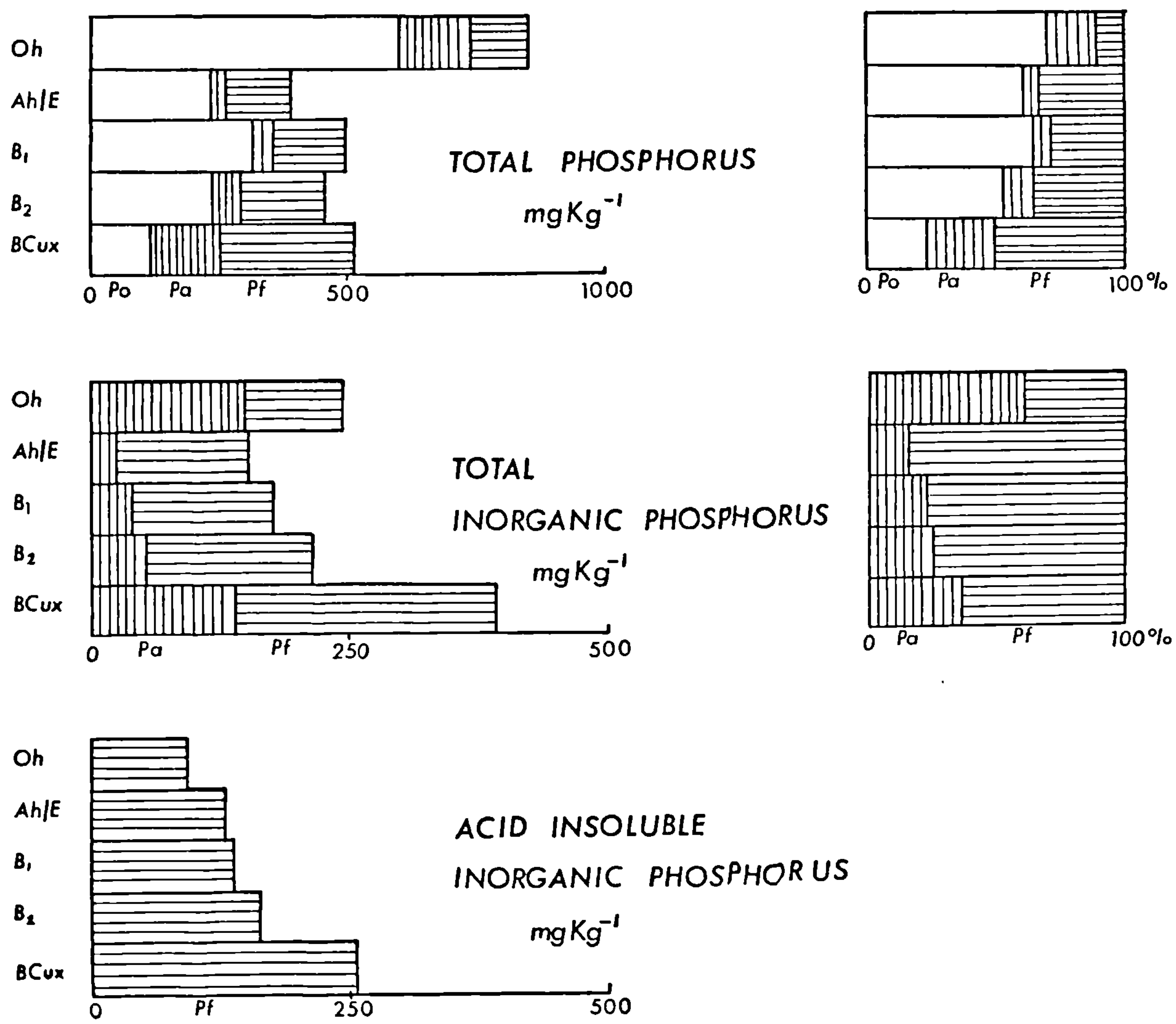


Fig. 3.22 Diagrams illustrating the general pattern of the vertical distribution of phosphorus (concentration by weight) in the stagnopodzol soils on Holne Moor

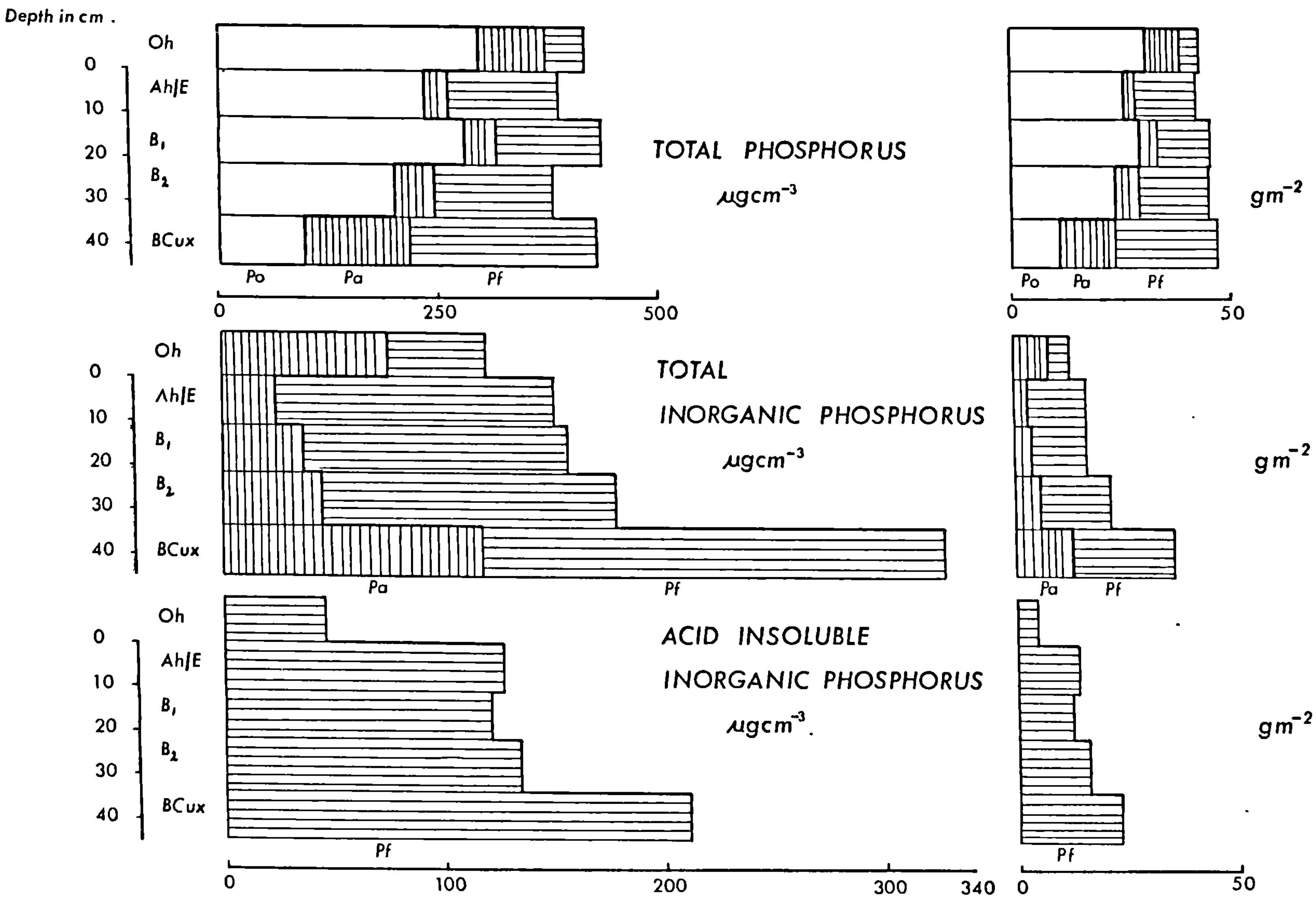


Fig. 3.23
Diagrams illustrating the general pattern of the vertical distribution of phosphorus (concentration by volume) in the stagnopodzol soils on Holne Moor.

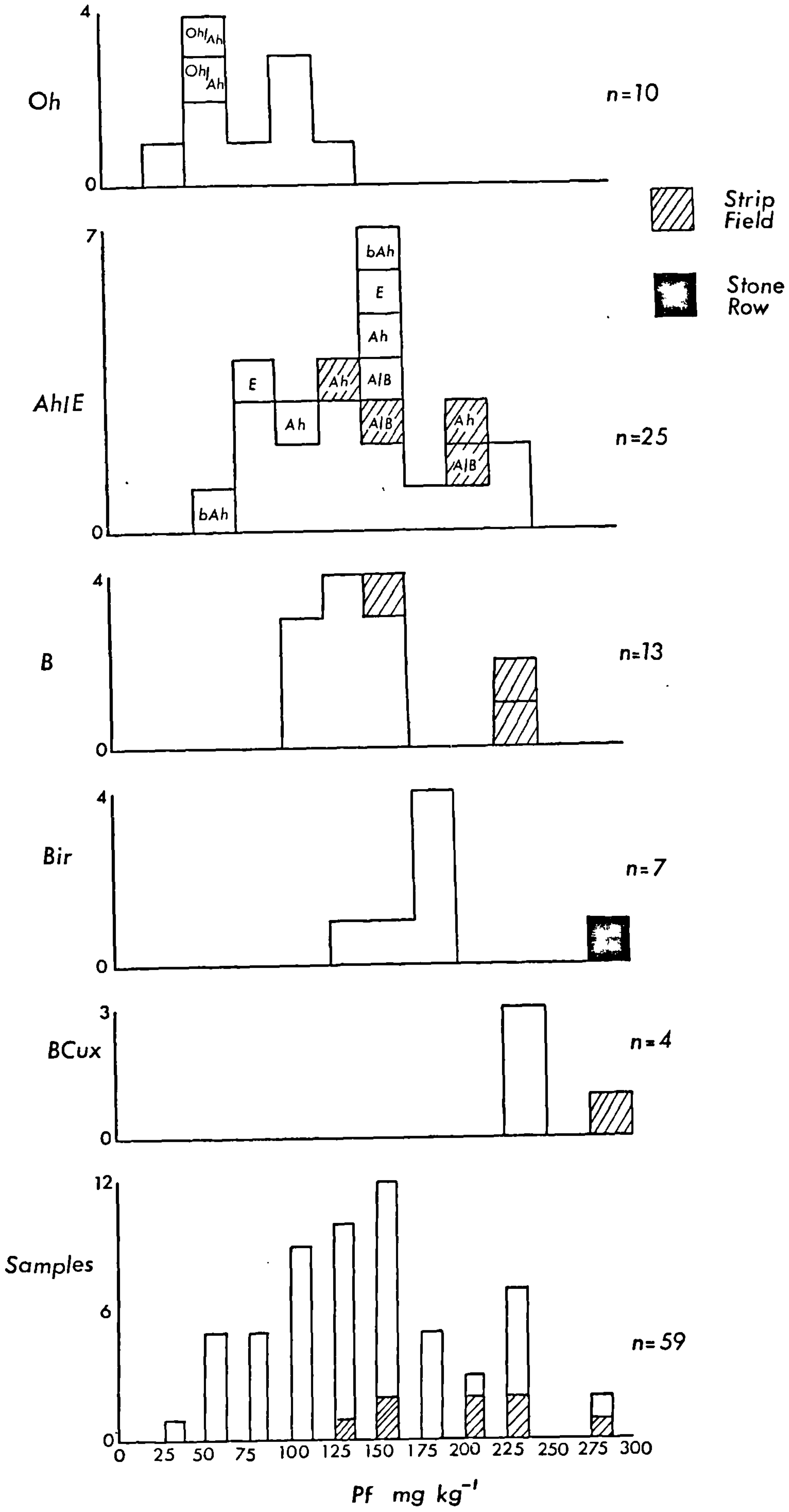


Fig. 3.24 Histograms showing the concentration of Pf in soil samples from Holne Moor.

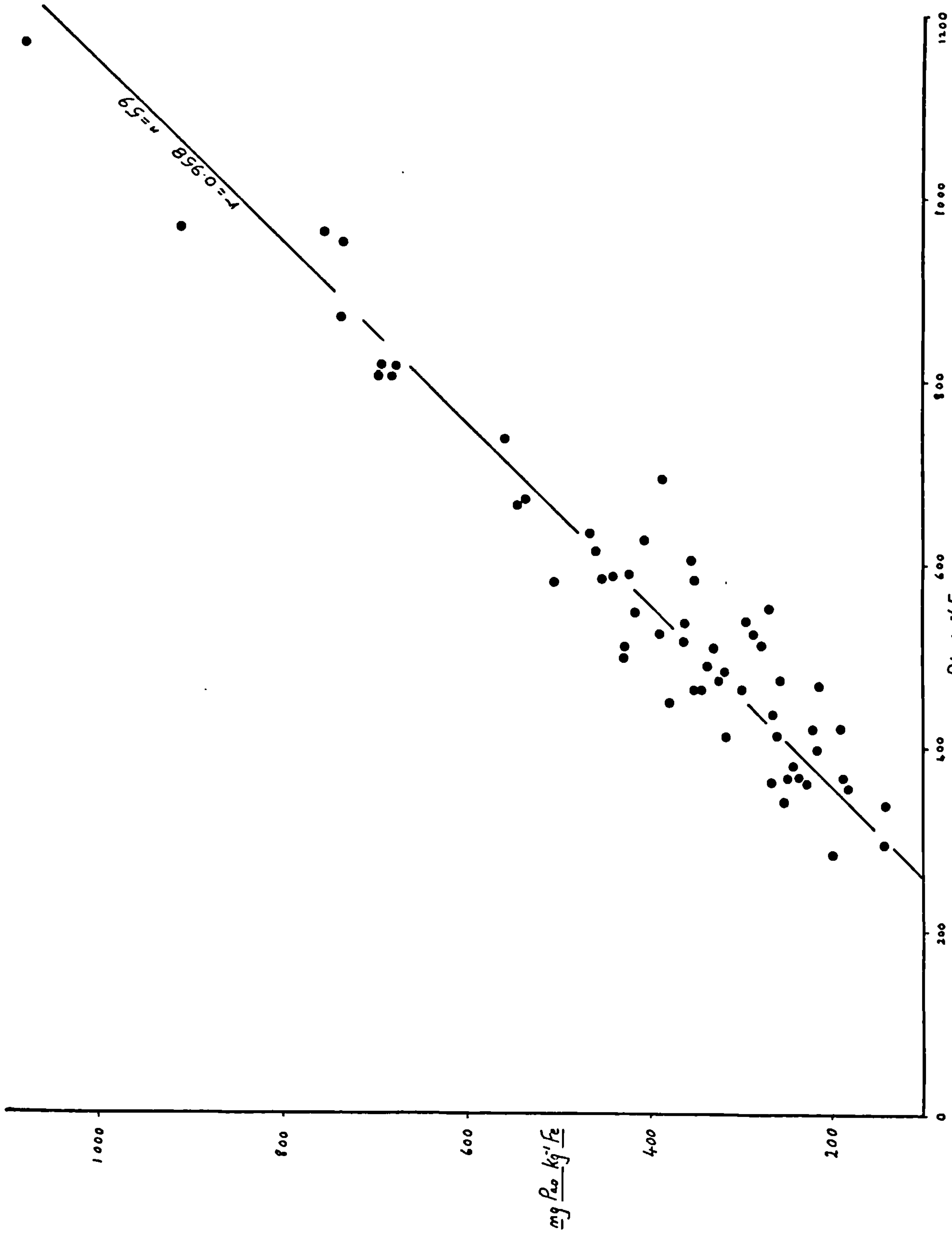


Fig. 3.25 Scattergram illustrating the relationship between Pt and Pao in soil samples from Holne Moor.

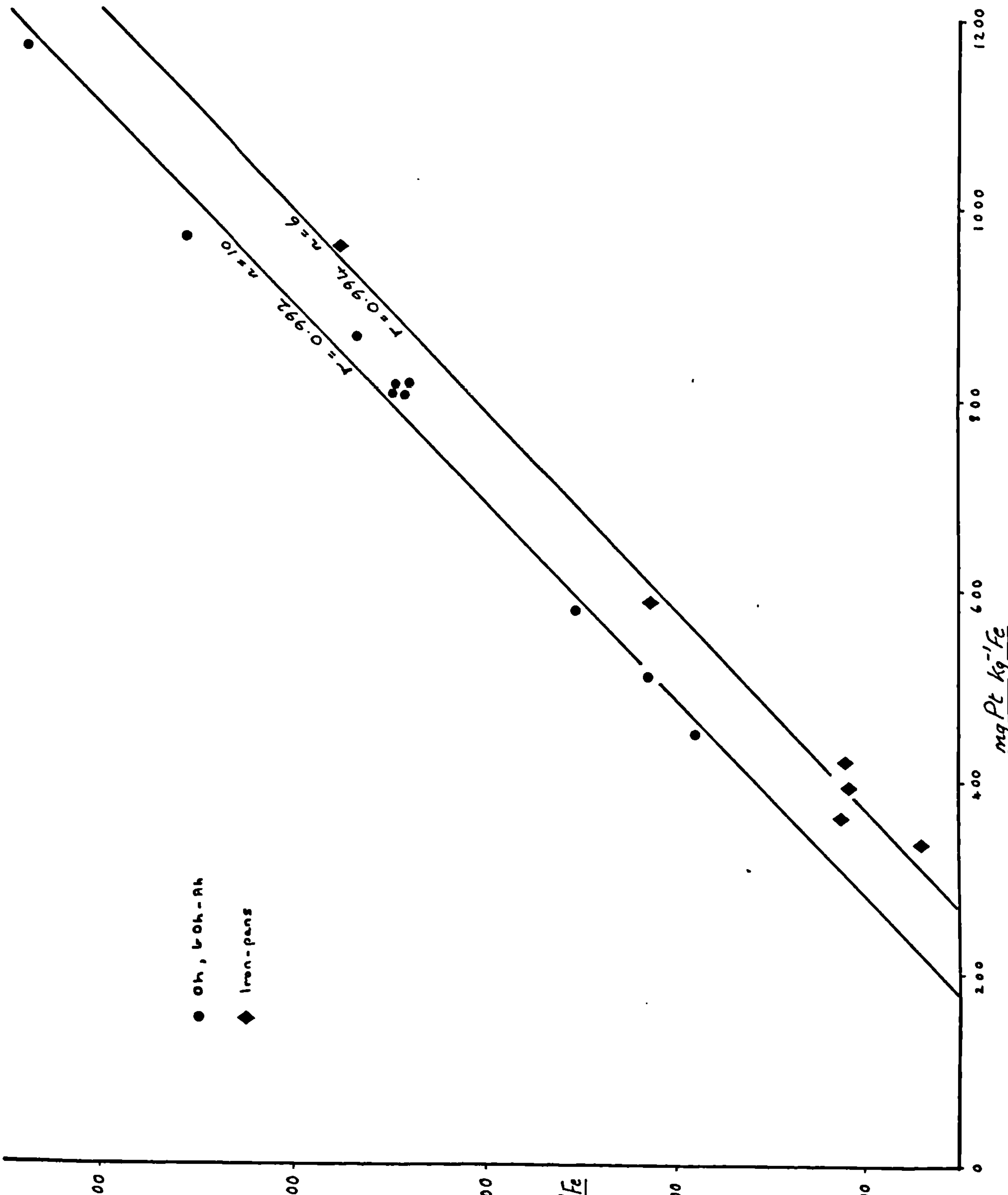


Fig. 3.26 Scattergram illustrating the relationship between Pt and Pao in Oh, bOh- Ah and ironpan samples from Holne Moor.

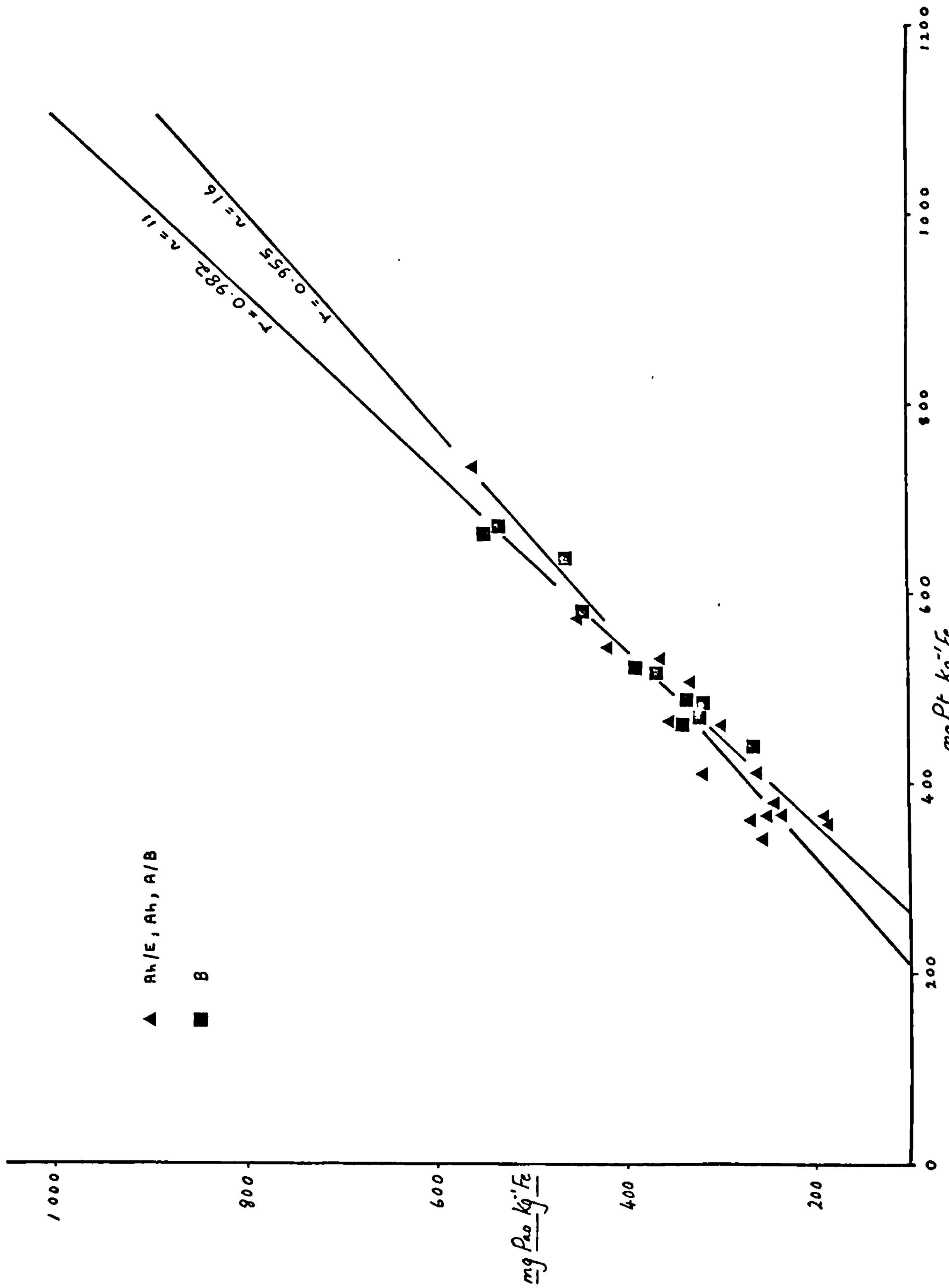


Fig. 3.27 Scattergram illustrating the relationship between Pt and Pao in Ah/E, Ah, A/B and B horizon samples from Holne Moor.

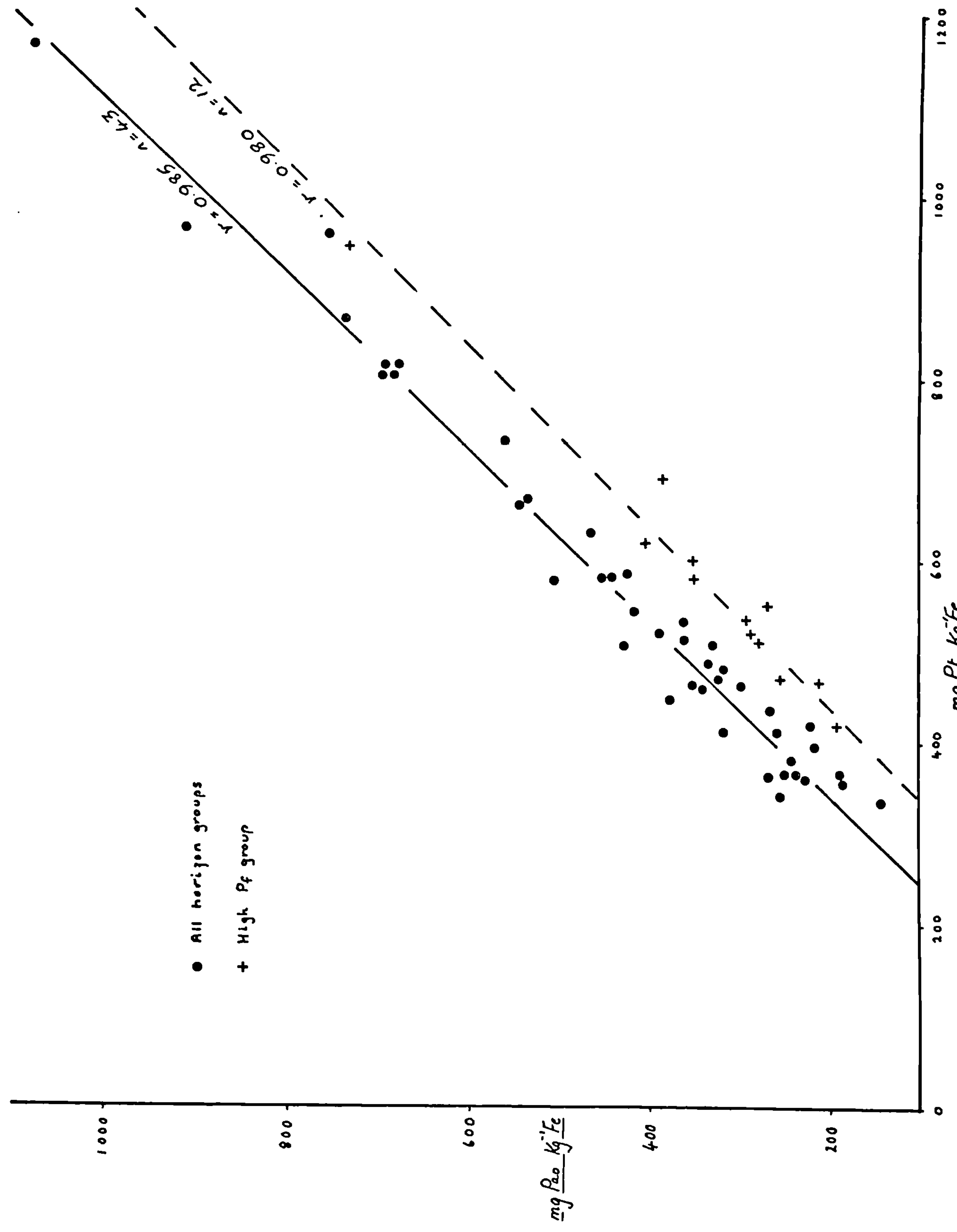


Fig. 3.28 Scattergram illustrating the relationship between Pt and Pao in the normal and the 'High Pf' soil samples from Holne Moor.

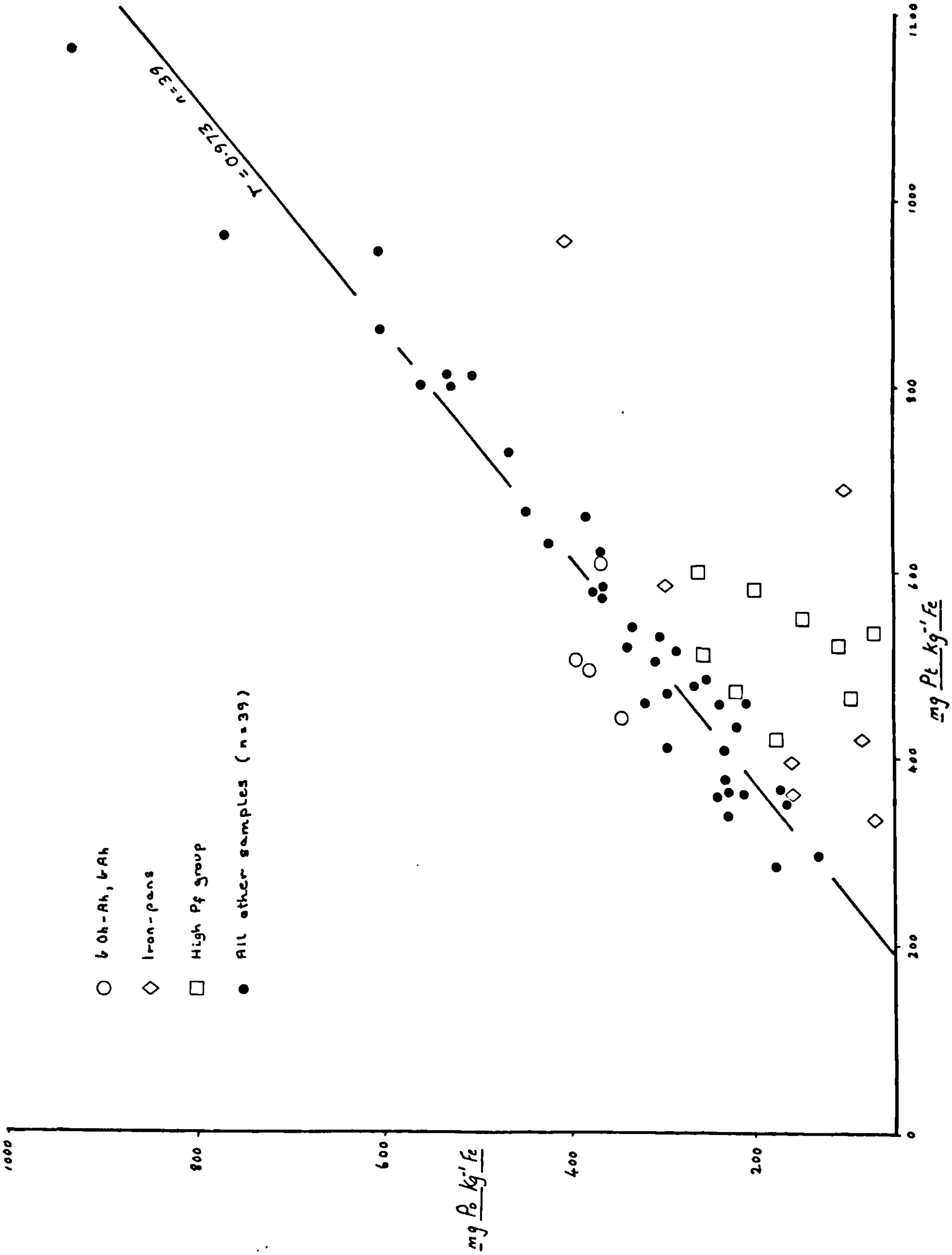
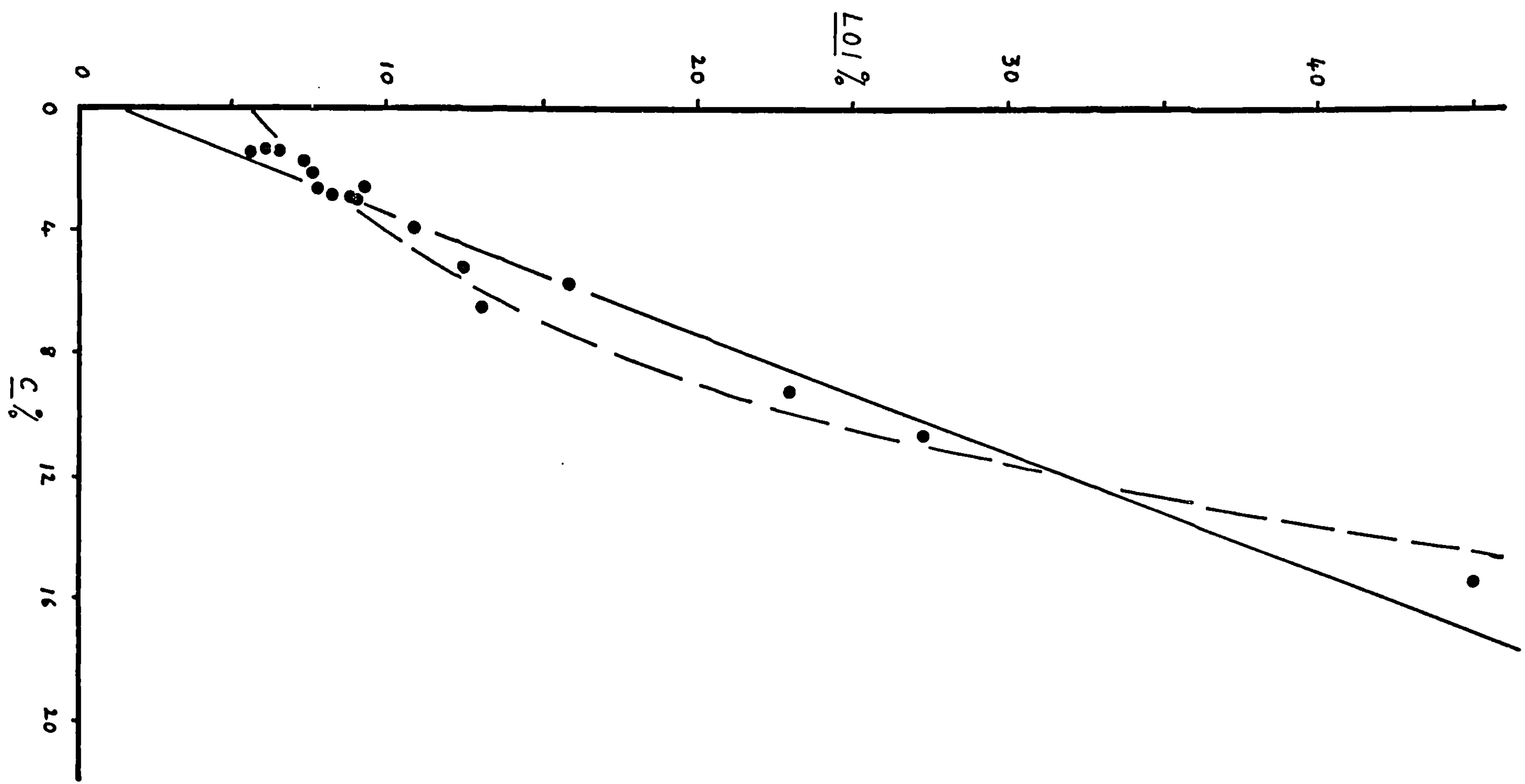


Fig. 3.29 Scattergram illustrating the relationship between Pt and Po in soil samples from Holne Moor.

Fig. 3.30 Scattergram illustrating the relationship between C and LOI in soil samples from Holne Moor.



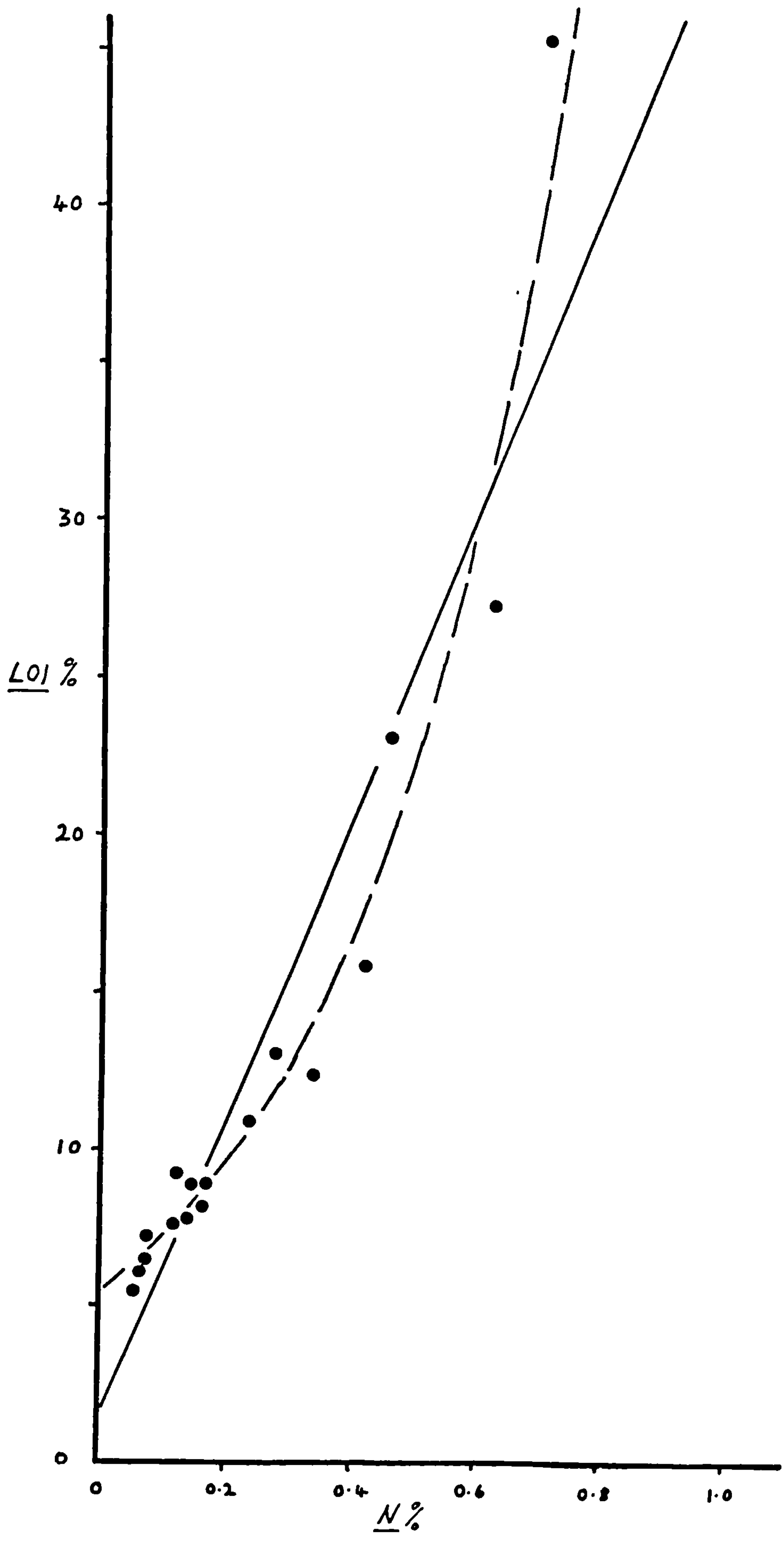


Fig. 3.31 Scattergram illustrating the relationship between N and LOI in soil samples from Holne Moor.

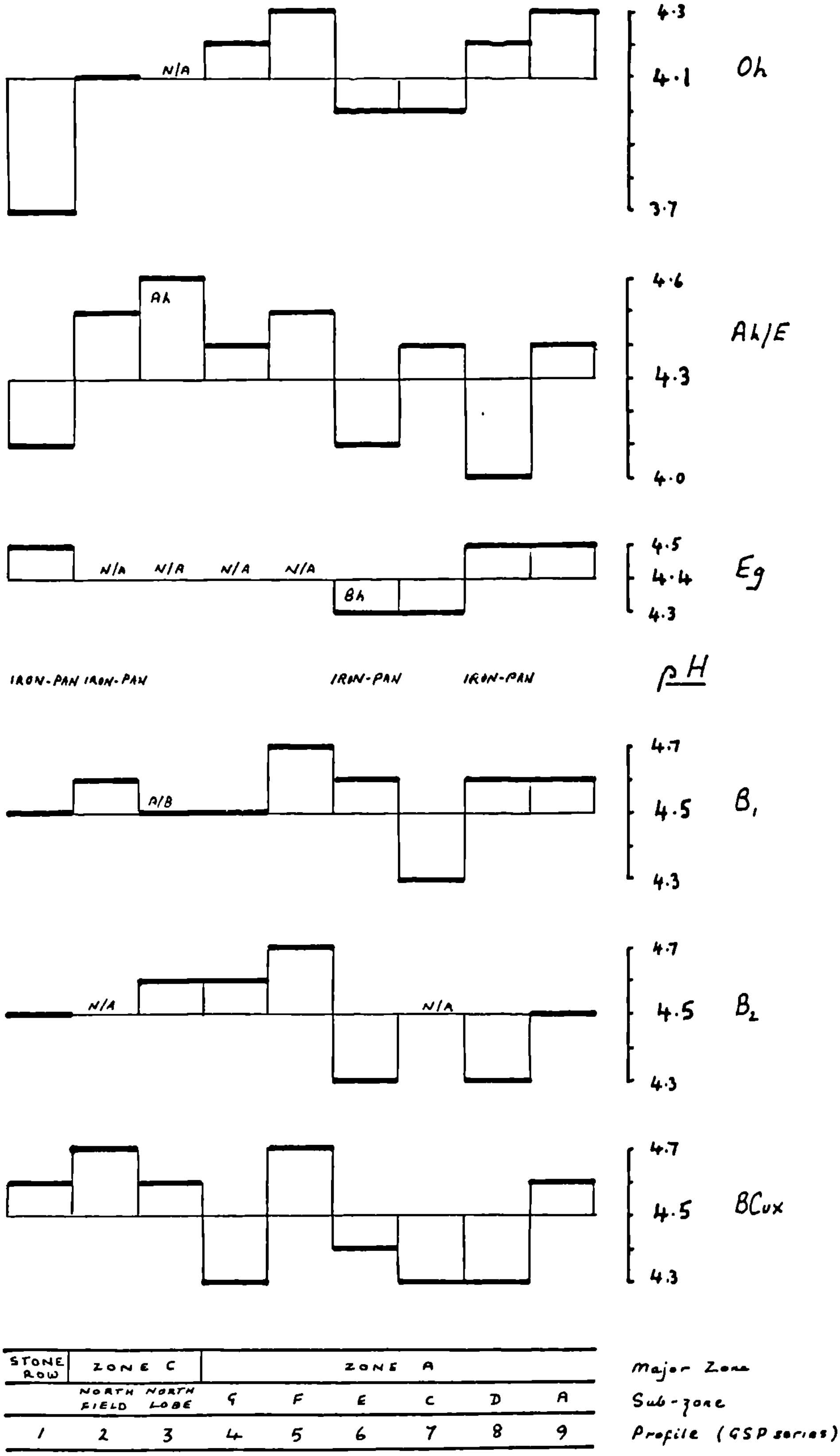


Fig. 3.32 Diagram illustrating pH values in soil samples from Holne Moor.

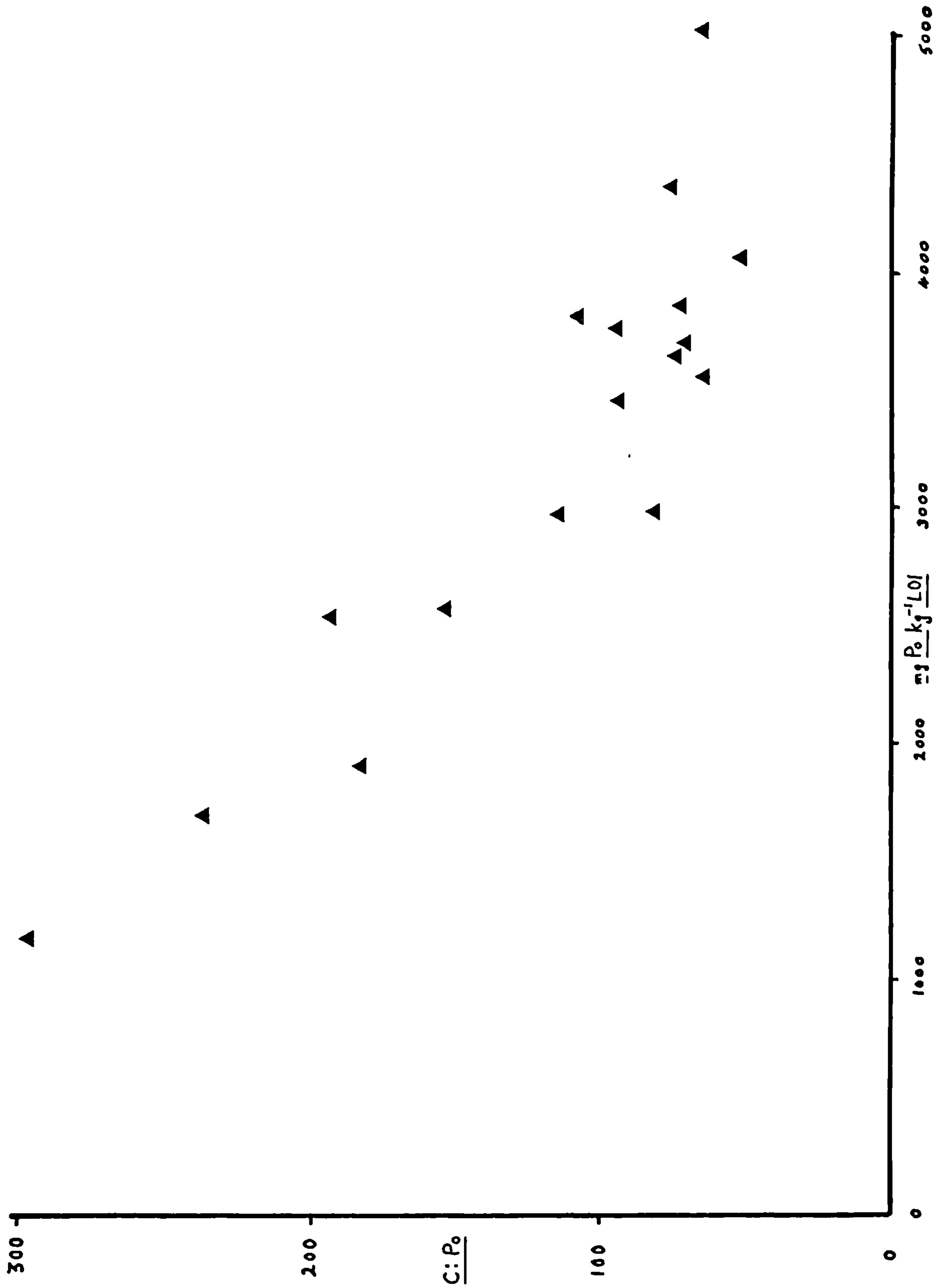


Fig. 3.33 Scattergram illustrating the relationship between different measures of the concentration of phosphorus in the organic matter of soil samples from Holne Moor (all samples for which C measurements are available)

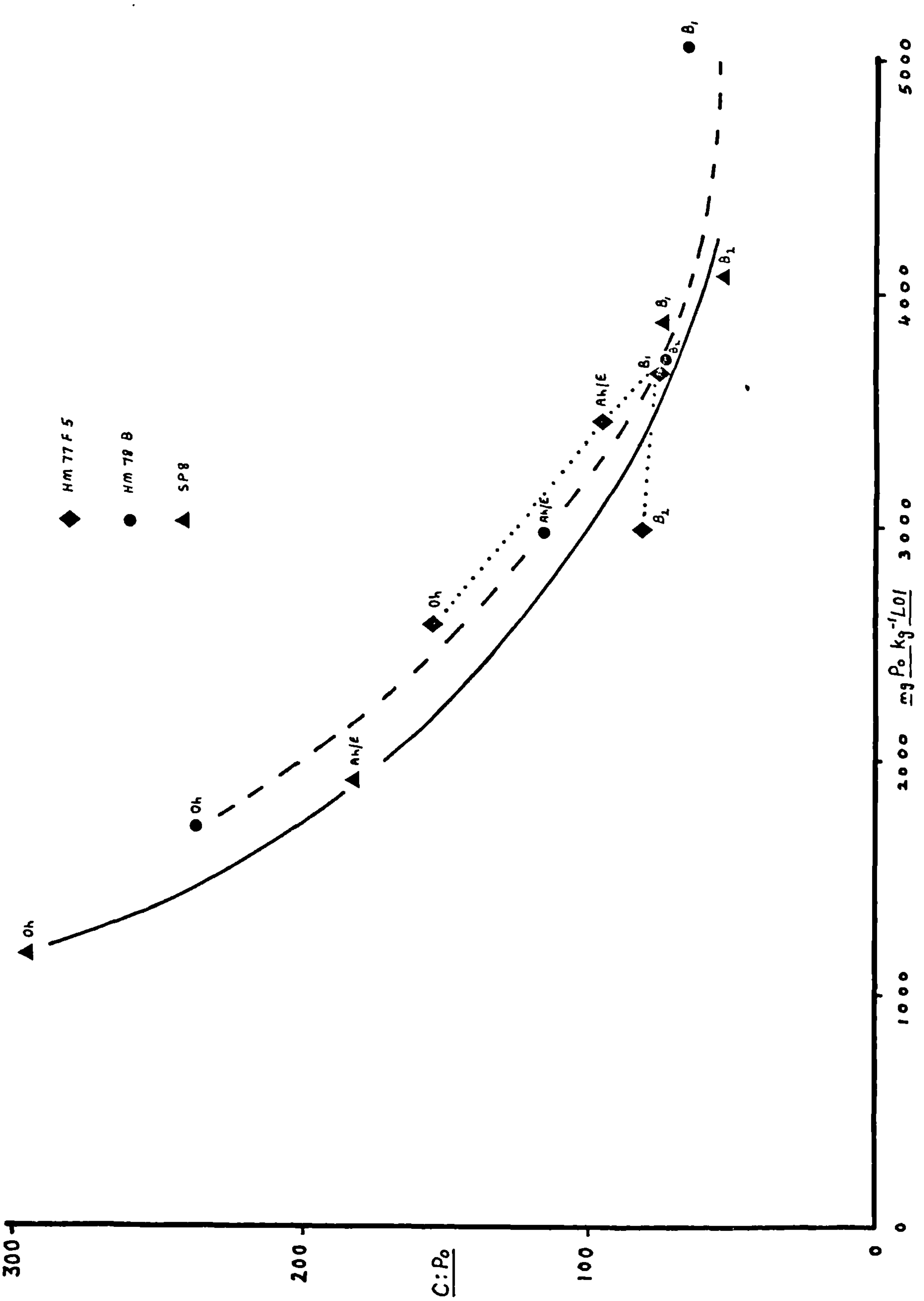


Fig. 3.34 Scattergram illustrating the relationship between different measures of the concentration of phosphorus in the organic matter of soil samples from Holne Moor (stagnopodzol soils only)

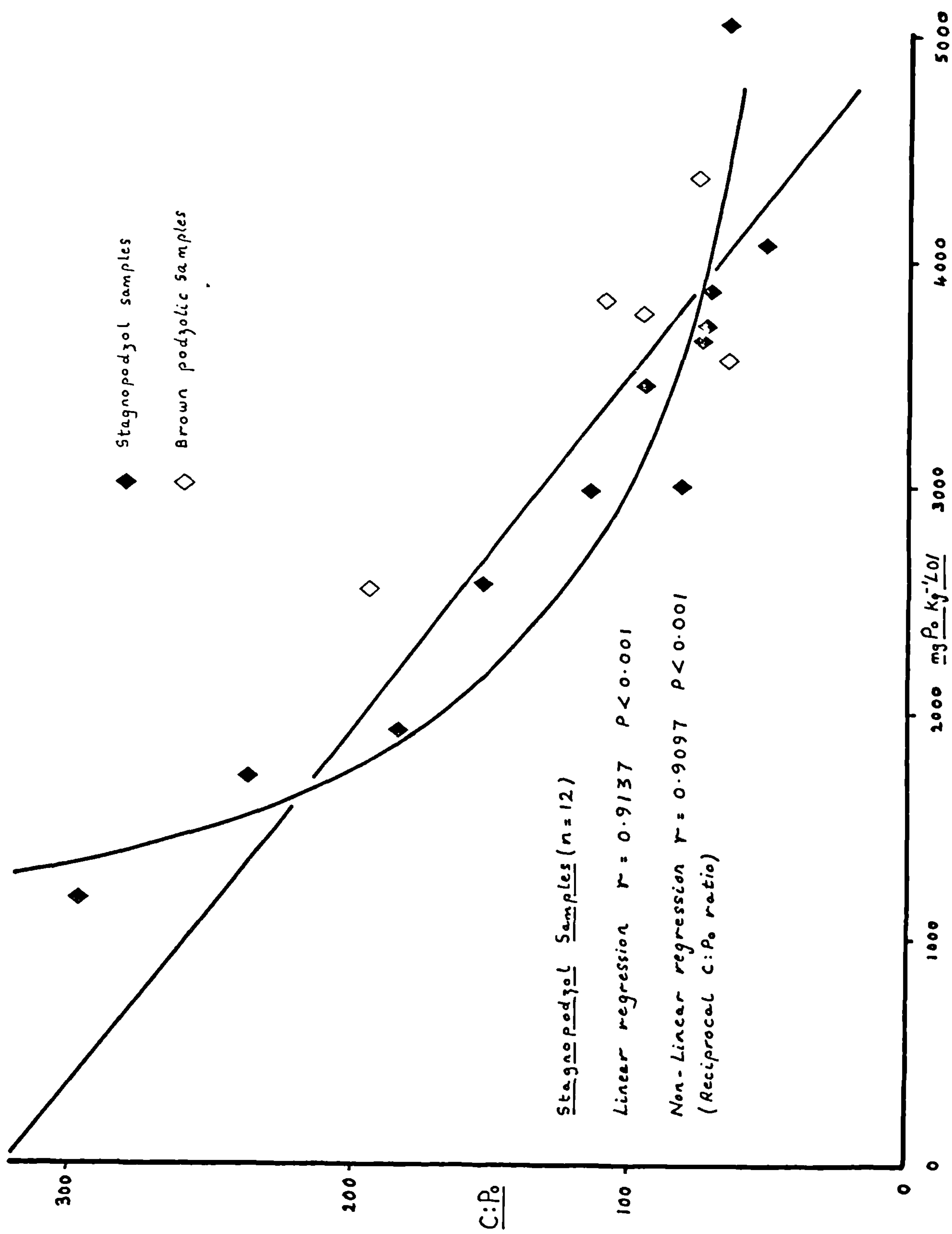


Fig. 3.35 Scattergram illustrating the statistical relationship between different measures of the concentration of phosphorus in the organic matter of soil samples from Holne Moor (linear and non-linear regression)

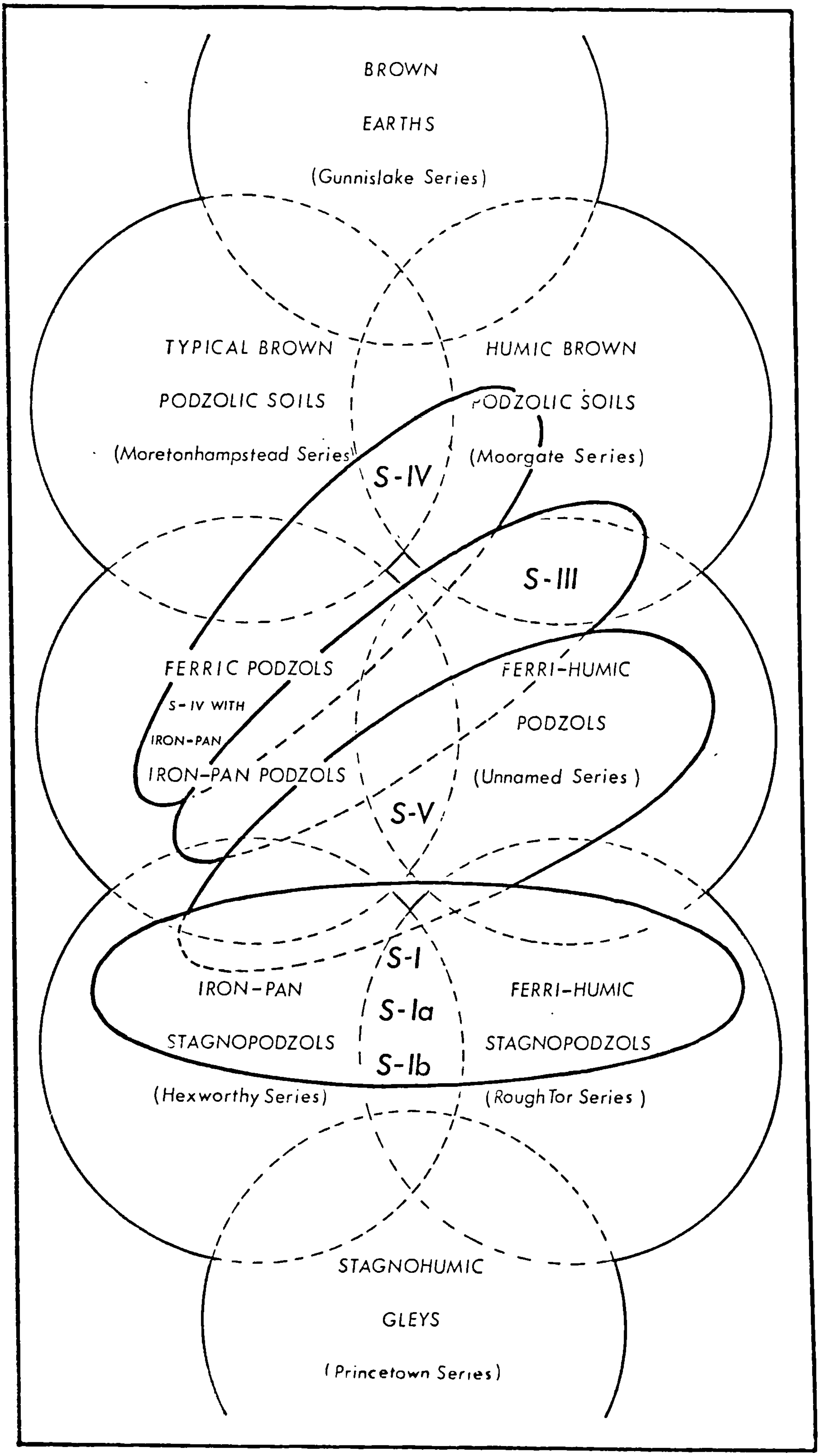


Fig. 4.1 Diagram illustrating the relationship between the surface soil classification units used on Holne Moor and the units used by the Soil Survey of England and Wales.

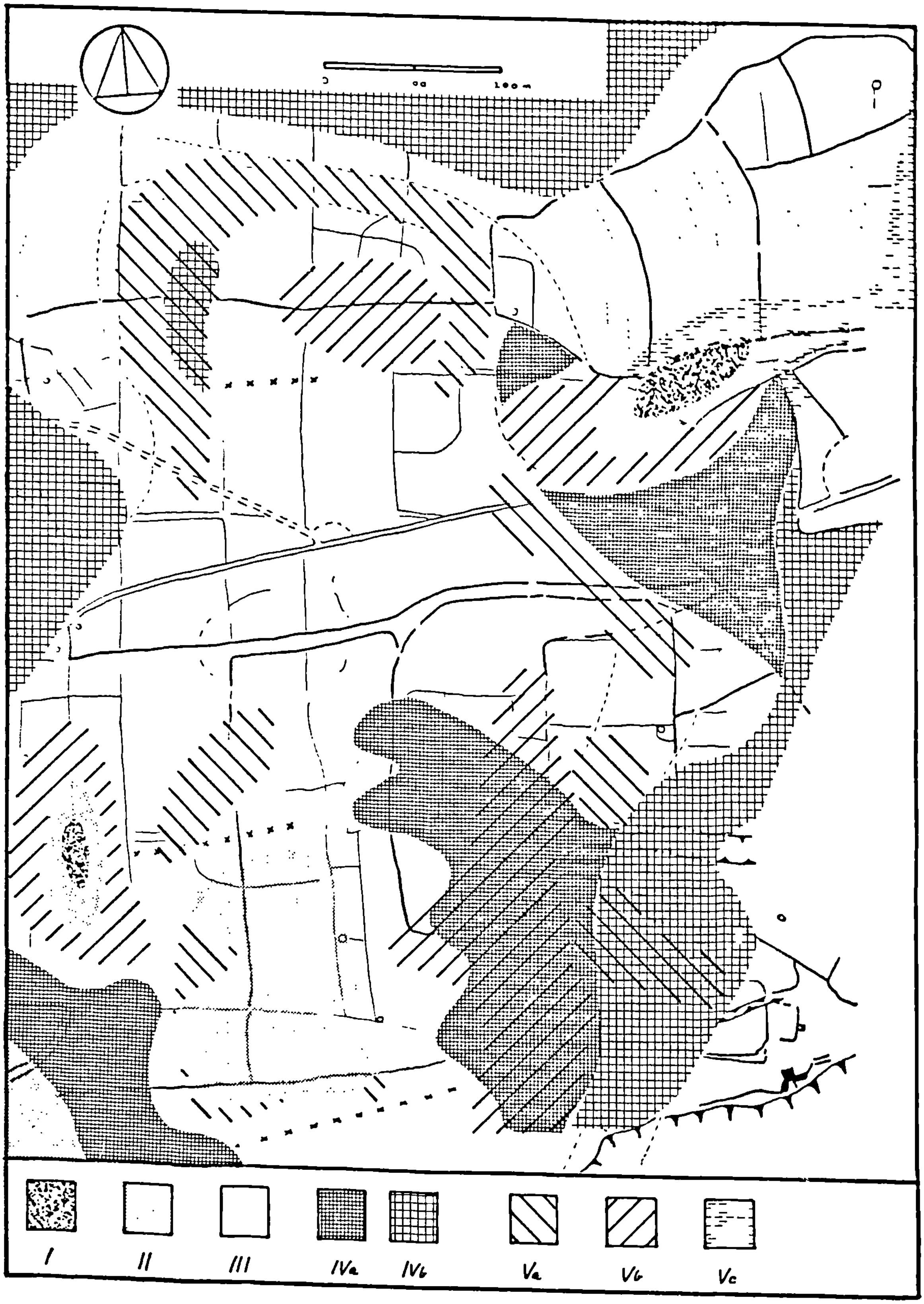


Fig. 4.2 Distribution of sub-soil classification units in the Holne Moor Study area (sub-soil classification units I - V are described in sections 4.2.1.1 and 4.2.2.1)

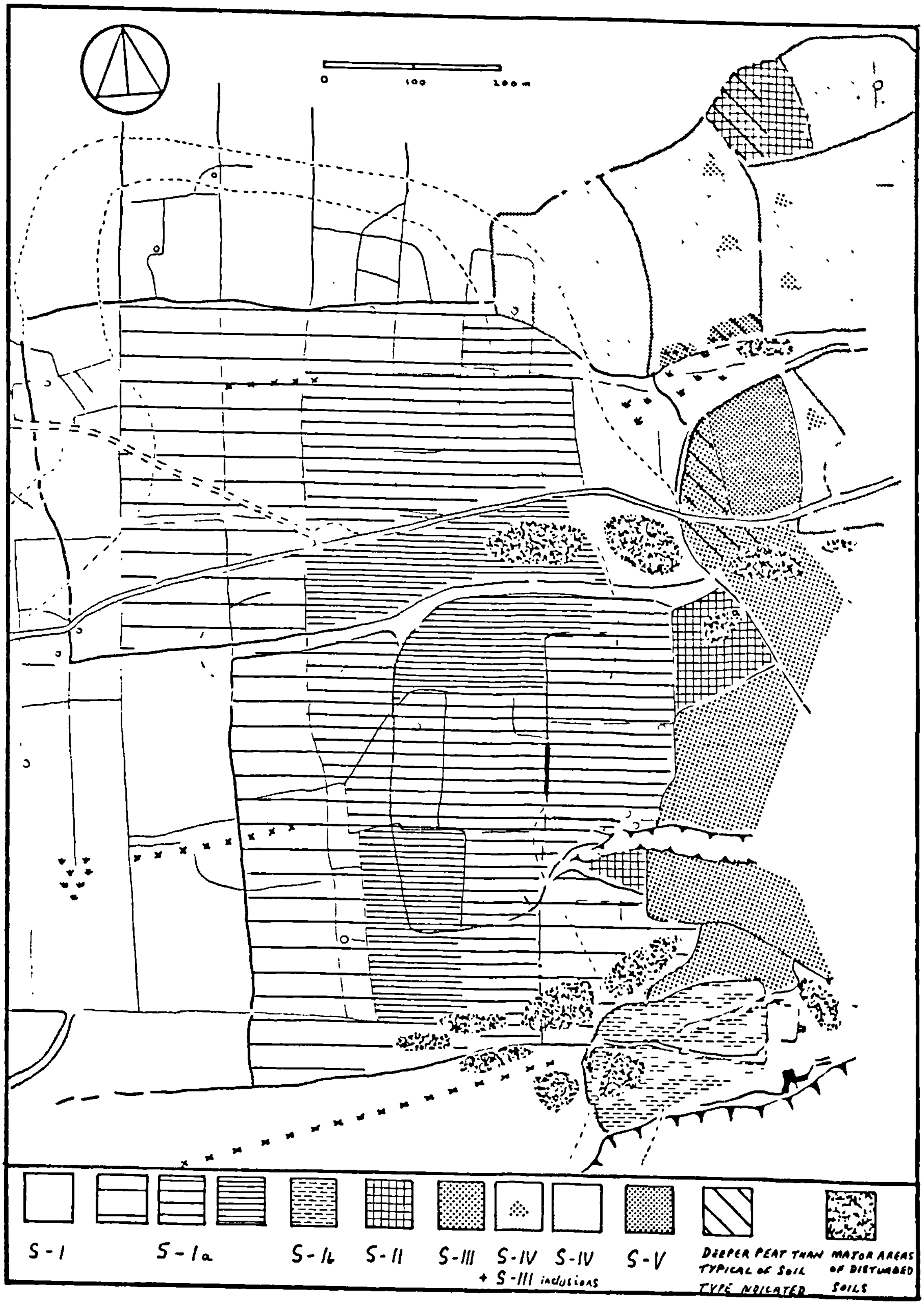


Fig. 4.3 Distribution of surface soil classification units in the Holne Moor Study area (surface soil classification units S-I – S-V are described in sections 4.2.1.2 and 4.2.2.2)

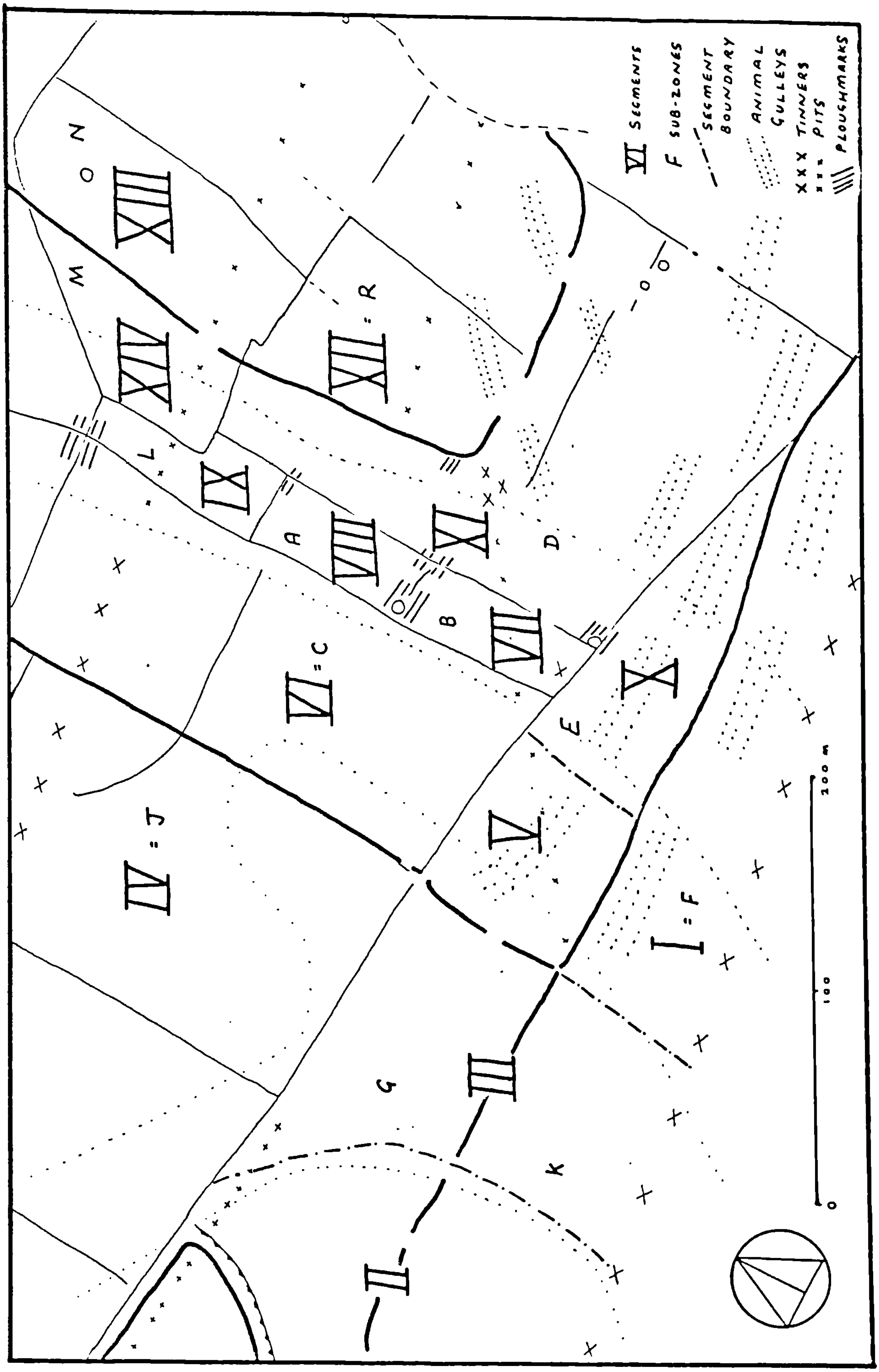


Fig. 4.4 Zone A - segment and sub-zone divisions, and the distribution of medieval plough marks, tinning and animal disturbances.

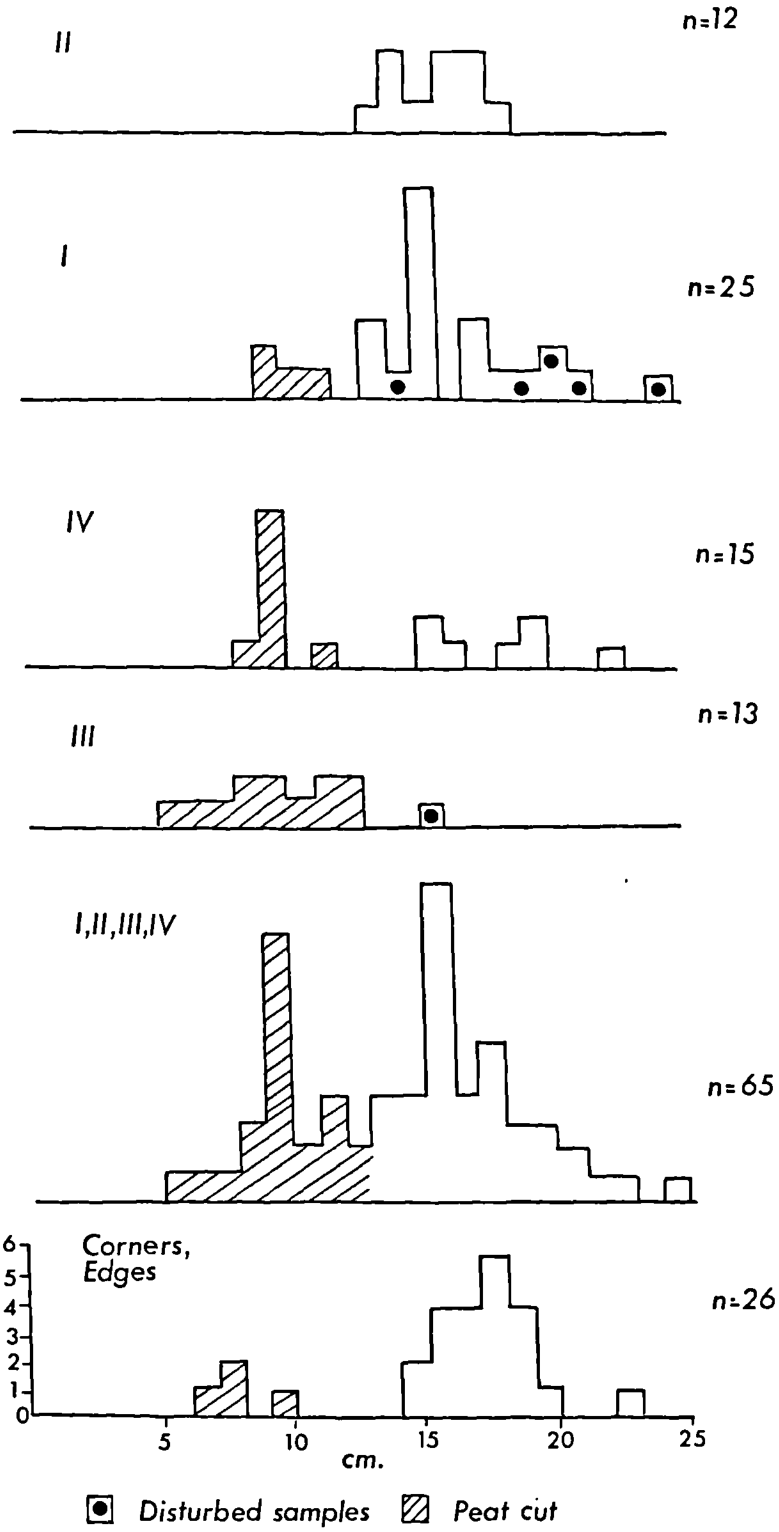


Fig. 4.5 Zone A - histograms of peat depth measurements in segments I - IV and corners and edges of enclosures.

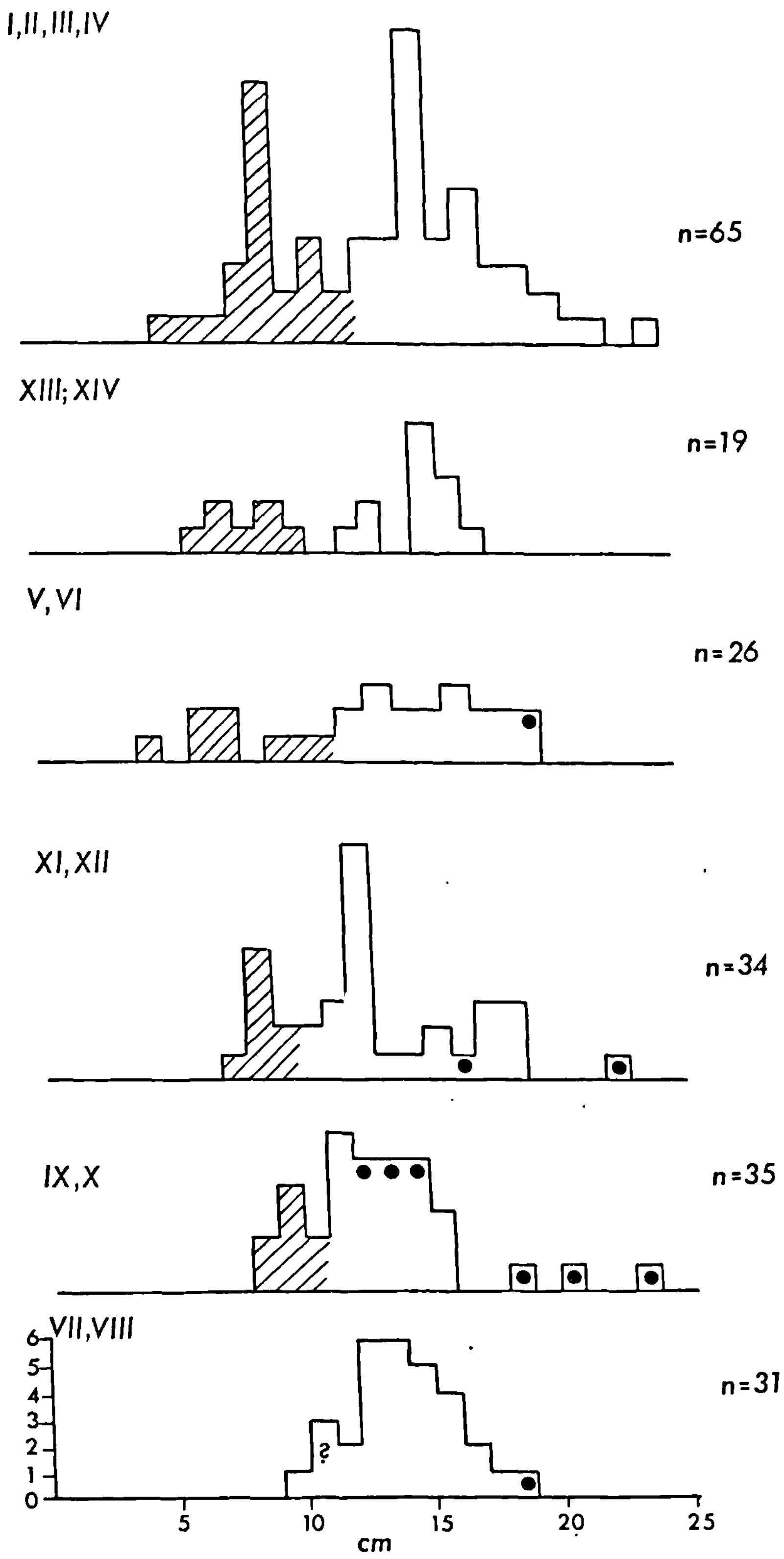


Fig. 4.6 Zone A - histograms of peat depth measurements in segments I - XIV.

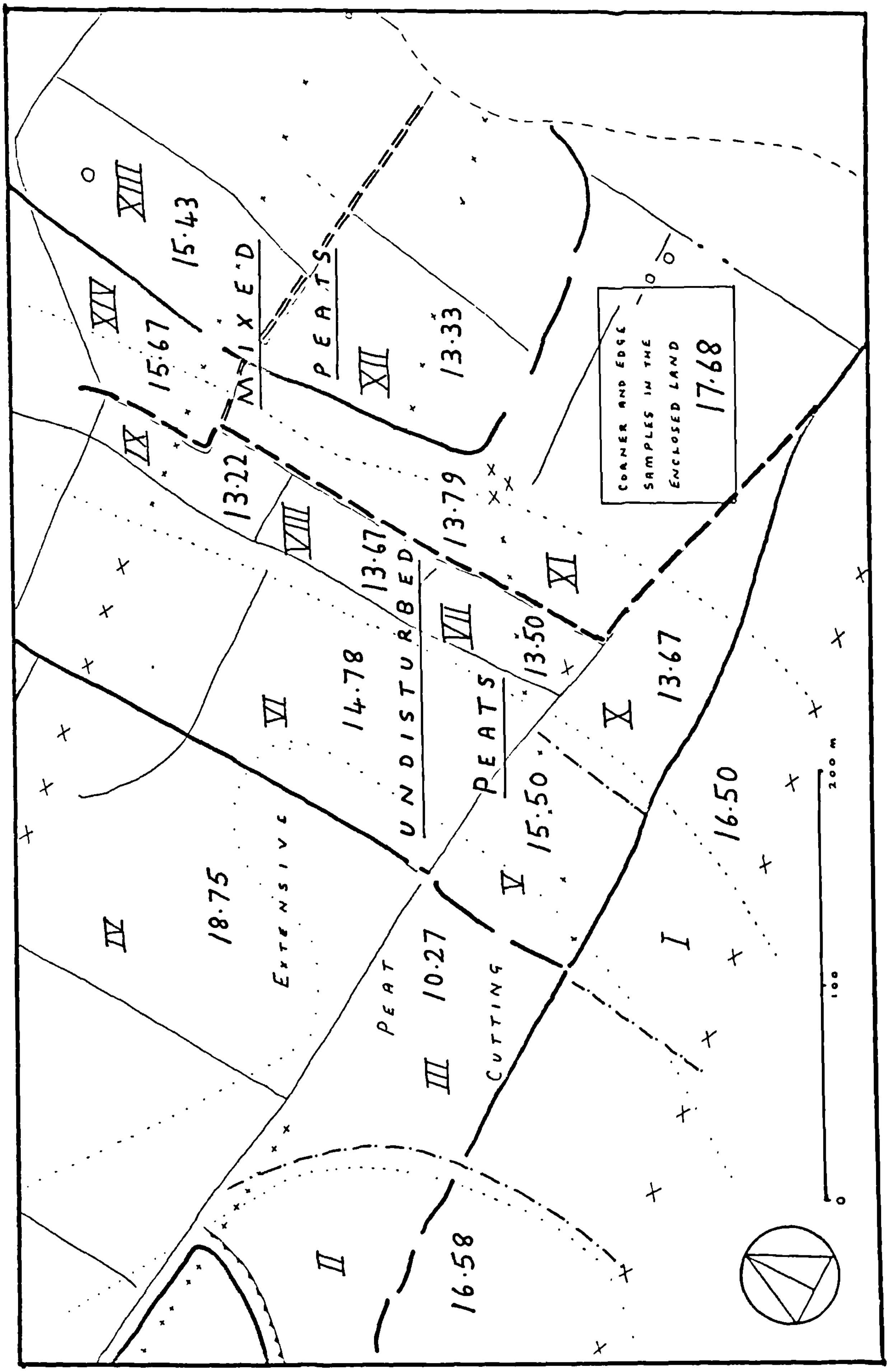


Fig. 4.7 Zone A - lateral variation in organic content of peat and mean peat depth in all segments (after exclusion of Corner, Edge and Peat cut samples).

Date tillage ceased	Drainage: Shedding	Drainage: Receiving
VERY EARLY ?	C L 1 (western parts including West Field) Deeper peat variant of S - III	
EARLY	C L 1 South (most areas) - - - - - - - C L 1 North (Central Field) C L 3 South Link Close SOIL S - III	SOIL S - V
LATE	SOIL S - IV North Lobe (most areas) - - - - - - - North Lobe (mainly in Central Field)* C L 1 North (East and Wedge Fields)	SOIL S - III

* Exceptionally, small flush area in Central Field, North Lobe is deeper peat variant of S - V

→ MORE HUMOSE/PEATY AND MORE FREQUENT IRON-PANS →

Fig. 4.8 Model of factors affecting re-emergence of stagnopodzol features in Holne Moor soils cultivated in medieval times.

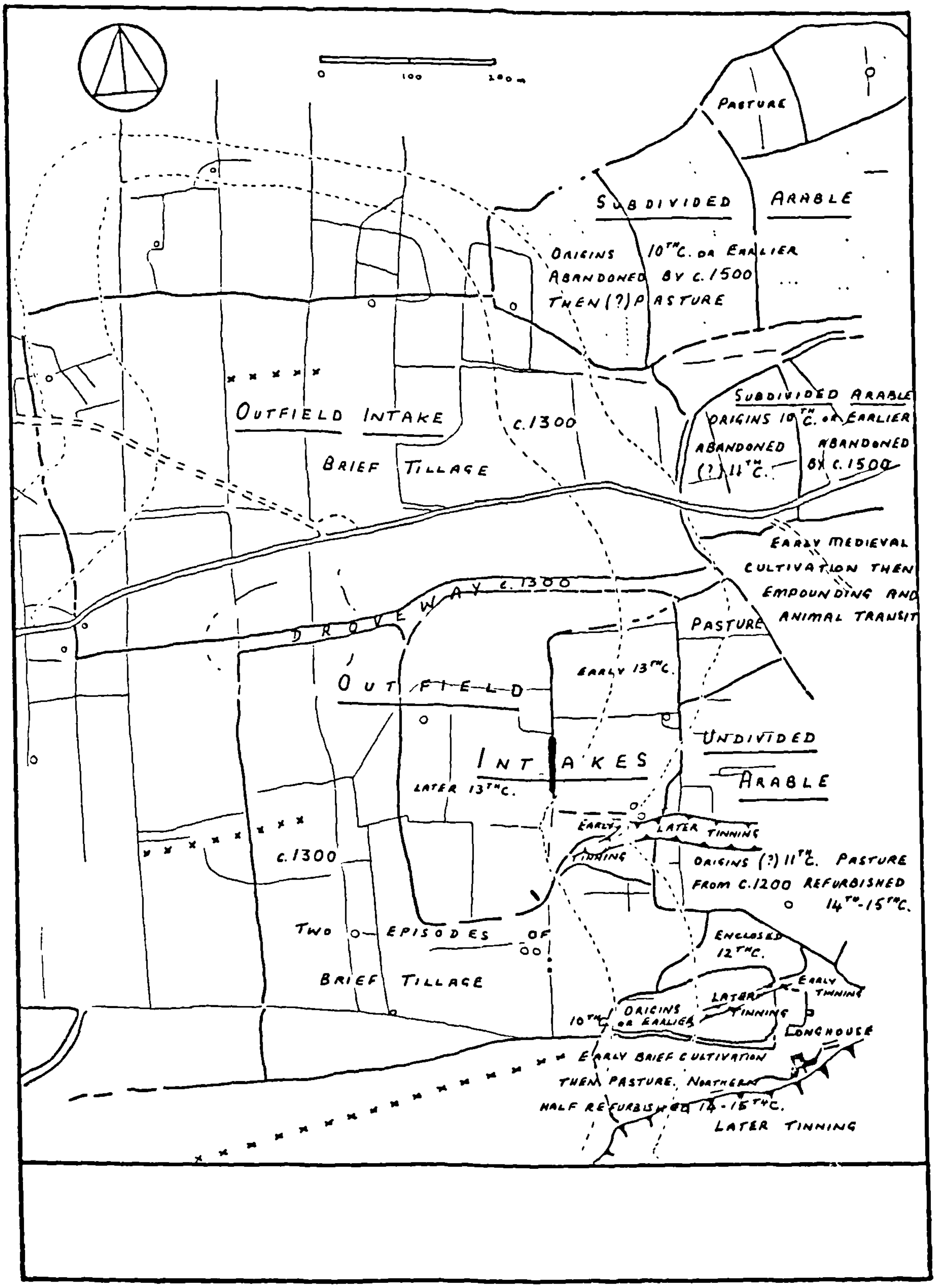


Fig. 4.9 Medieval land use in the Holne Moor study area (after Fleming and Ralph: in press)

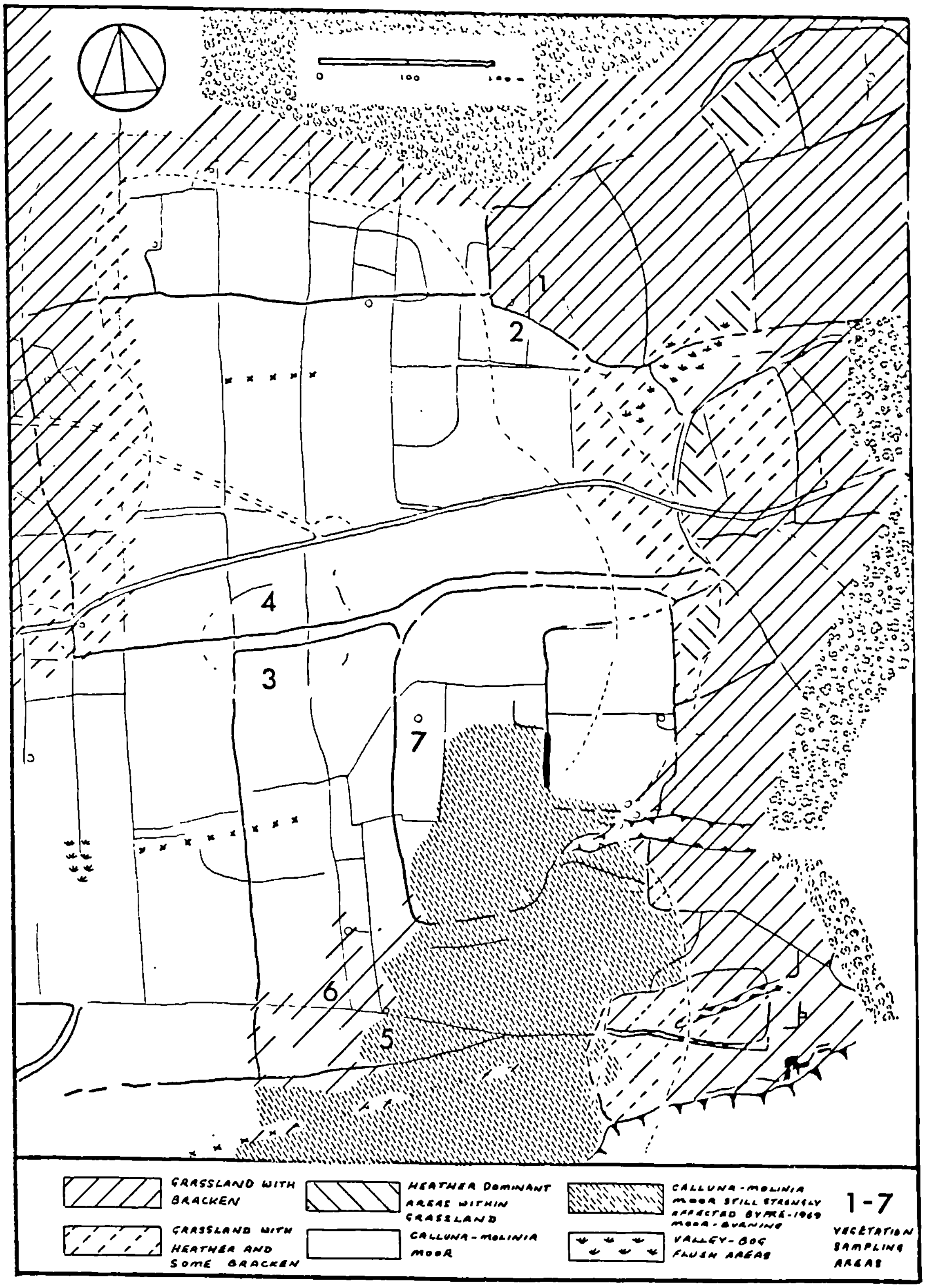


Fig. 4.10 Distribution of vegetation in the Holne Moor Study area in 1976-1977, and the location of vegetation sampling sites 1 - 7.

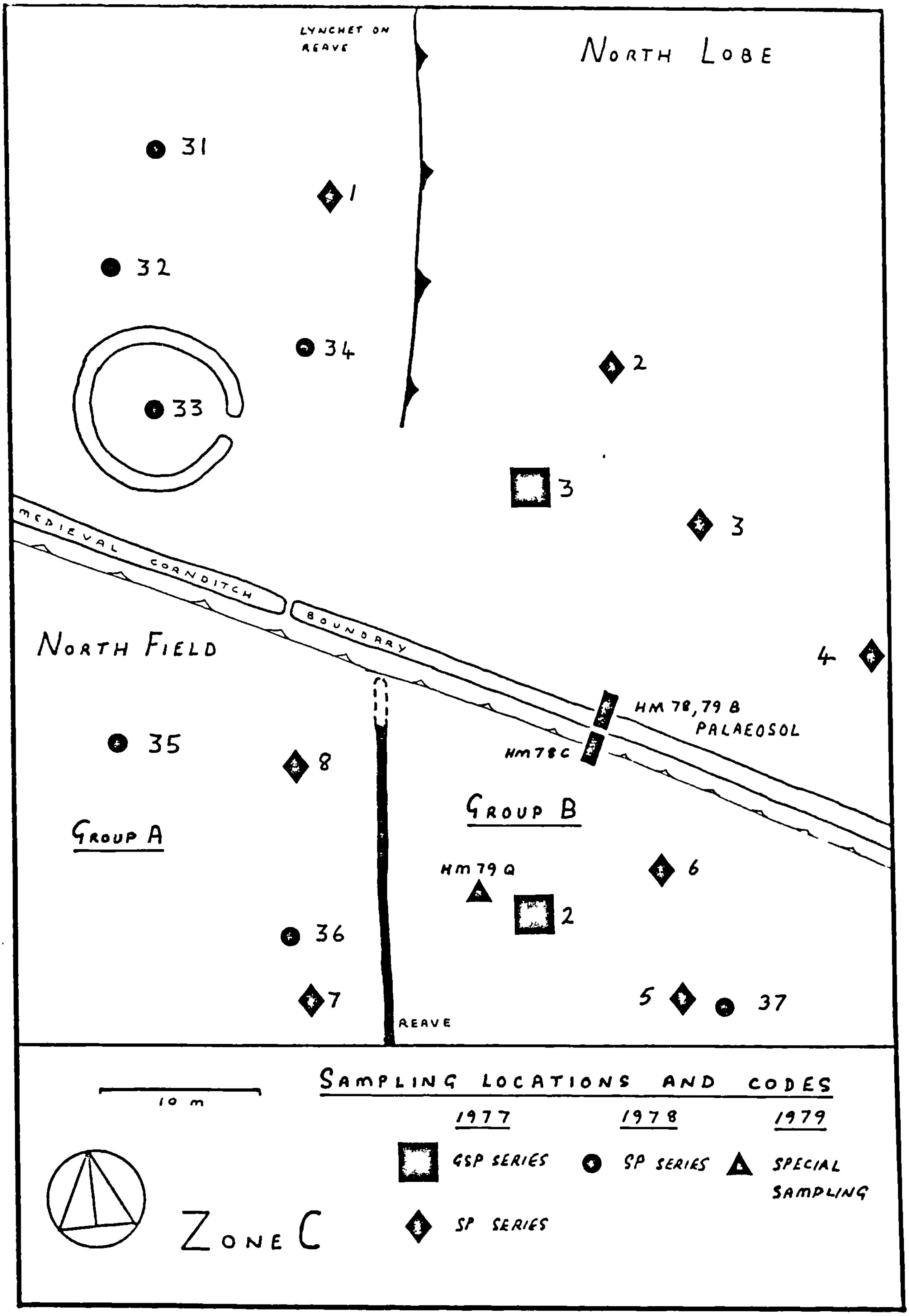


Fig. 5.1 Zone C - Location of sampled profiles

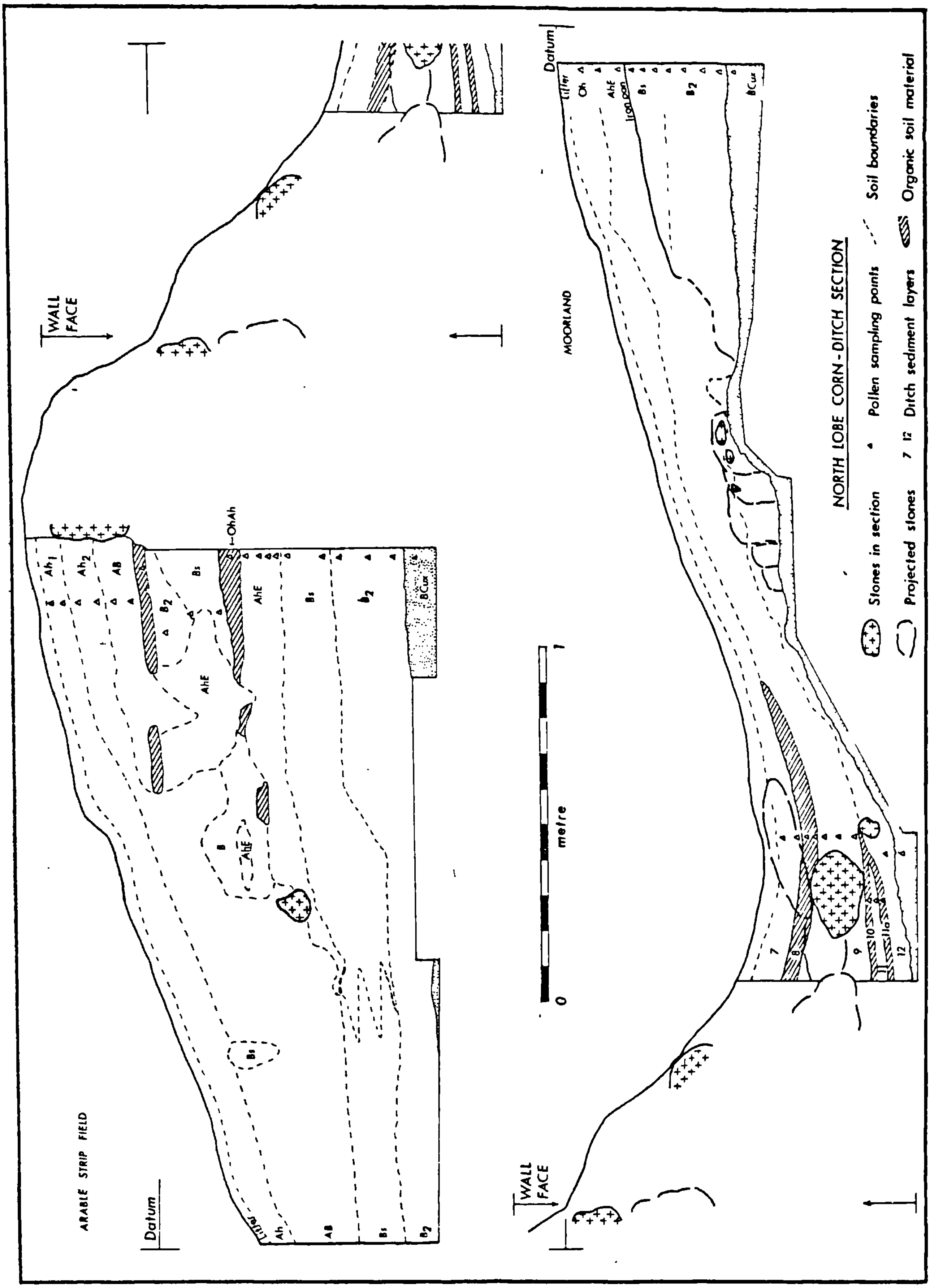


Fig. 5.2 Zone C - Section through North Lobe corn-ditch showing the principal features of the buried medieval palaeosol and its overburden

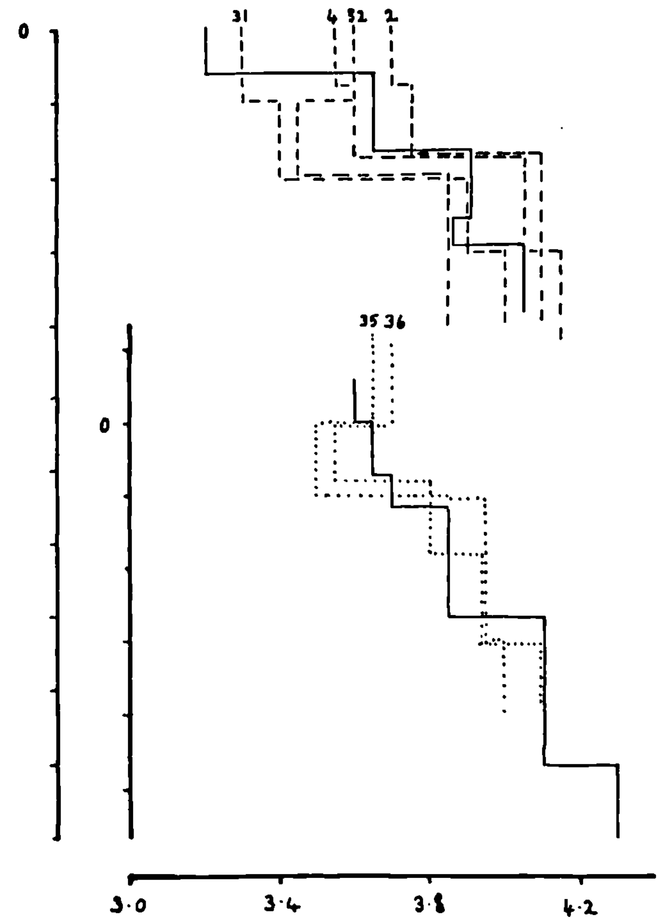


Fig 5.3 pH

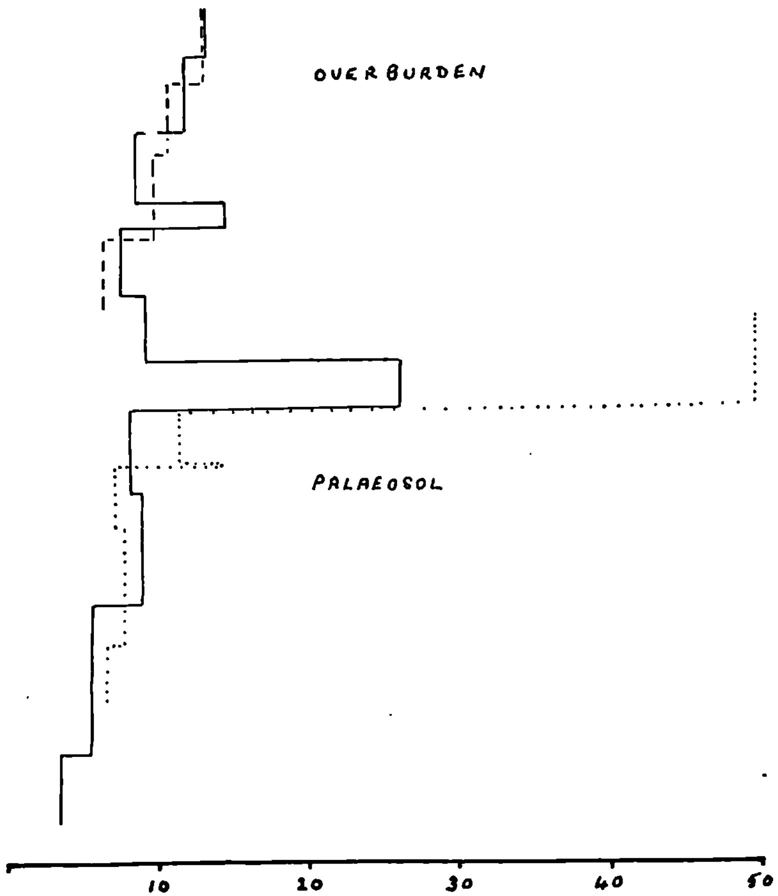


Fig 5.4 LOI %

——— medieval palaeosol and overburden (HM 78, 79 B)
- - - - North Lobe, SP series profiles
. . . . . . North Field, SP series profiles

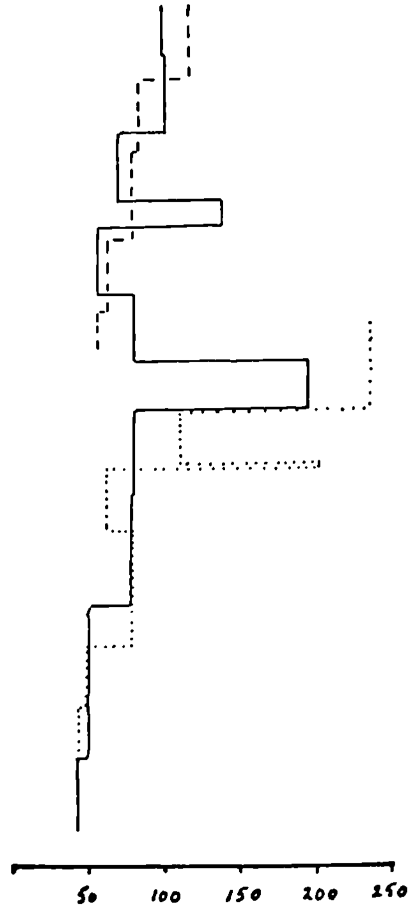


Fig 5.5 mg LOI cm^{-3}

- - - - North Lobe, SP series, $\bar{x}$ (n=6)
. . . . North Field, SP series, Group A, $\bar{x}$ (n=4)

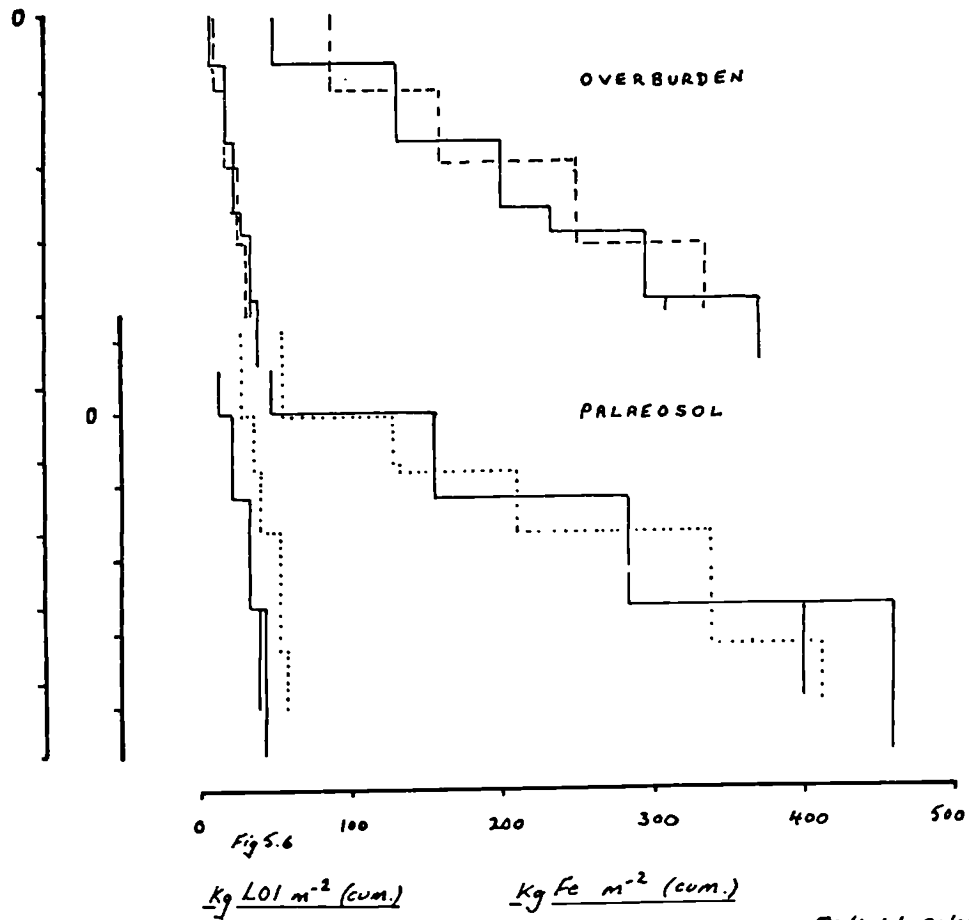


Fig 5.6

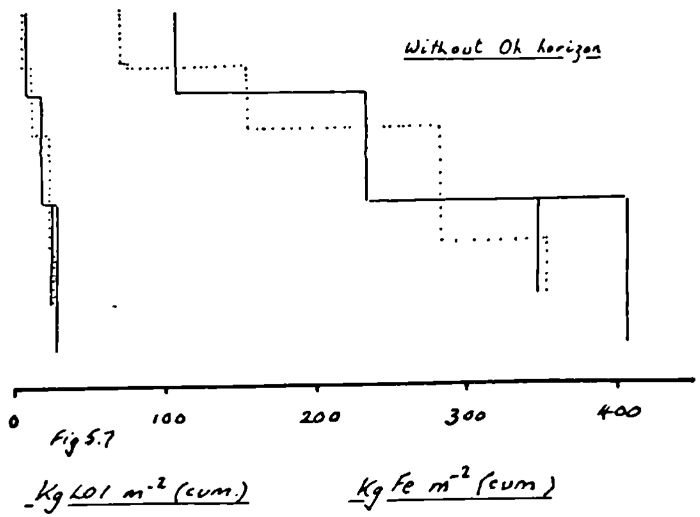
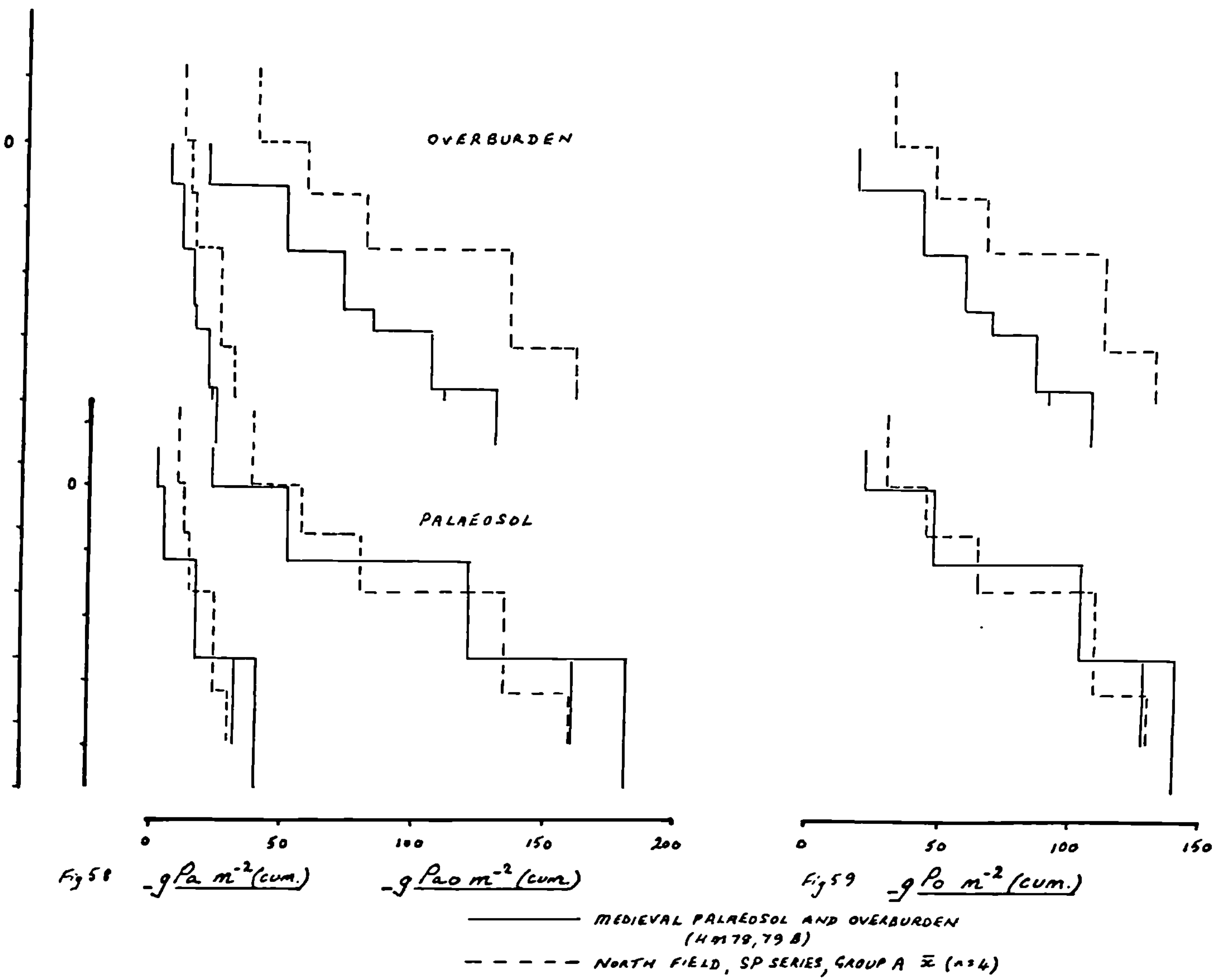


Fig 5.7

——— Medieval palaeosol and overburden (HM 78, 79B)
– – – North Lobe, SP series, $\bar{x}$ (n=6)
······· North Field, SP series, Group A, $\bar{x}$ (n=4)



OVERBURDEN
PALAEOSOL
0
0
0
50
100
150
200
0
50
100
150
-g Pa m⁻² (cum.)
-g Pao m⁻² (cum.)
-g Po m⁻² (cum.)
MEDIEVAL PALAEOSOL AND OVERBURDEN (HM78, 79 B)
NORTH FIELD, SP SERIES, GROUP A x̄ (n=4)

Fig 58

Fig 59

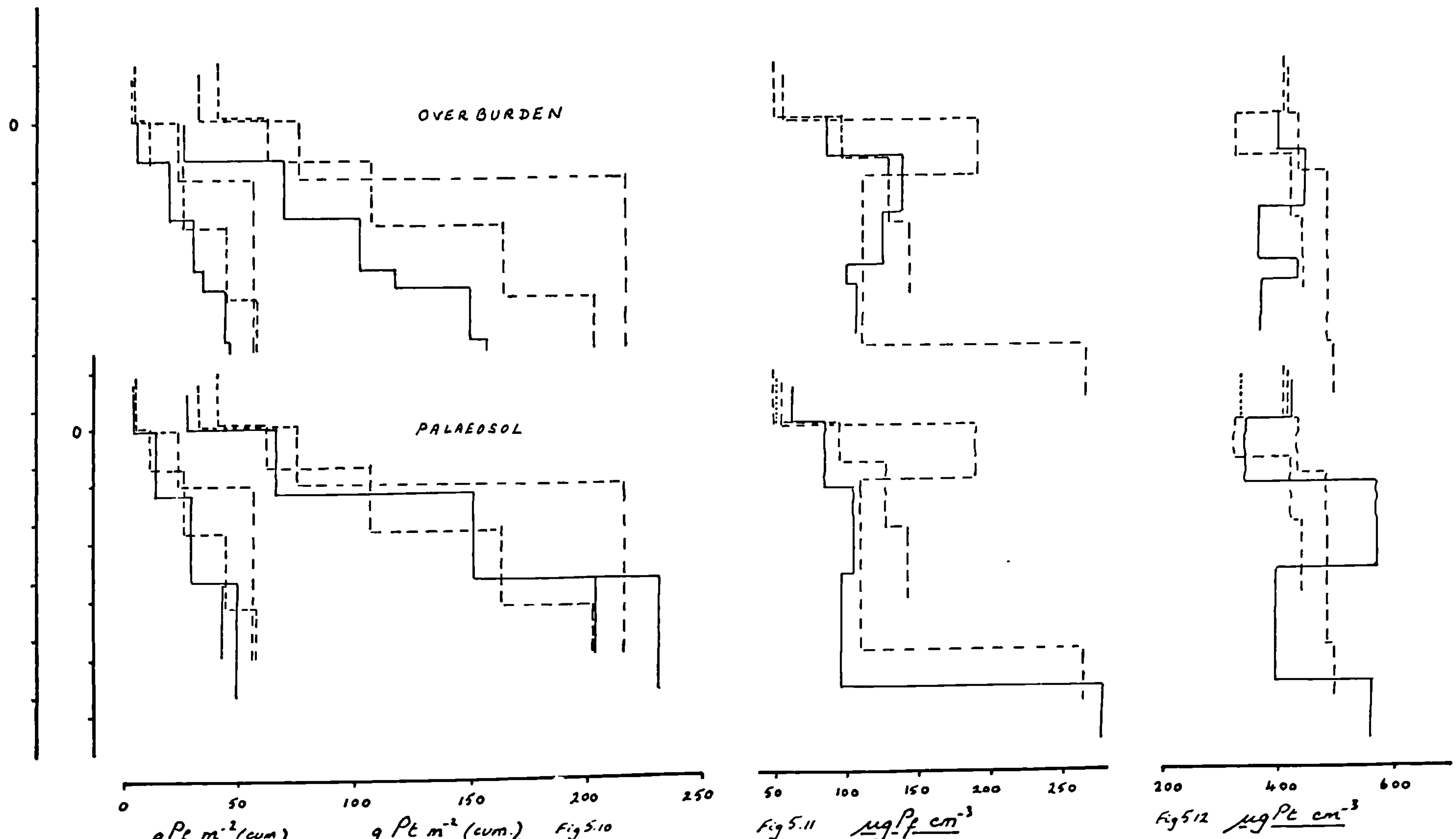


Fig 5.10 Fig 5.11 Fig 5.12

——— MEDIEVAL PALAEOSOL AND OVERBURDEN (HM78, 79B)

– – – – NORTH FIELD, GSP2 AND SP8 ······ 6 Oh-Al adjusted value

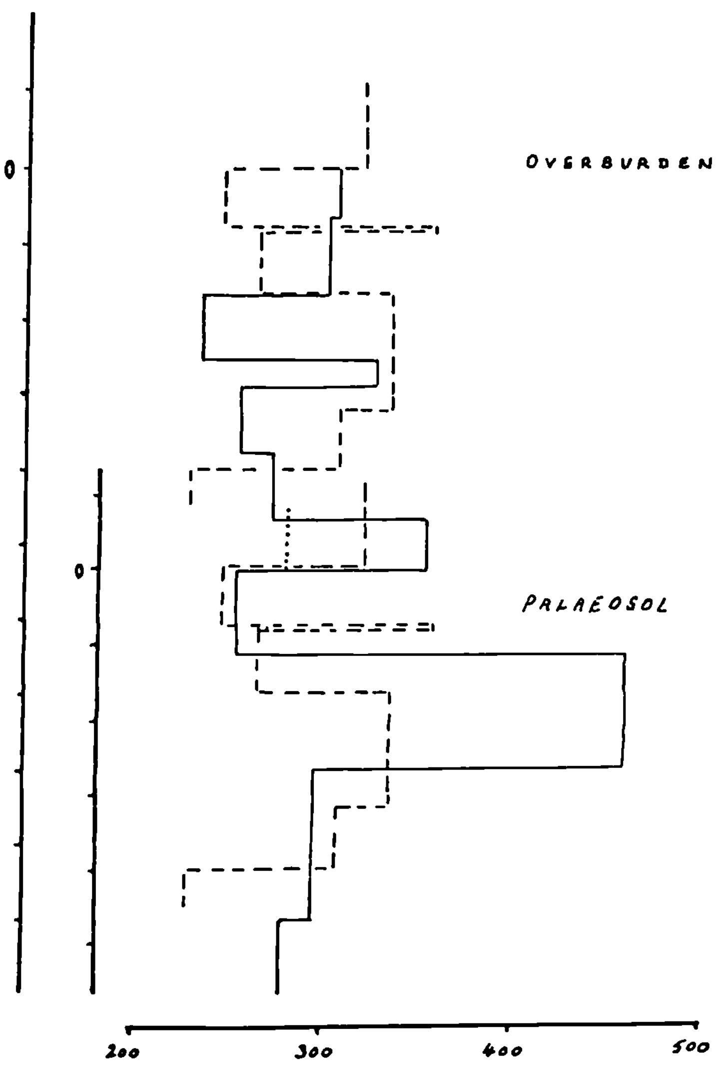


Fig 5.13 μg Pao cm⁻³

——— MEDIEVAL PALAEOSOL AND OVERBURDEN (HM 78, 79 B)

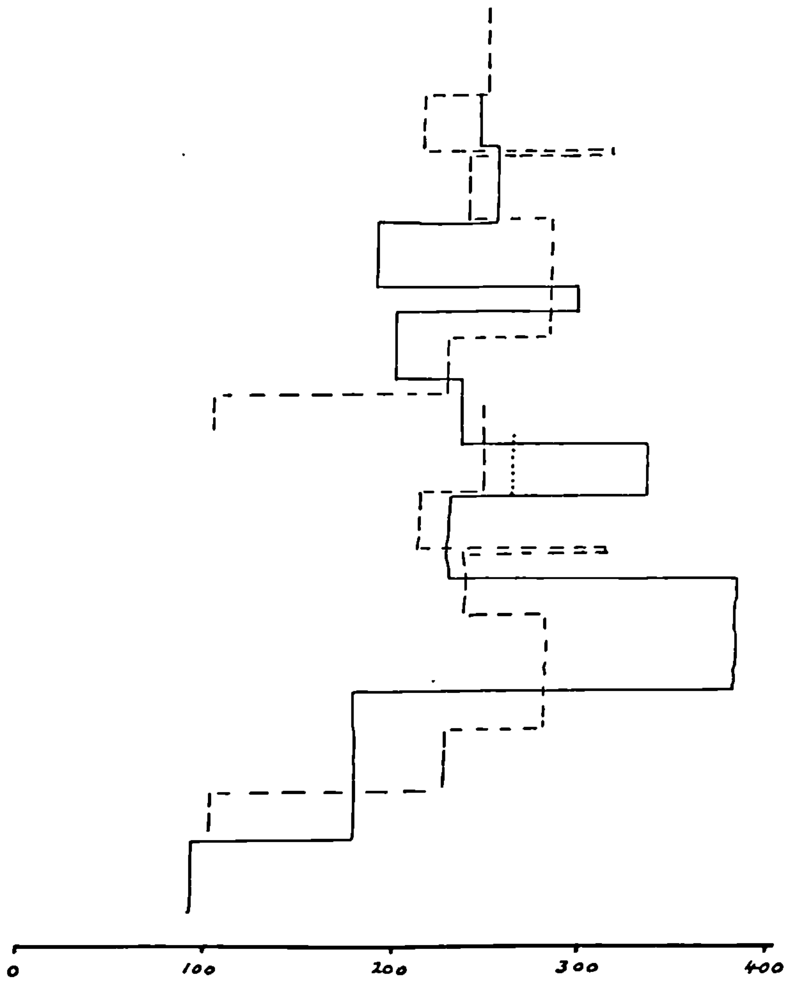


Fig 5.14 μg Po cm⁻³

– – – – – NORTH FIELD, SP SERIES, GROUP A $\bar{x}$ (n=4) ...... 6 Oh-Ah adjusted value

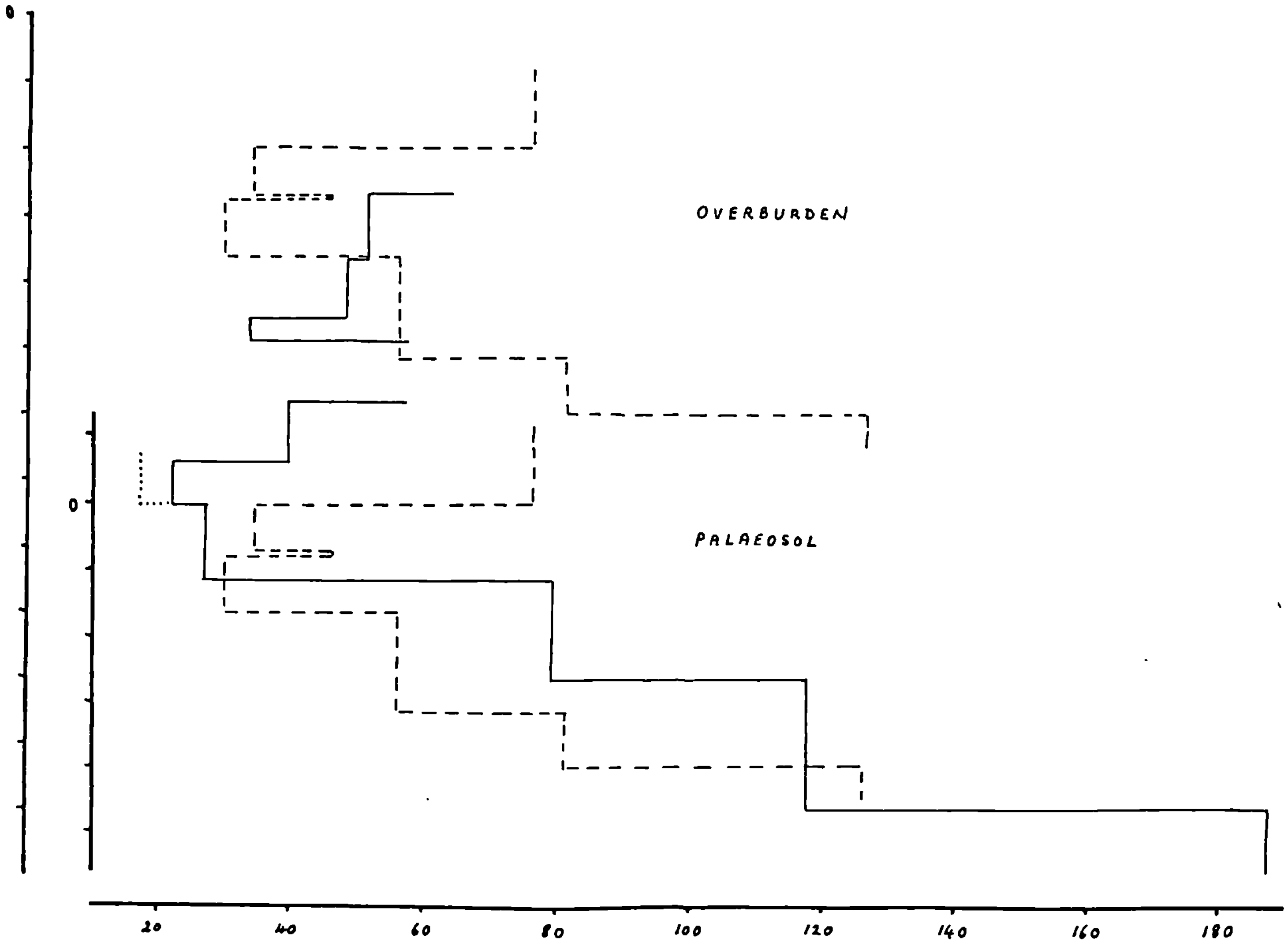


Fig 5.15 $\mu g\ P_a\ cm^{-3}$

——— MEDIEVAL PALAEOSOL AND OVERBURDEN (HM79, 79B) – – – – NORTH FIELD, SP SERIES GROUP A, $\bar{x}$ (n=4) .... 6 Ol-Al adjusted value

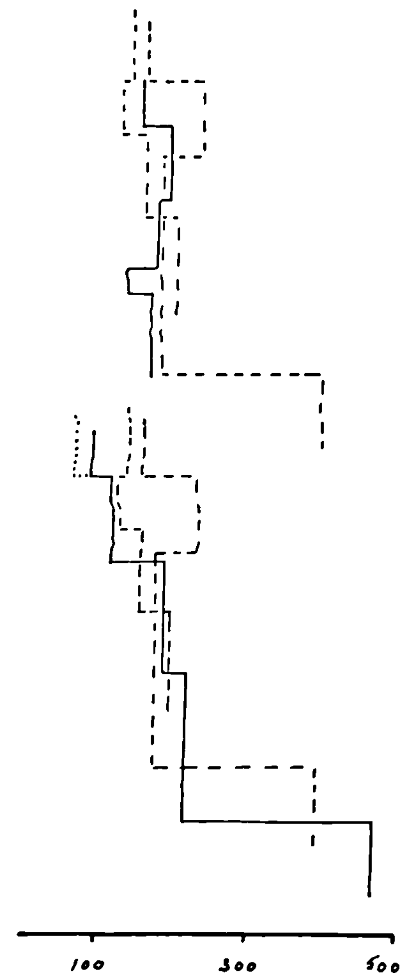


Fig 5.16 $\mu g\ P_i\ cm^{-3}$

– – – – NORTH FIELD, GSP2 AND SP8

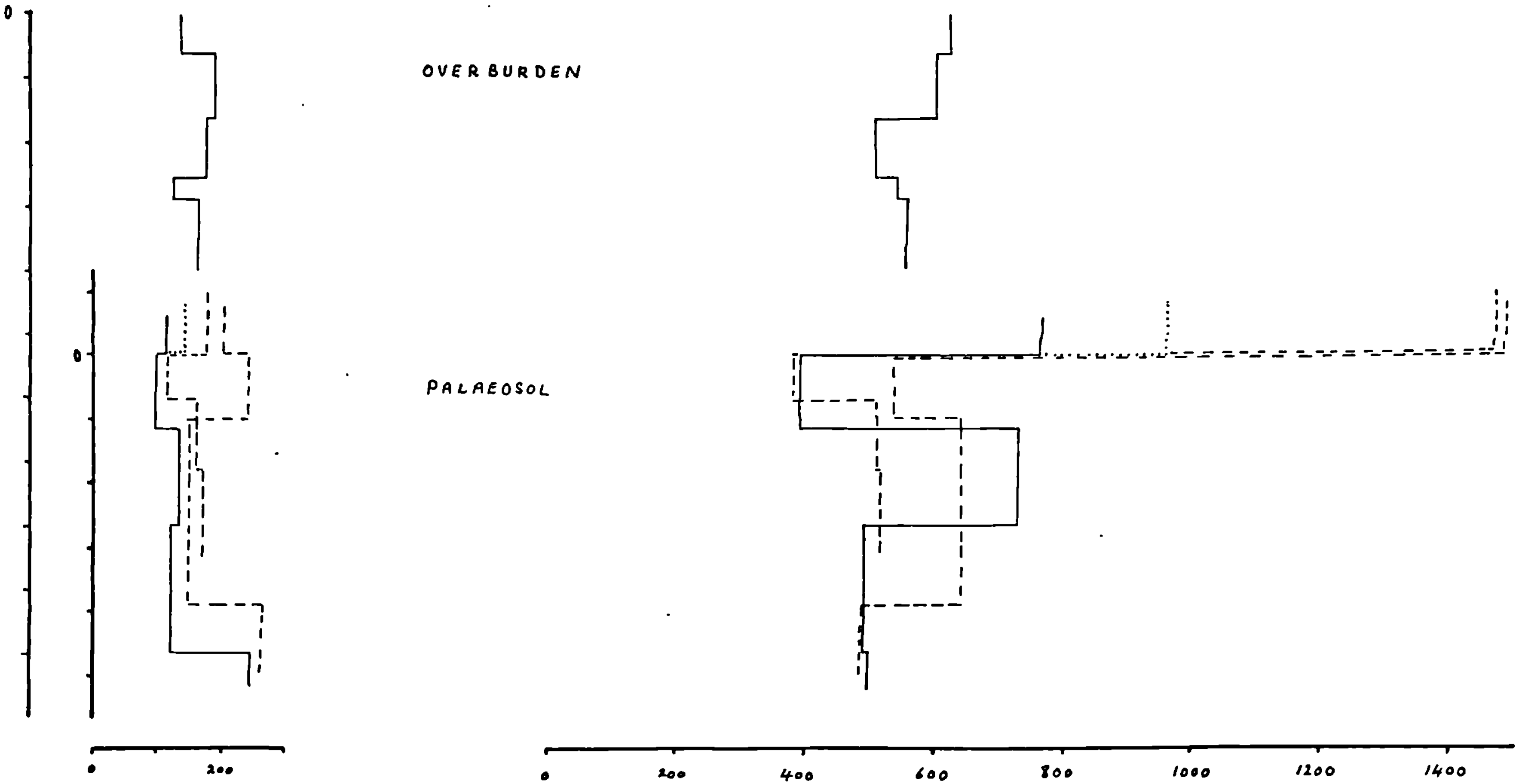


Fig 5.17 mg Pt kg^{-1} IFe

Fig 5.18 mg Pt kg^{-1} IFe

——— MEDIEVAL PALAEOSOL AND OVERBURDEN (Hm 78, 79 B) – – – – NORTH FIELD, GSP2 AND SP8 .... 6 Oh-Ah Adjusted value

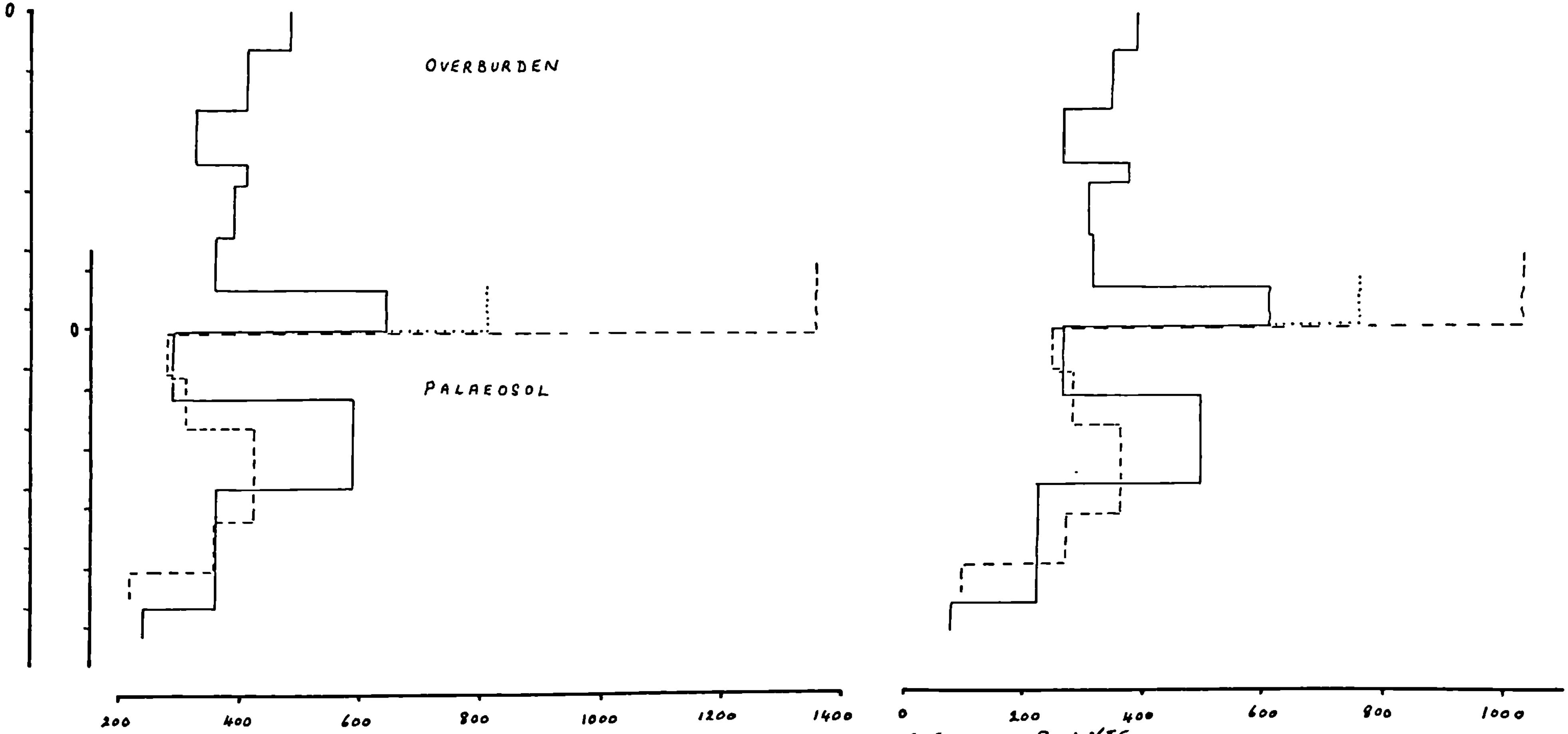


Fig 5.19 mg Pao Kg⁻¹ IFe

——— MEDIEVAL PALAEOSOL AND OVERBURDEN (HM 78, 79 B)

- - - - - - NORTH FIELD, SP SERIES, GROUP A $\bar{x}$ (n = 4)

Fig 5.20 mg Po Kg⁻¹ IFe

……. 60L-Ah adjusted value

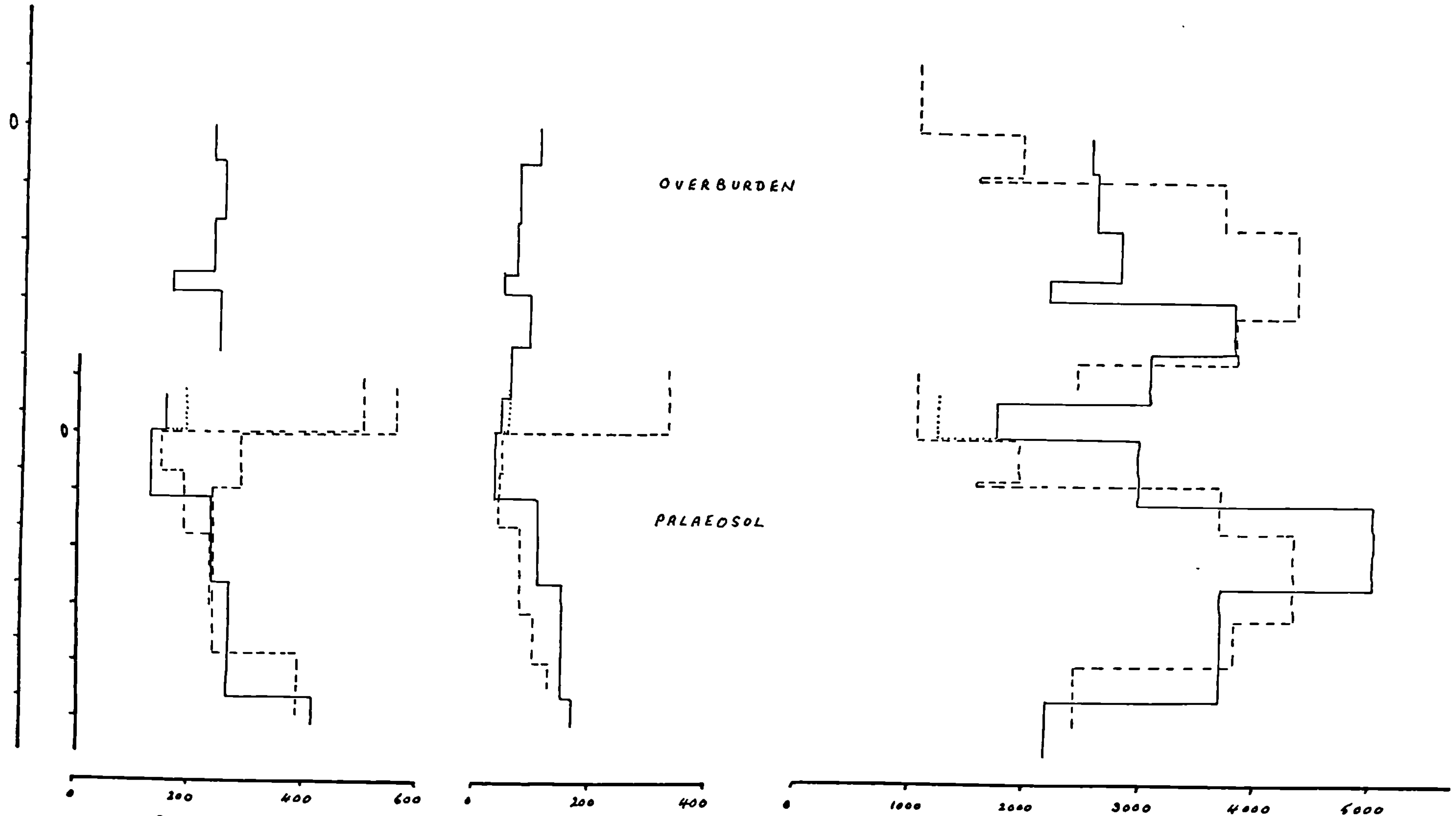


Fig 5.21 mg Pi kg⁻¹ IFe

Fig 5.22 mg Pa kg⁻¹ IFe

Fig 5.23 mg Po kg⁻¹ LOI

- - - - - NORTH FIELD, GSP2 AND SP8

- - - - - NORTH FIELD, SP SERIES, GROUP A $\bar{x}$ (n=4)

——— MEDIEVAL PALAEOSOL AND OVERBURDEN (HM78, 79 B)

.... b OL-AL adjusted value

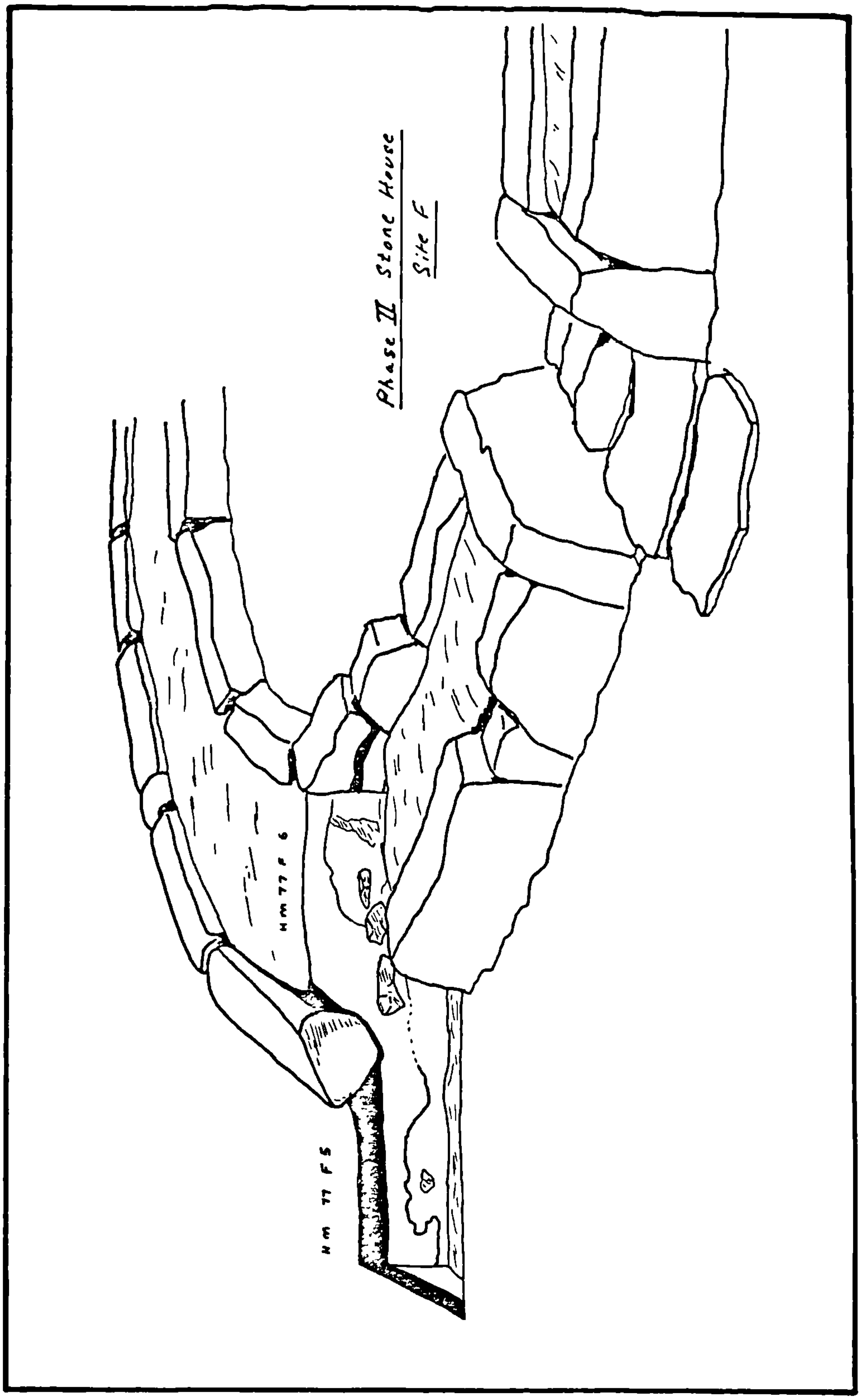


Fig. 5.24 Schematic view of the palaeosol trench through the wall of the prehistoric house on archaeological site F

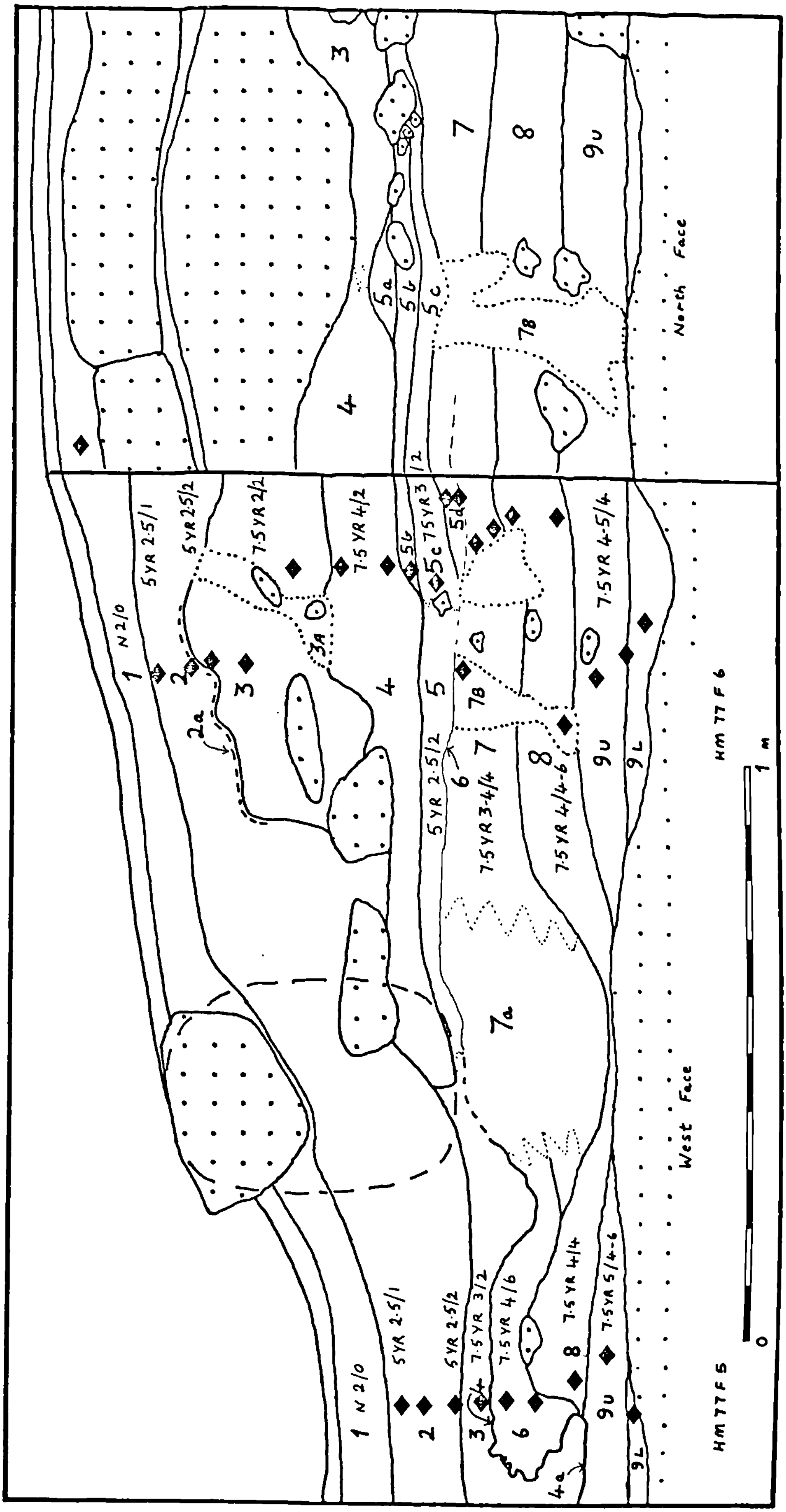


Fig. 5.25 Section through site F house wall showing the principal features of the buried prehistoric palaeosol and its overburden

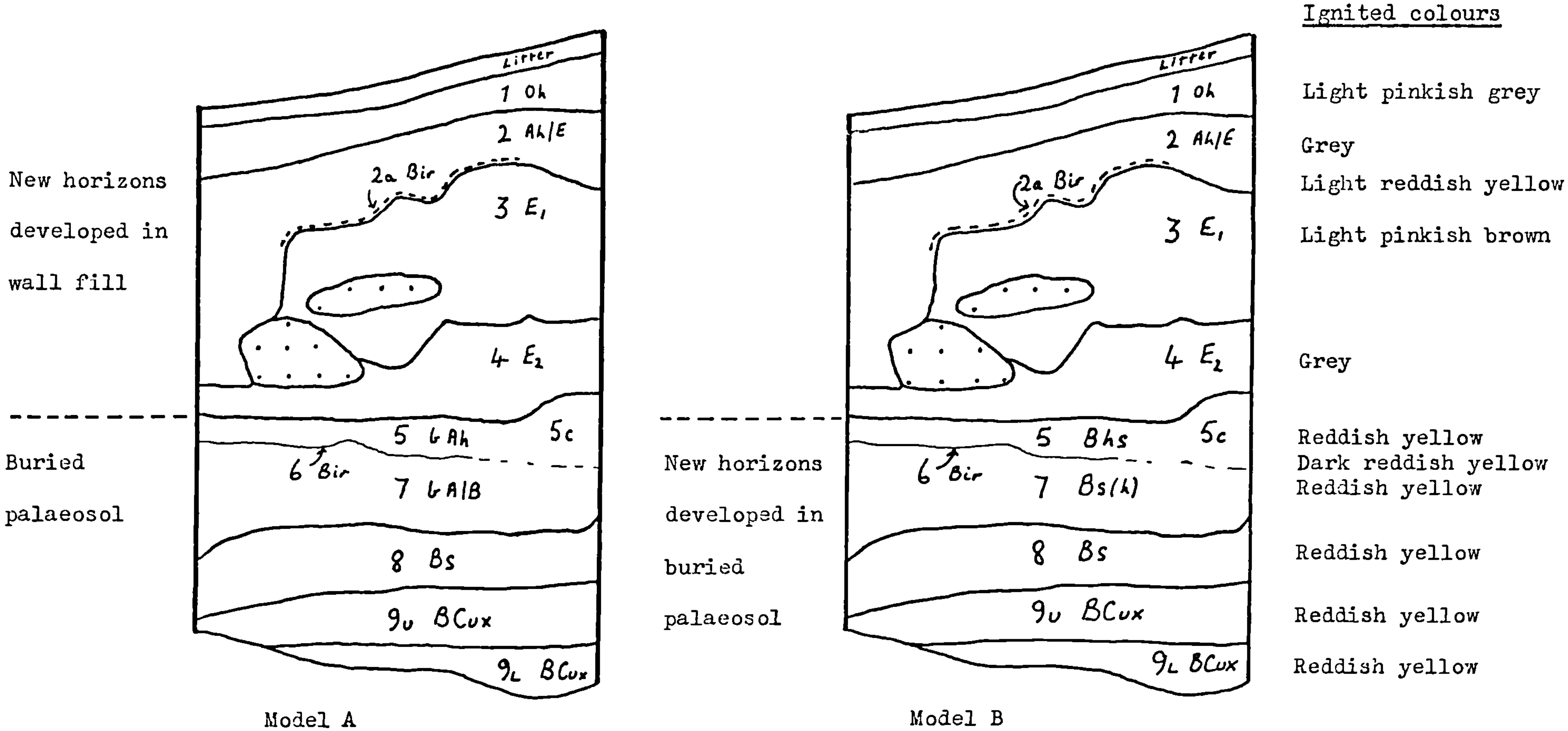


Fig. 5.26 Schematic sections showing alternative horizon nomenclature and ignited colours of soils in the prehistoric palaeosol and its overburden

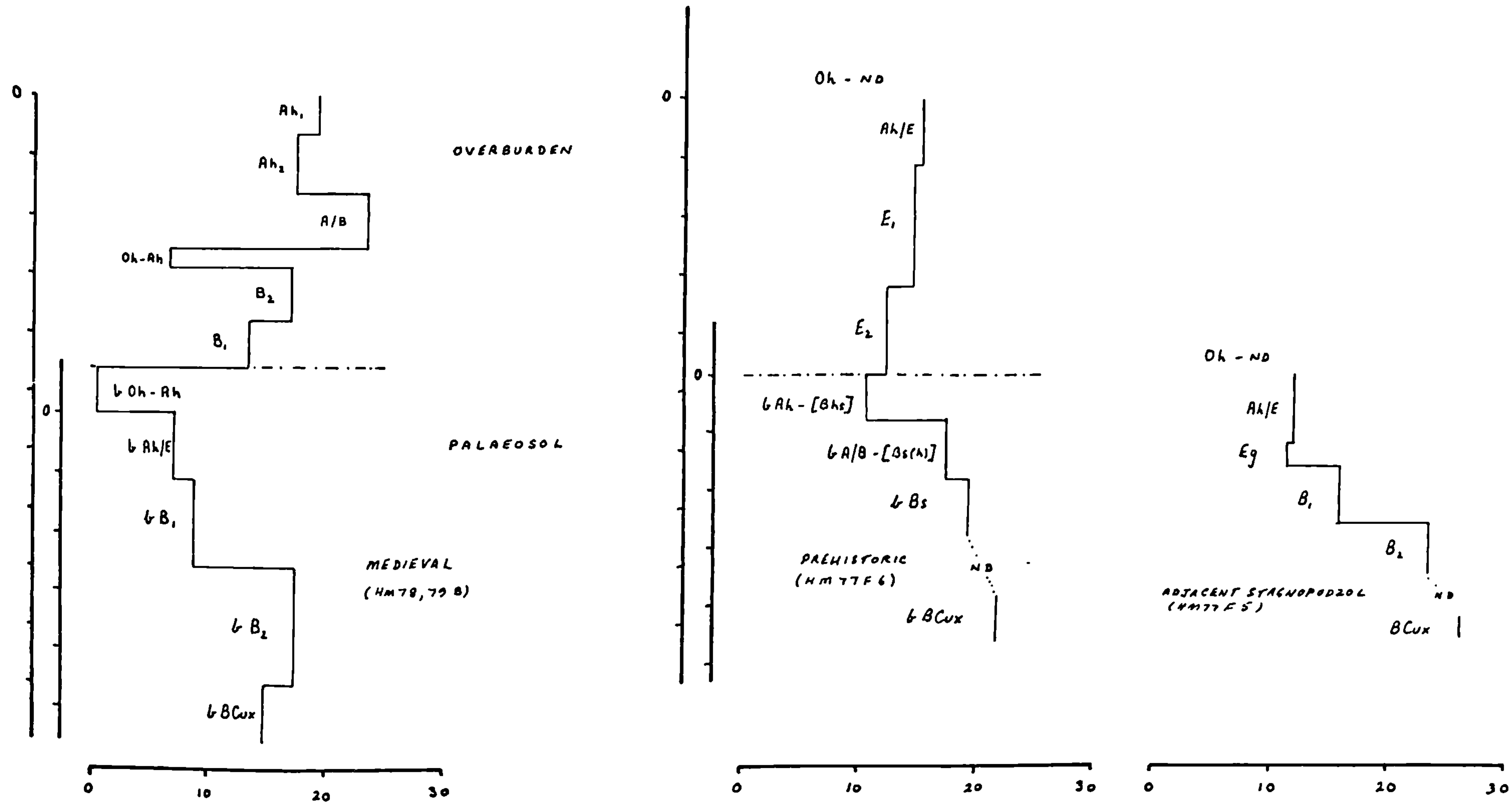


Fig 5.27 Stones (2-8 mm) expressed as a percentage of soil (< 8mm) [weight]

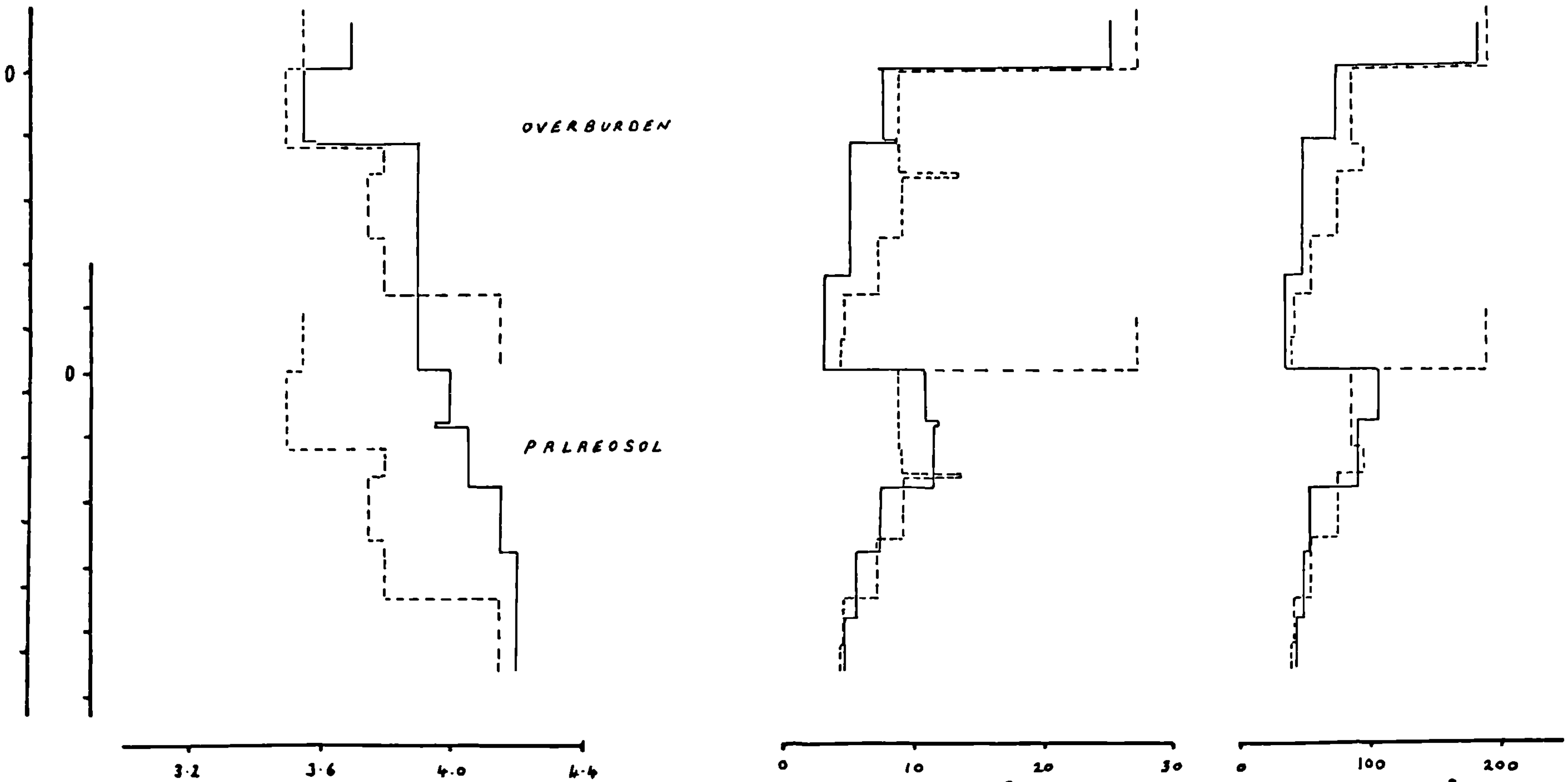


Fig 5.28 pH

Fig 5.29 LOI %

Fig 5.30 mg LOI cm^{-3}

——— PREHISTORIC PALAEOSOL AND OVERBURDEN (HM77F6)

– – – – – ADJACENT STAGNOPODZOL (HM77F5)

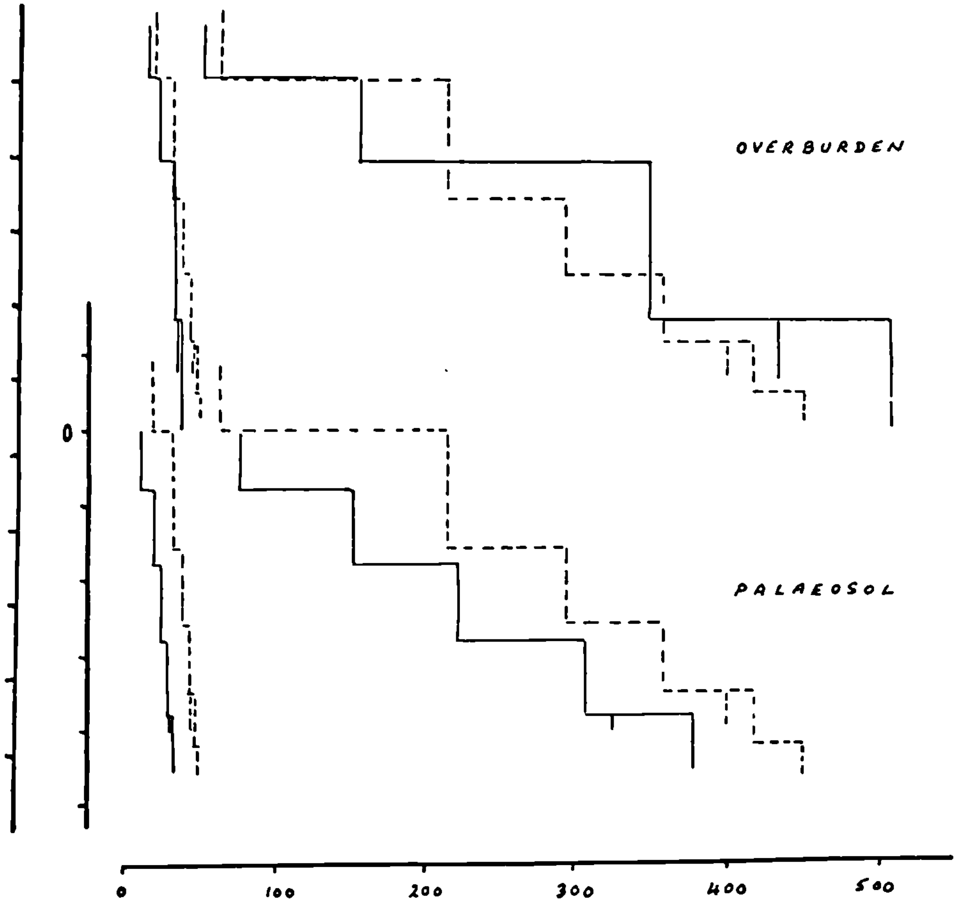


Fig 5.31 kg LOI m^{-2} (cum.) kg Fe m^{-2} (cum.)

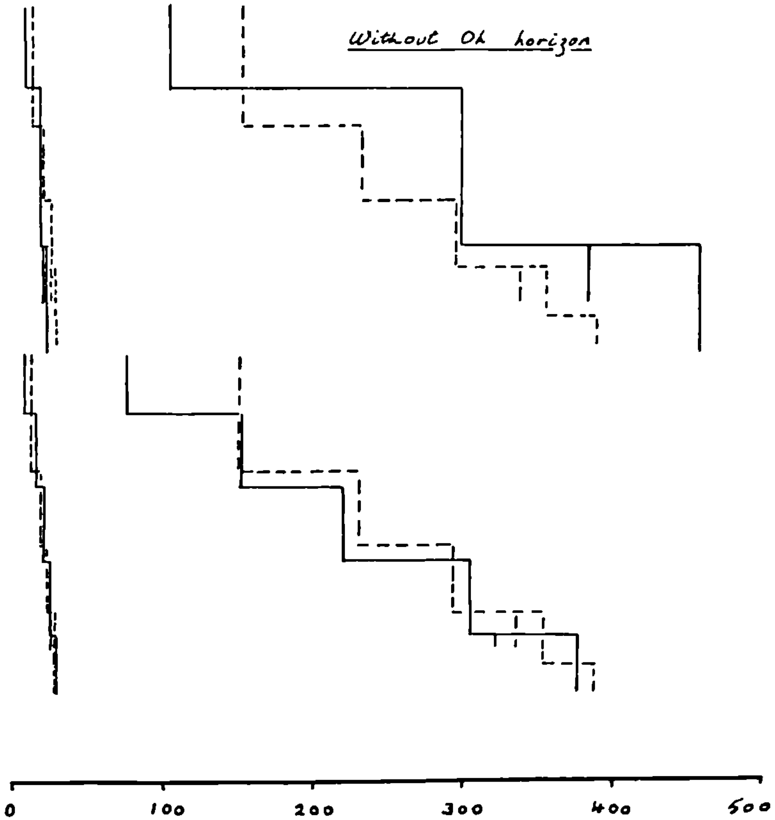


Fig 5.32 kg LOI m^{-2} (cum.) kg Fe m^{-2} (cum.)

——— PREHISTORIC PALAEOSOL AND OVERBURDEN (HM77F6) - - - - - - ADJACENT STAGNOPODZOL (HM77F5)

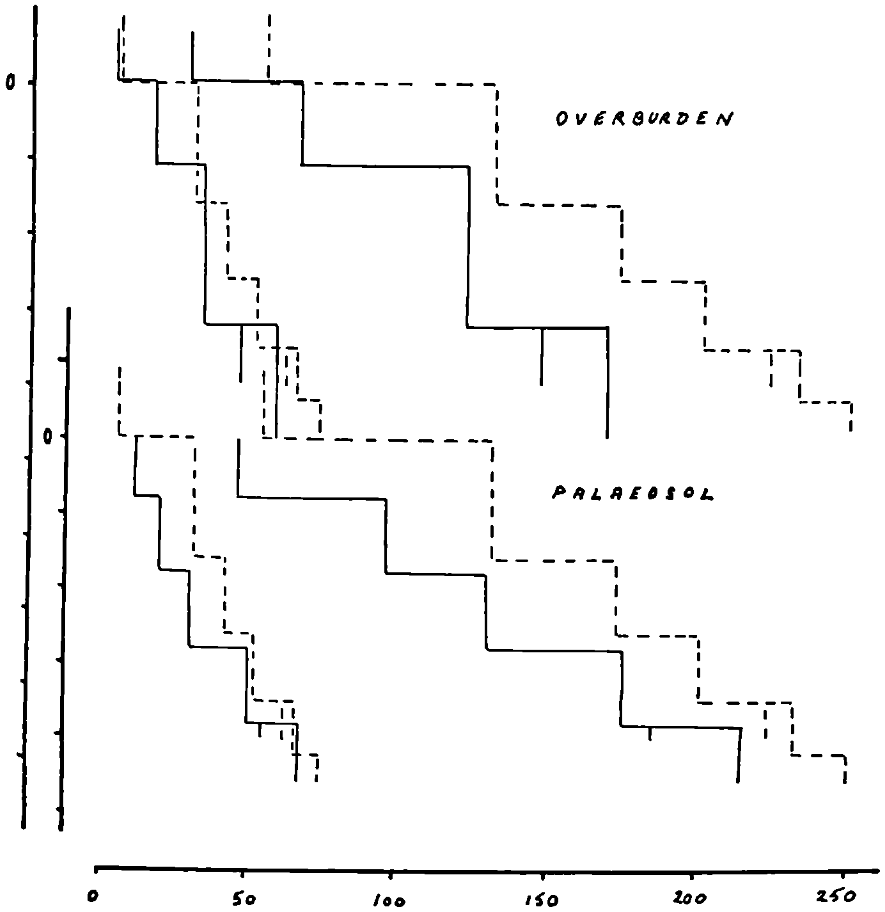


Fig 5.33 g P_f m^{-2} (cum.) g P_t m^{-2} (cum.)

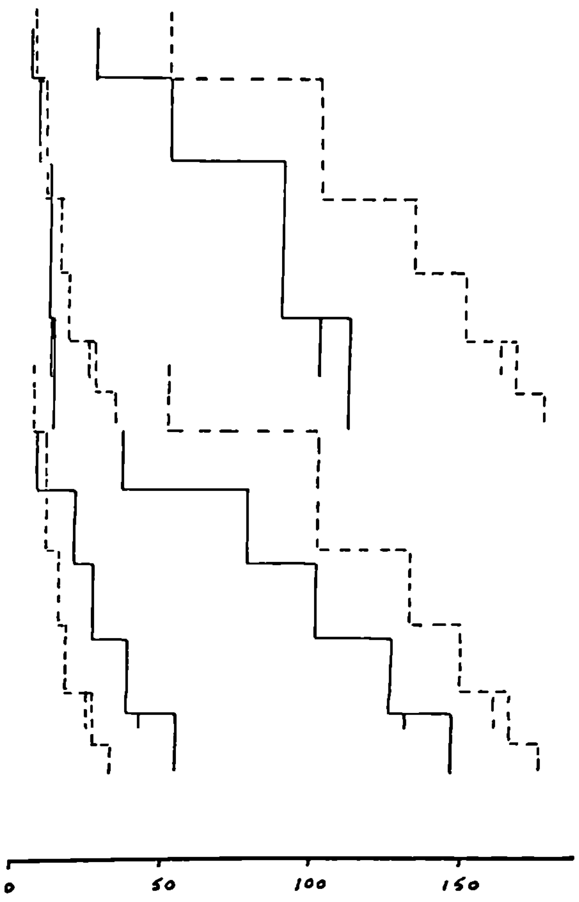


Fig 5.34 g P_a m^{-2} (cum.) g P_{ao} m^{-2} (cum.)

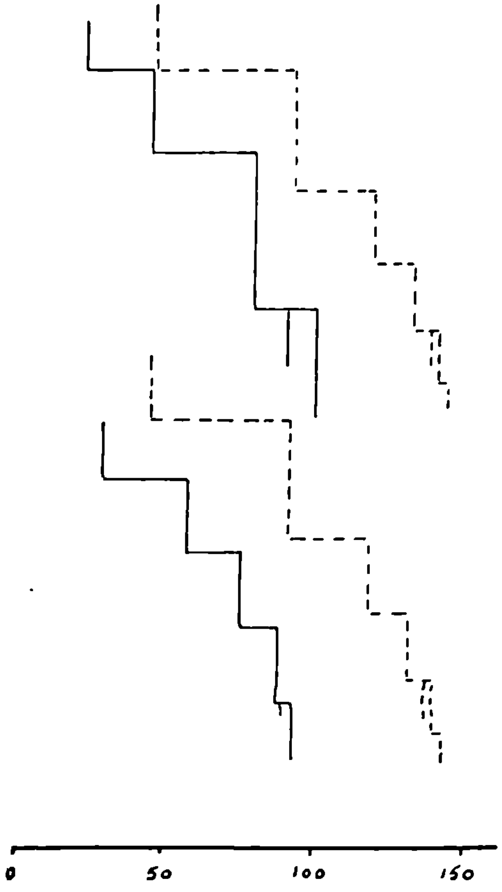


Fig 5.35 g P_o m^{-2} (cum.)

——— PREHISTORIC PALAEOSOL AND OVERBURDEN (HM77F6)

- - - - - ADJACENT STAGNOPODZOL (HM77F5)

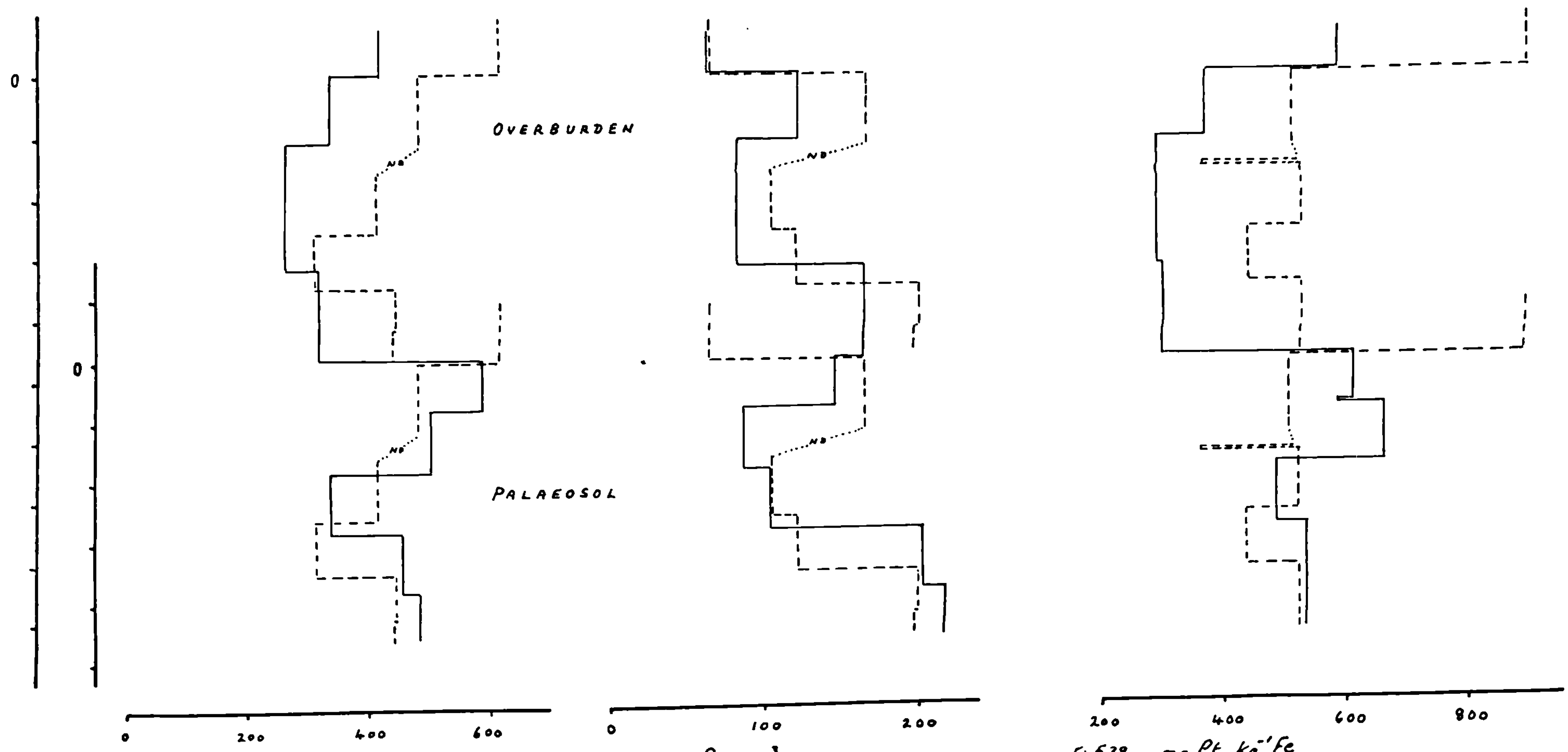


Fig 5.36 $\mu g \; Pt \; cm^{-3}$

Fig 5.37 $\mu g \; Pt \; cm^{-3}$

Fig 5.38 $ng \; Pt \; kg^{-1} \; Fe$

——— PREHISTORIC PALAEOSOL AND OVERBURDEN (HM77F6)

– – – – – ADJACENT STAGNOPODZOL (HM77F5)

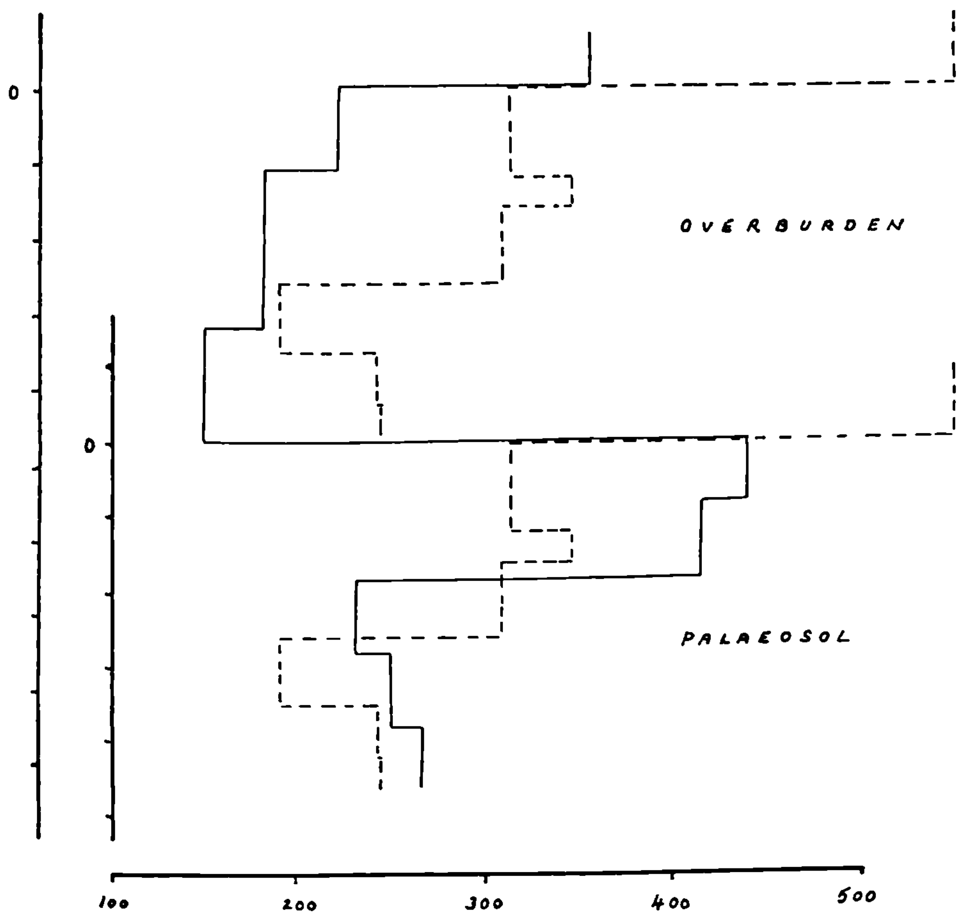


Fig 5.39 $\mu g\ P_o\ cm^{-3}$

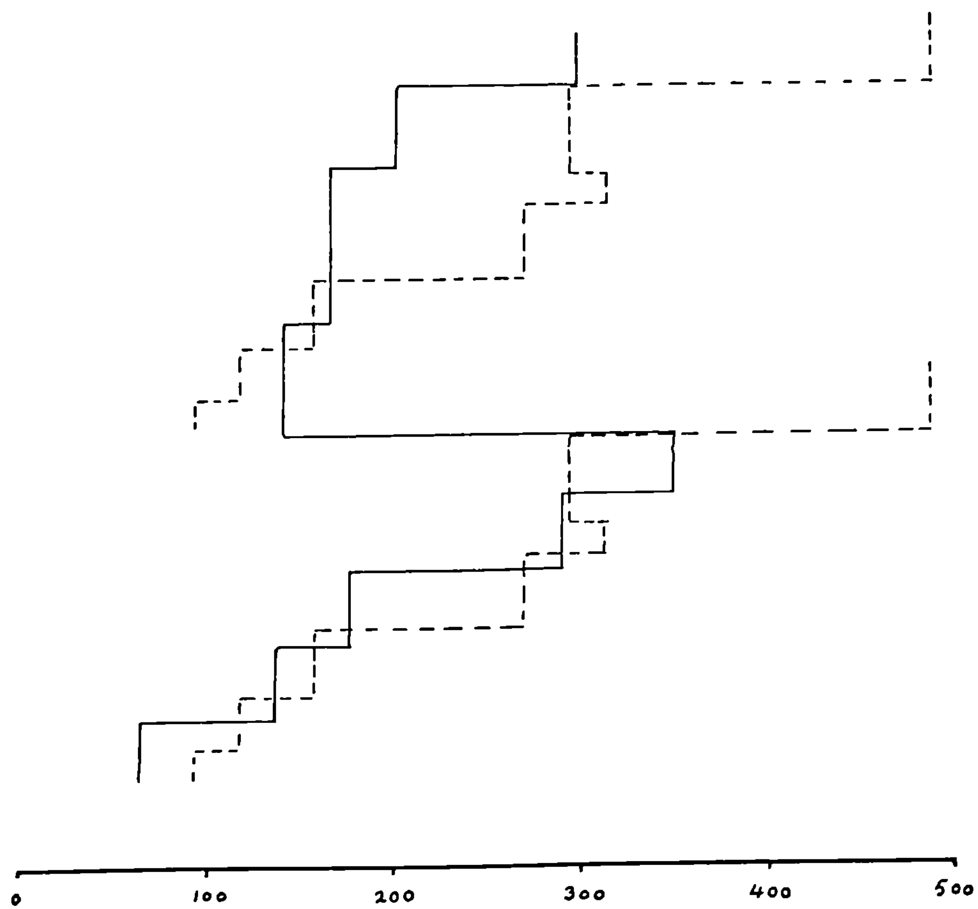
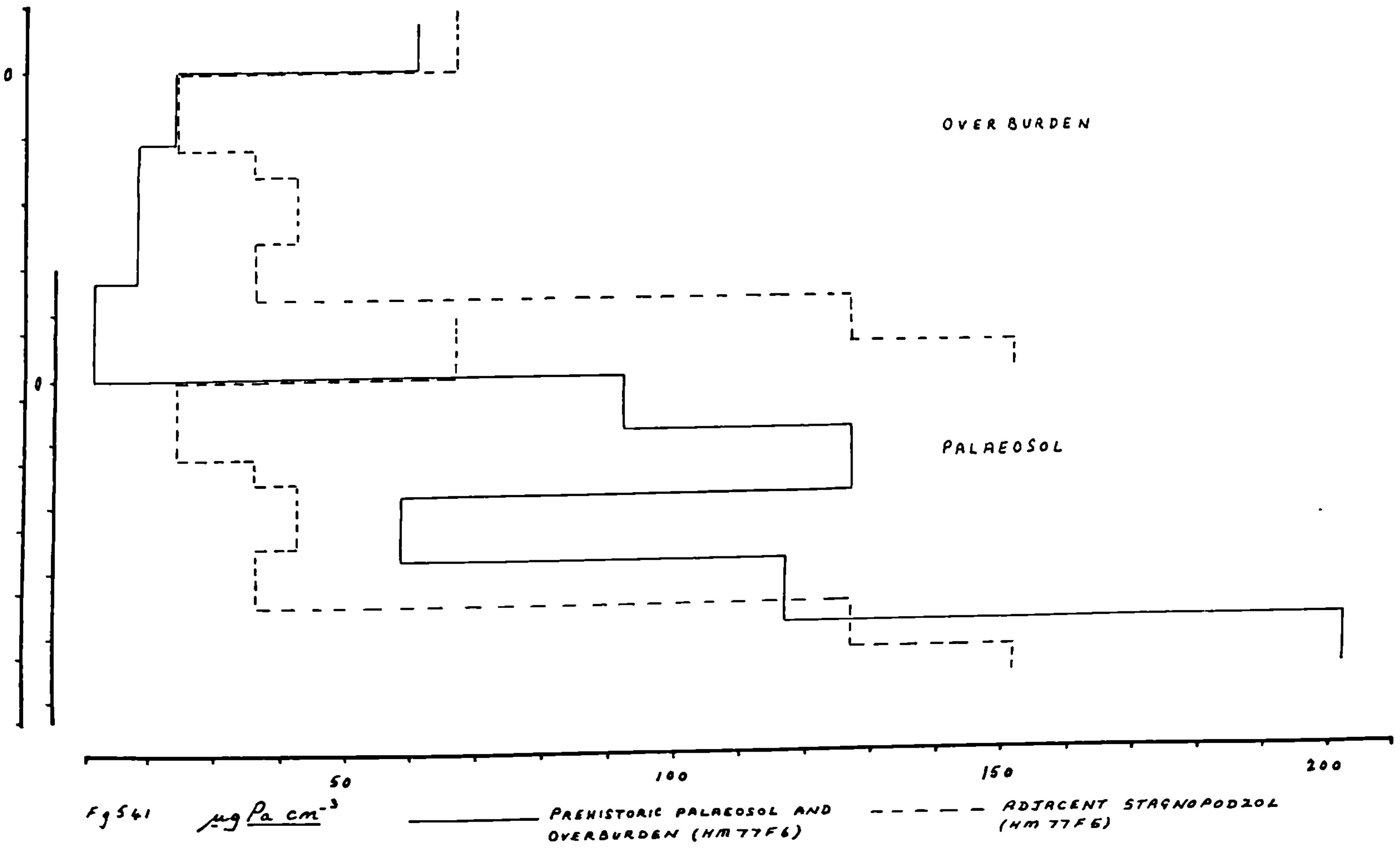


Fig 5.40 $\mu g\ P_o\ cm^{-3}$

——— PREHISTORIC PALAEOSOL AND OVERBURDEN (HM77F6)

– – – – ADJACENT STAGNOPODZOL (HM77F5)


0
0
OVER BURDEN
PALAEOSOL
50
100
150
200
μg Pa cm⁻³
PREHISTORIC PALAEOSOL AND OVERBURDEN (HM77F6)
ADJACENT STAGNOPODZOL (HM 77F6)

Fg 5 41

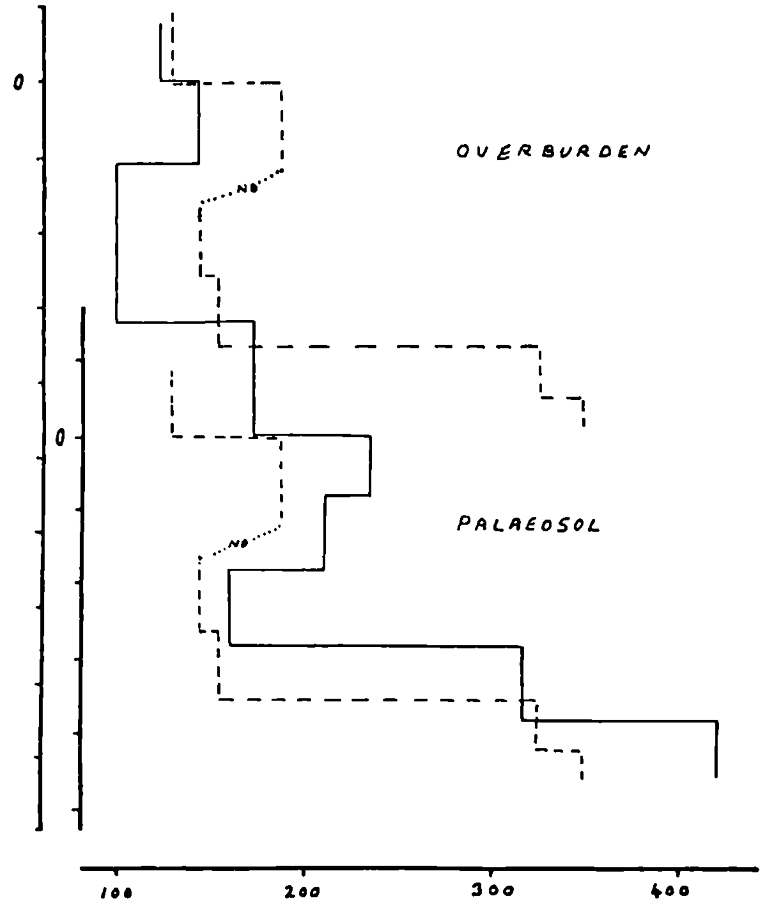


Fig 5.42 $\mu g\ P_i\ cm^{-3}$

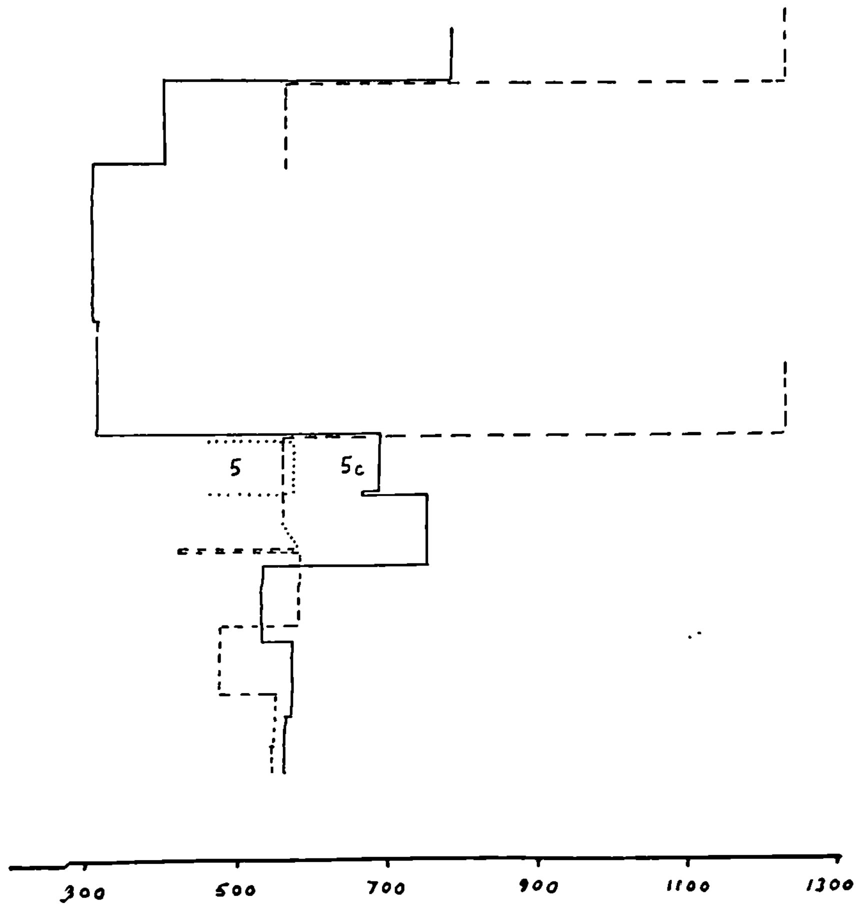


Fig 5.43 $mg\ P_t\ kg^{-1}\ IFe$

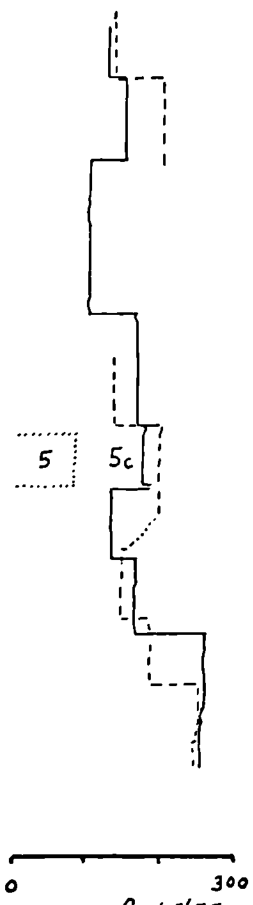


Fig 5.44 $mg\ P_f\ kg^{-1}\ IFe$

——— PREHISTORIC PALAEOSOL AND OVERBURDEN (HM77F6)

– – – – ADJACENT STAGNOPODZOL (HM77F5)

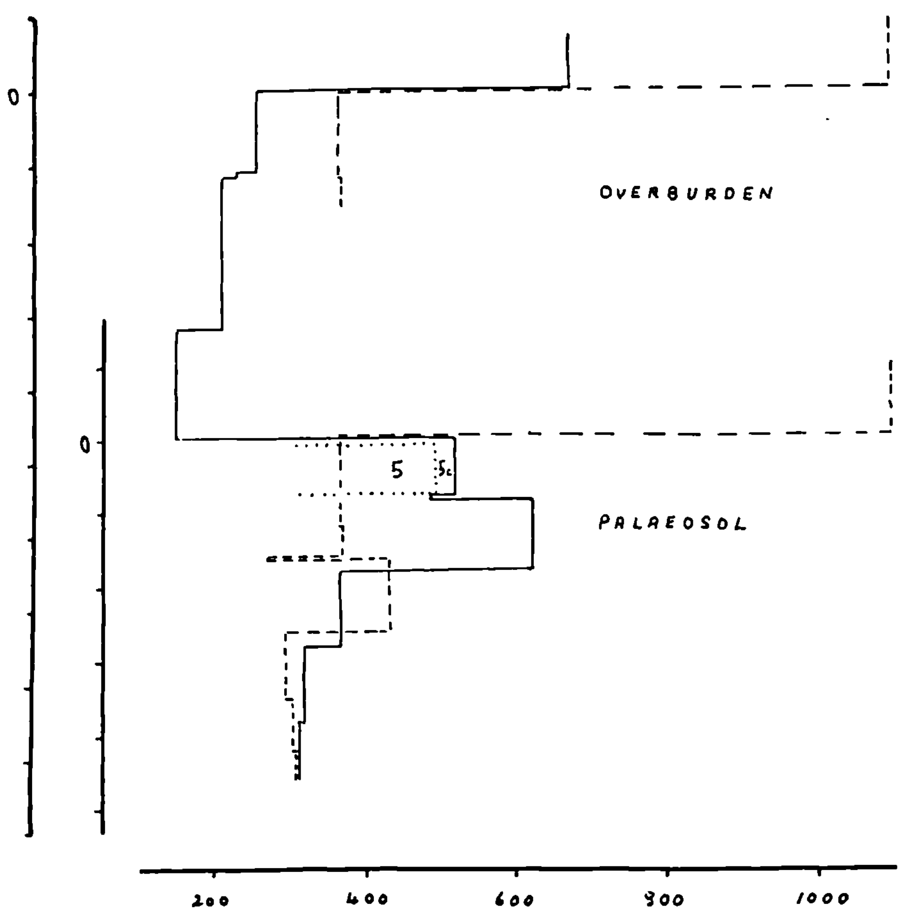


Fig 5.45 mg Pao kg⁻¹ Fe

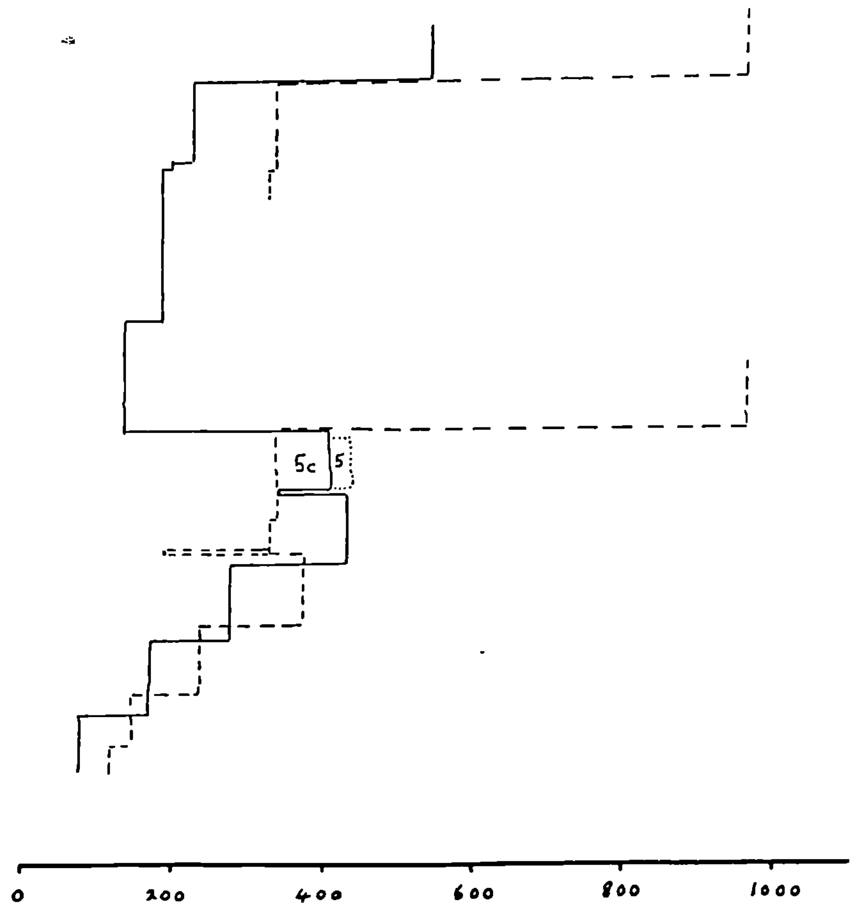


Fig 5.46 mg Po kg⁻¹ Fe

——— PREHISTORIC PALAEOSOL AND OVERBURDEN (HM77F6)

– – – – ADJACENT STAGNOPODZOL (HM77F5)

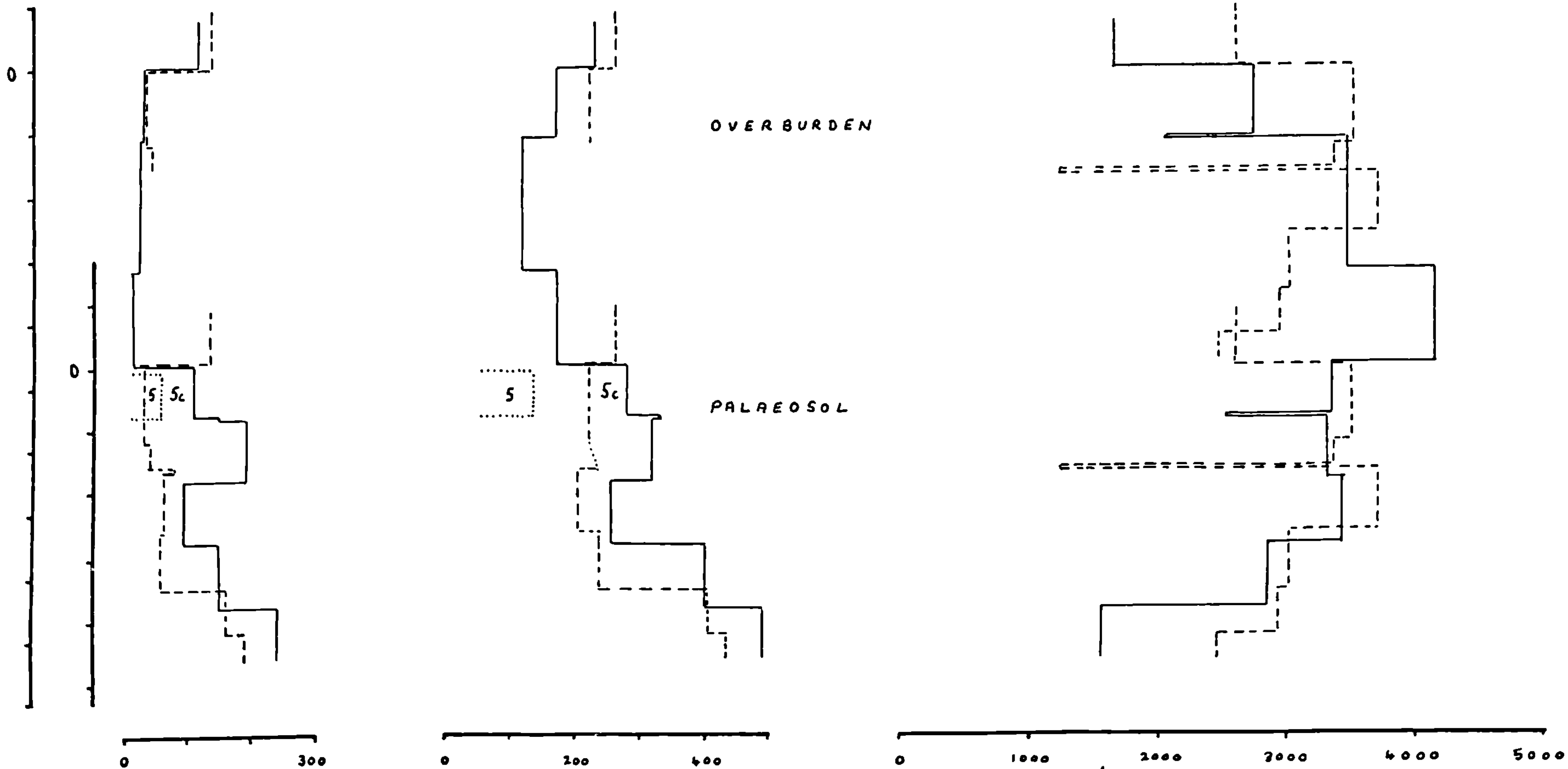
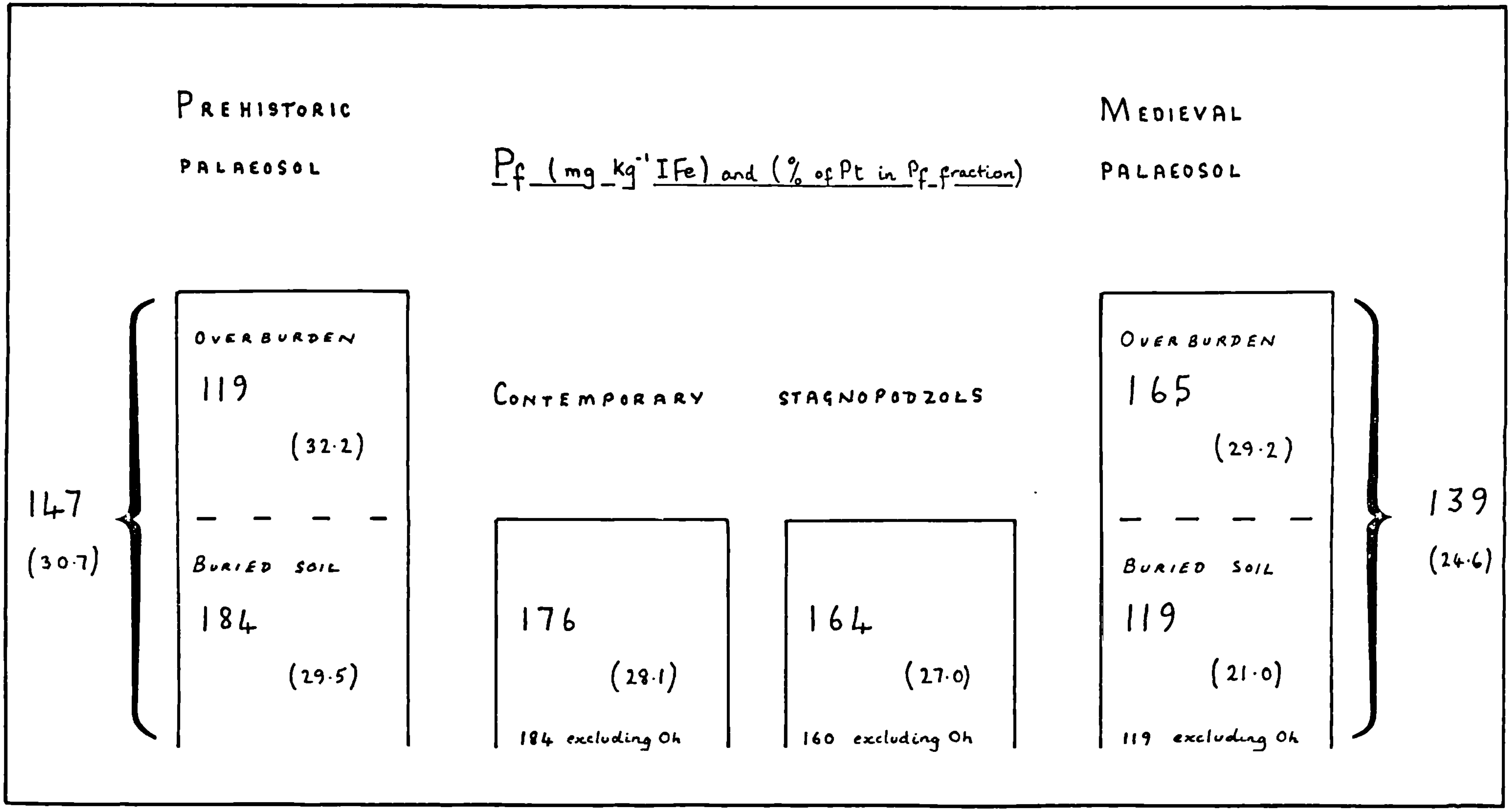


Fig 547 $mg\,P_a\,kg^{-1}\,IFe$ Fig 548 $mg\,P_i\,kg^{-1}\,IFe$ Fig 550 $mg\,P_o\,kg^{-1}\,LOI$

——— PREHISTORIC PALAEOSOL AND OVERBURDEN (HM 77 F 6)

– – – – – ADJACENT STAGNOPODZOL (HM 77 F 5)

Fig 5.49 Prehistoric and medieval palaeosols and their overburdens: concentration of Pf in entire profiles and the percentage of Pt in the Pf fraction



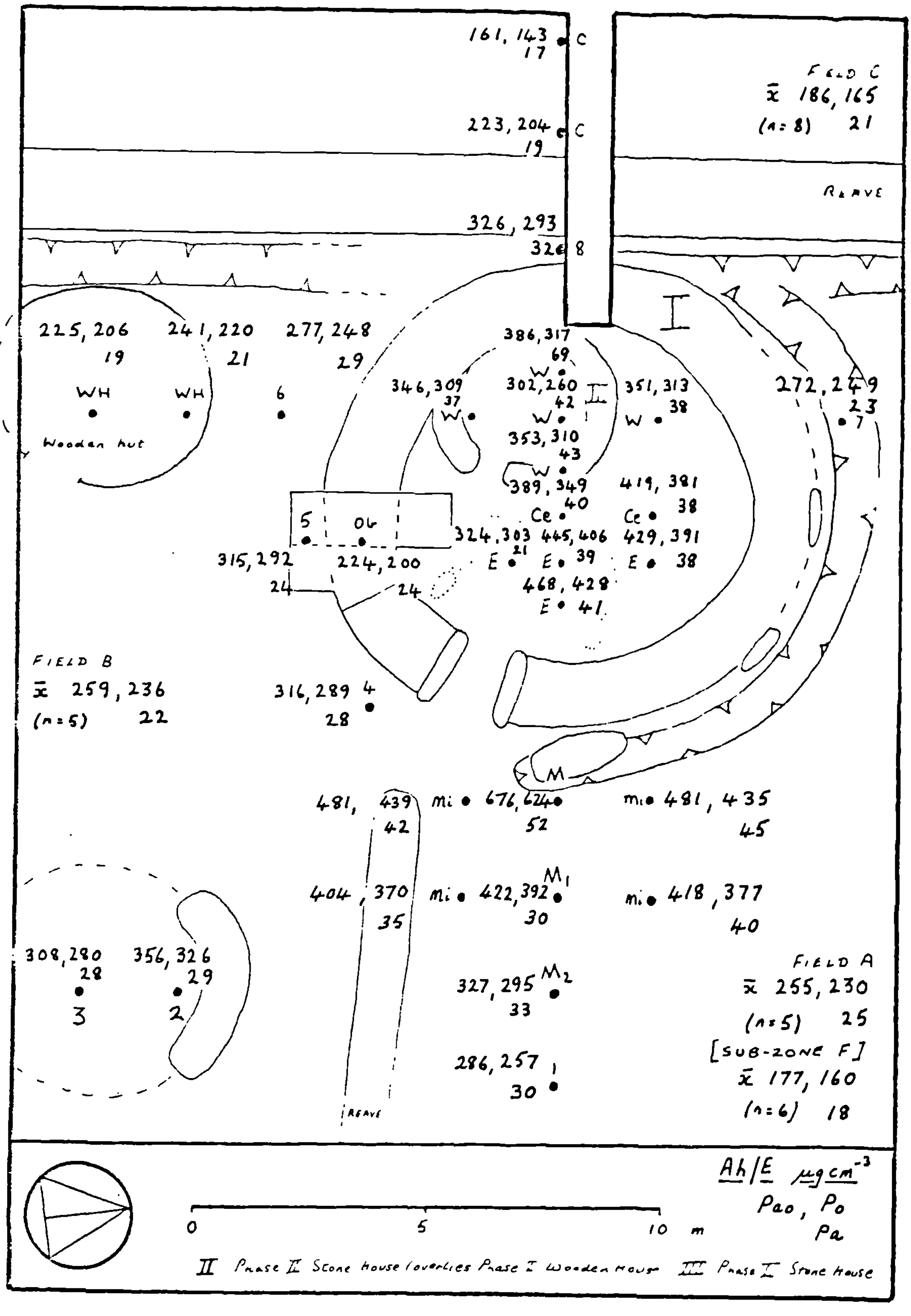


Fig. 5.51 Site F - Lateral distributions: Pao, Po and Pa in the Ah/E horizon

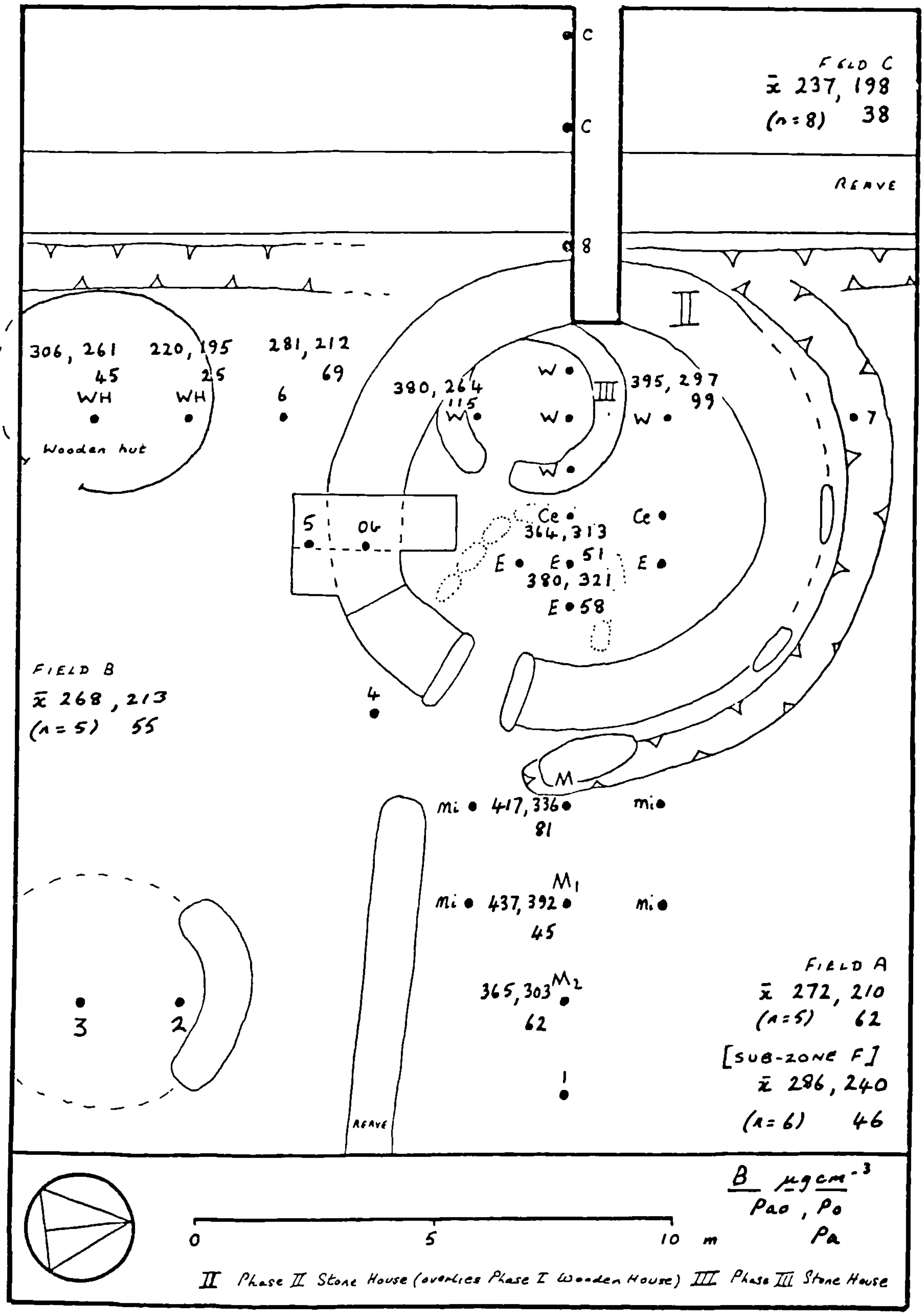
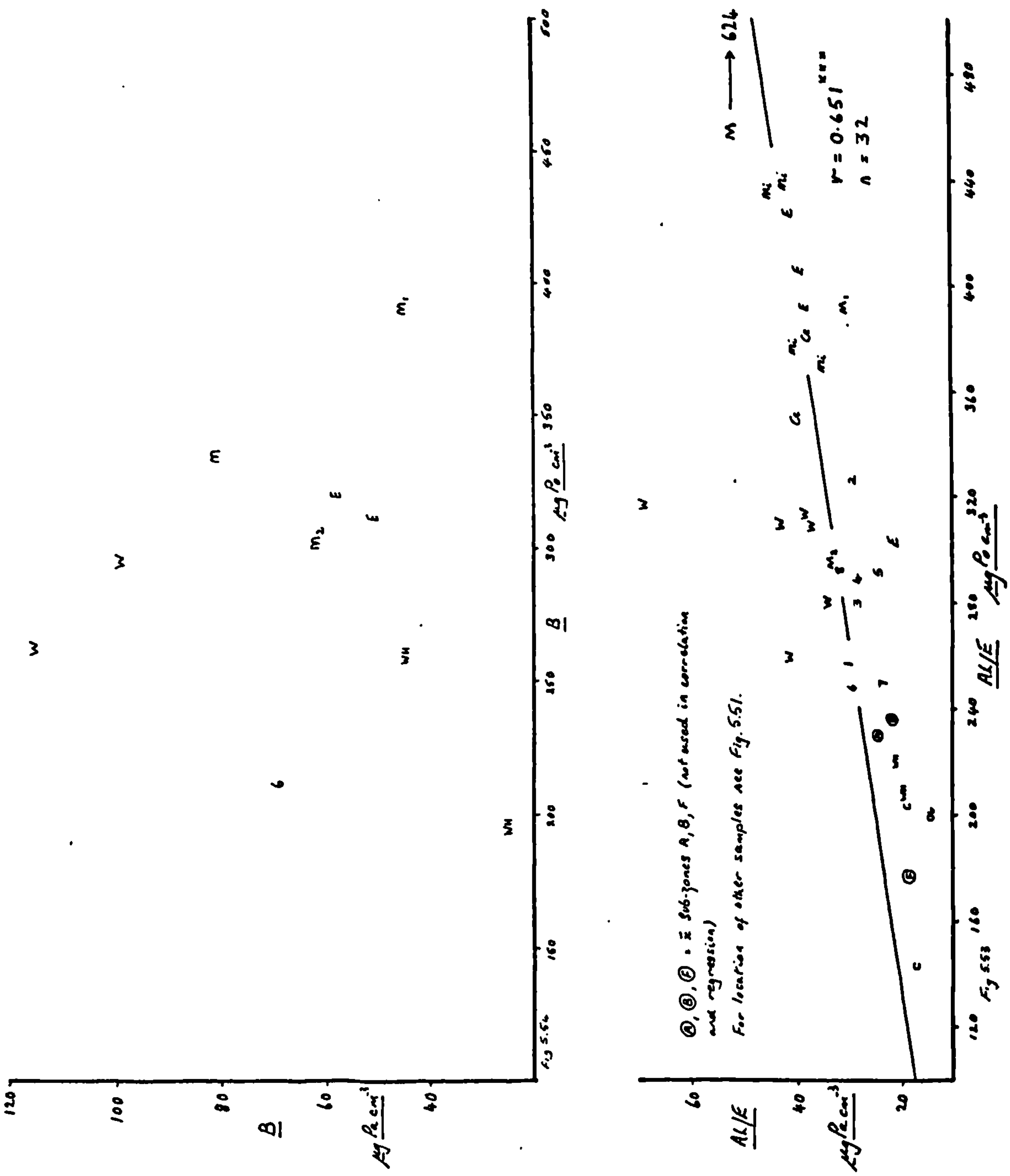


Fig. 5.52 Site F - Lateral distributions: Pao, Po and Pa in the B horizon



Figs. 5.53 and 5.54 Site F - Scattergrams illustrating the relationship between Po and Pa in Ah/E and B horizon samples

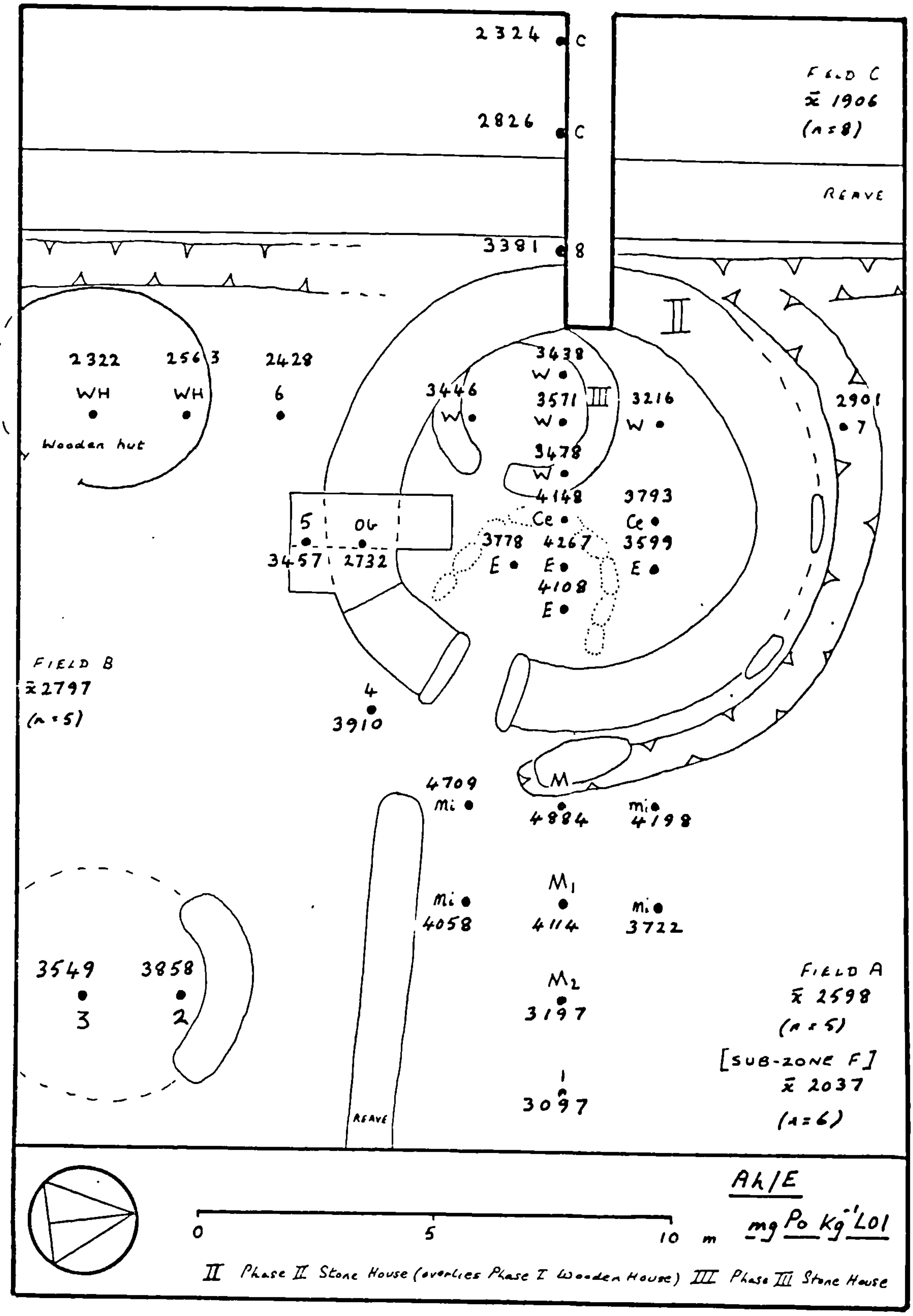


Fig. 5.55 Site F - Lateral distributions: mgPo kg^{-1} LOI in the Ah/E horizon

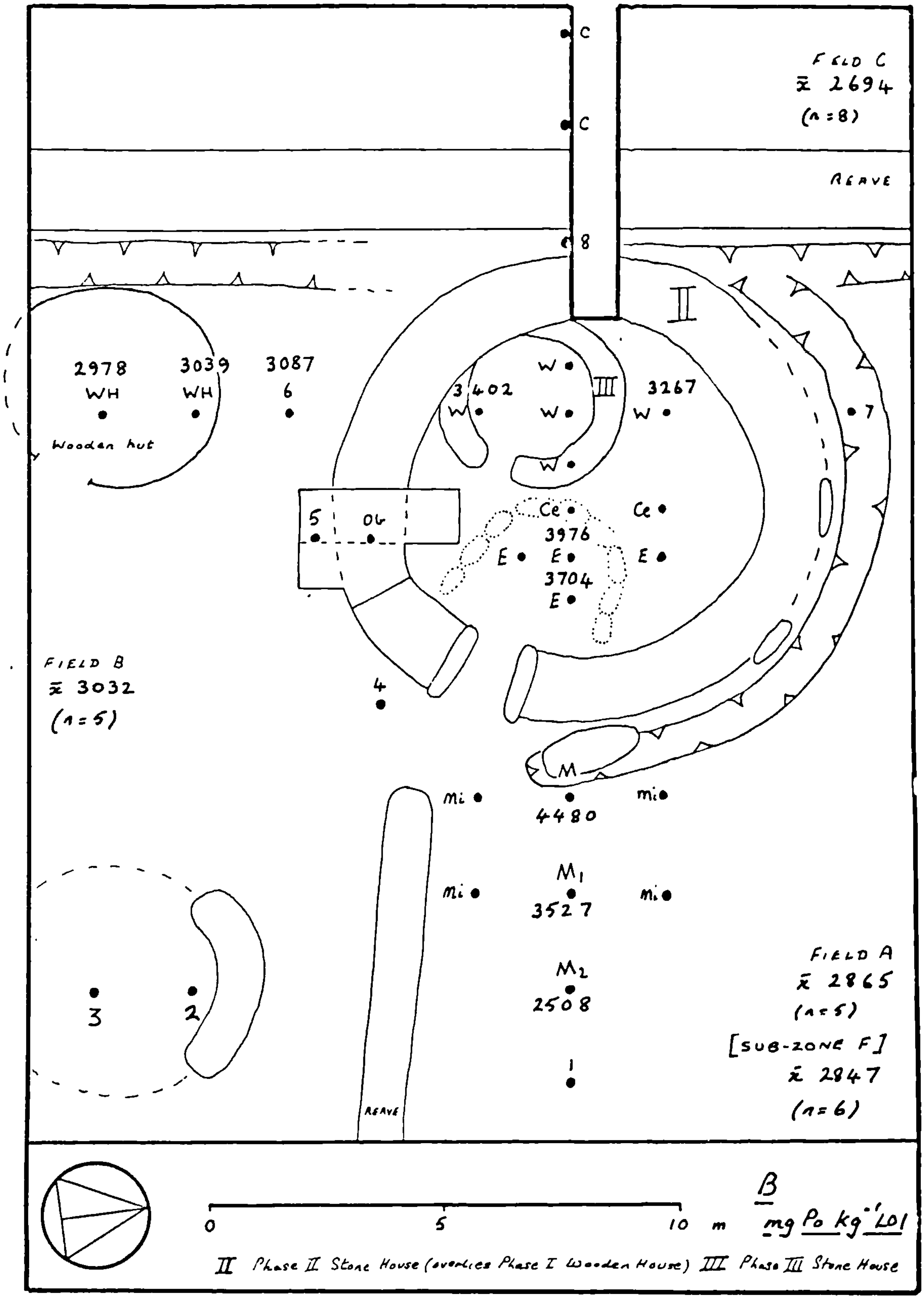


Fig. 5.56 Site F - Lateral distributions: mgPo kg^{-1} LOI in the B horizon

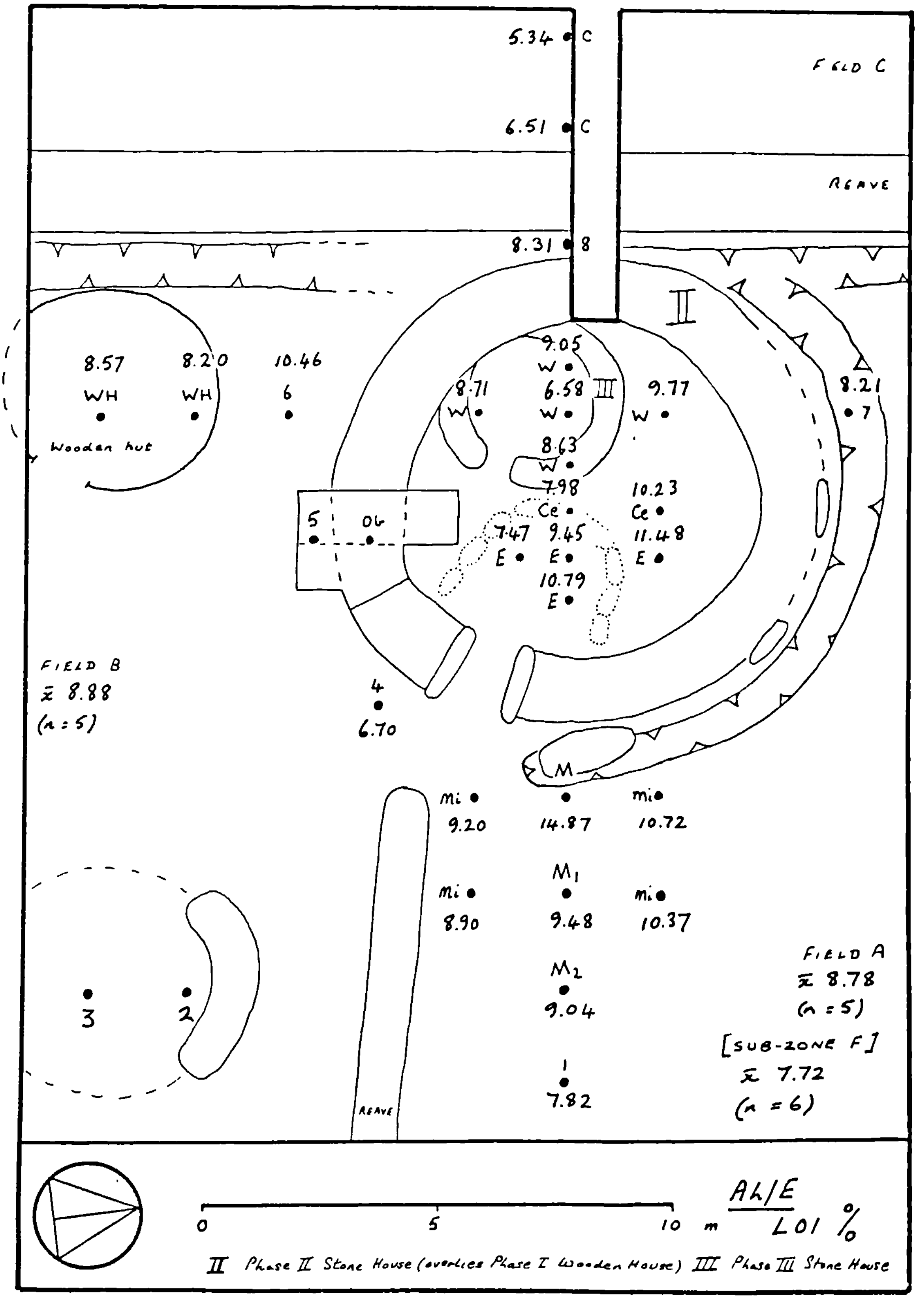


Fig. 5.57 Site F - Lateral distributions: LOI % in the Ah/E horizon

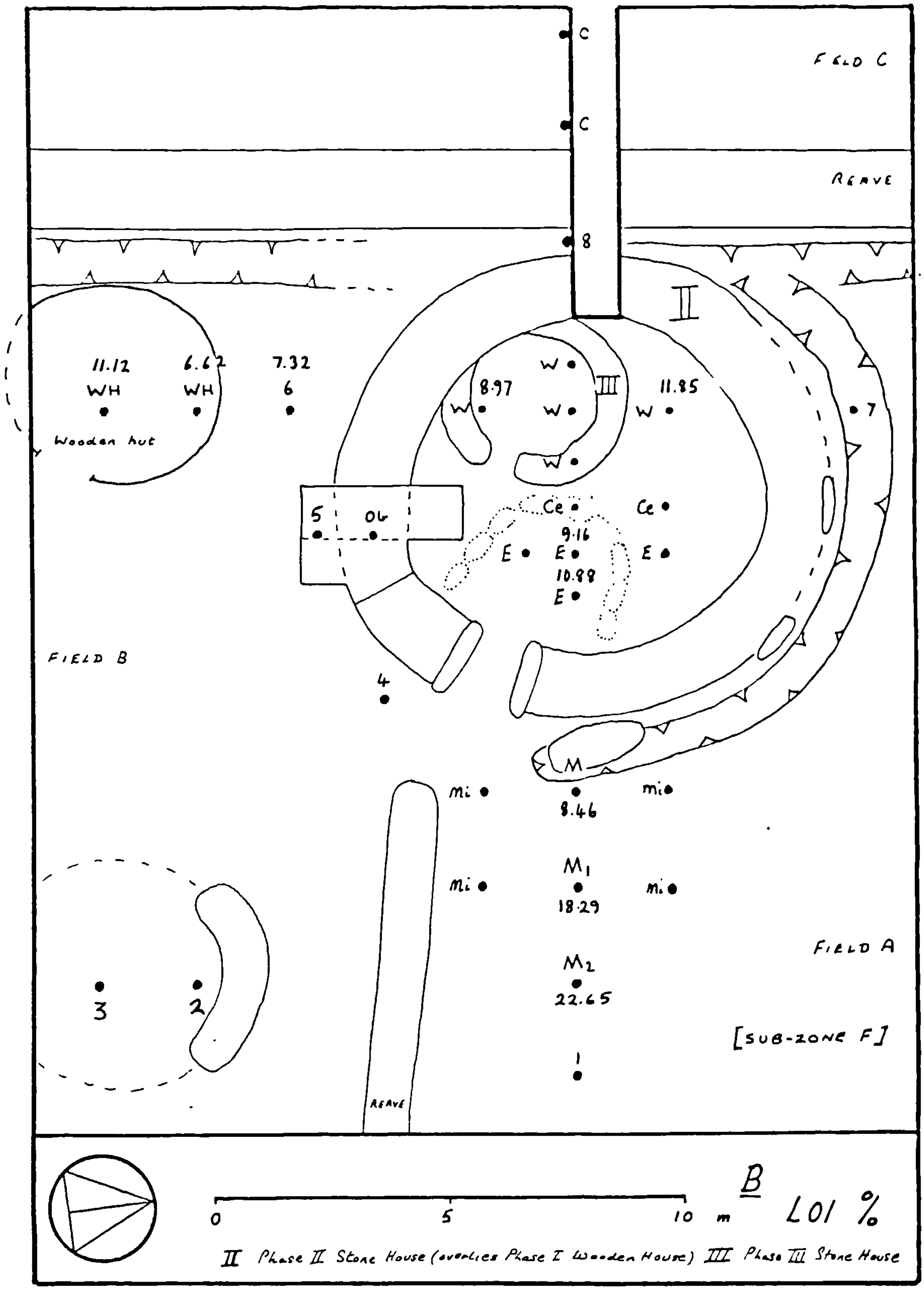
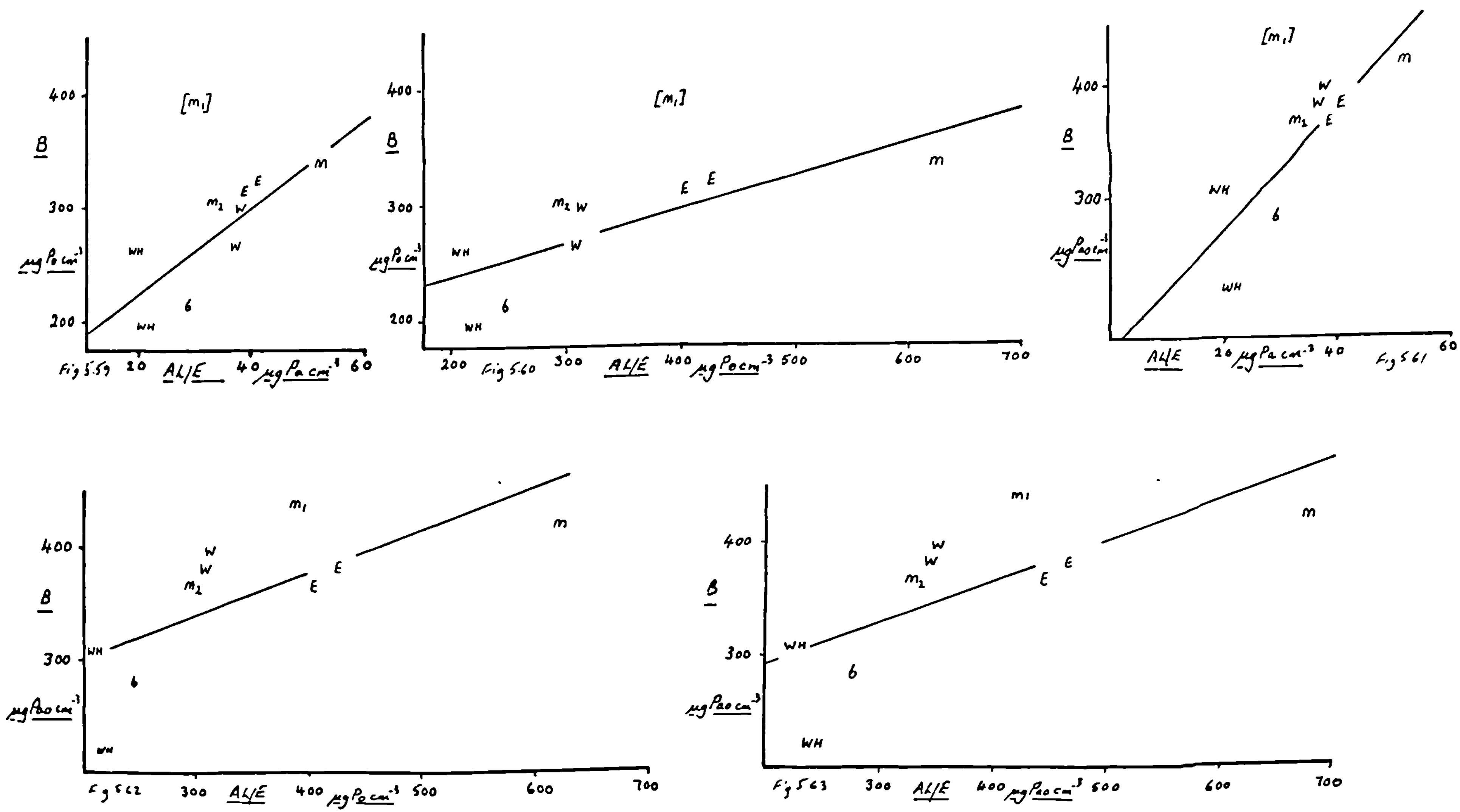
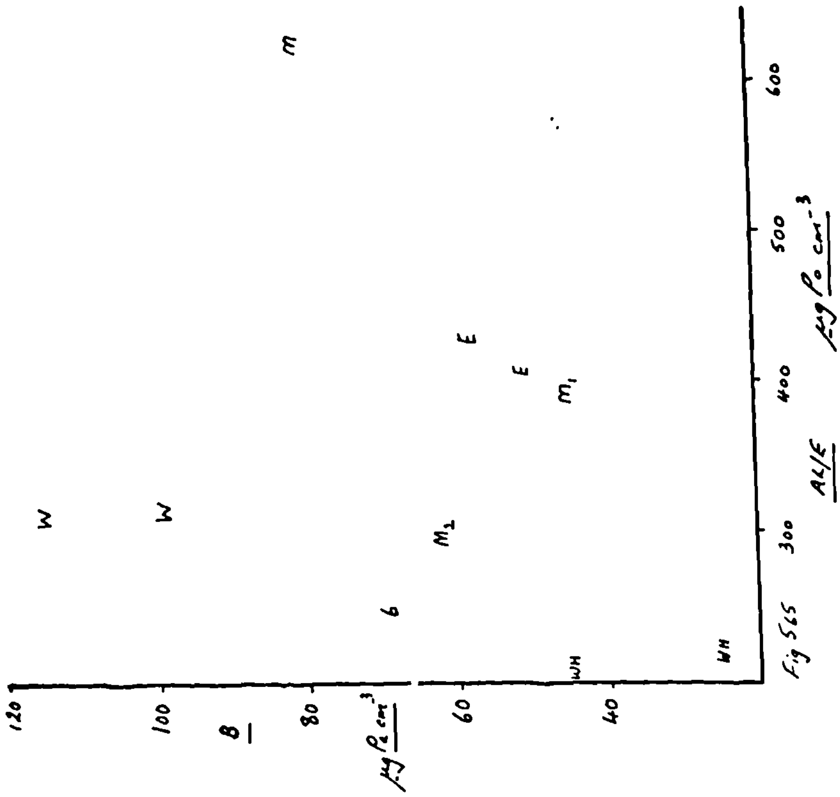


Fig. 5.58 Site F - Lateral distributions: LOI % in the B horizon

Figs. 5.59 - 5.63 Site F - Scattergrams (for location of samples see code numbers on Figs.5.51 - 5.58)



Figs. 5.64 and 5.65 Site F - Scattergrams (for location of samples see code numbers on Figs. 5.51 - 5.58)



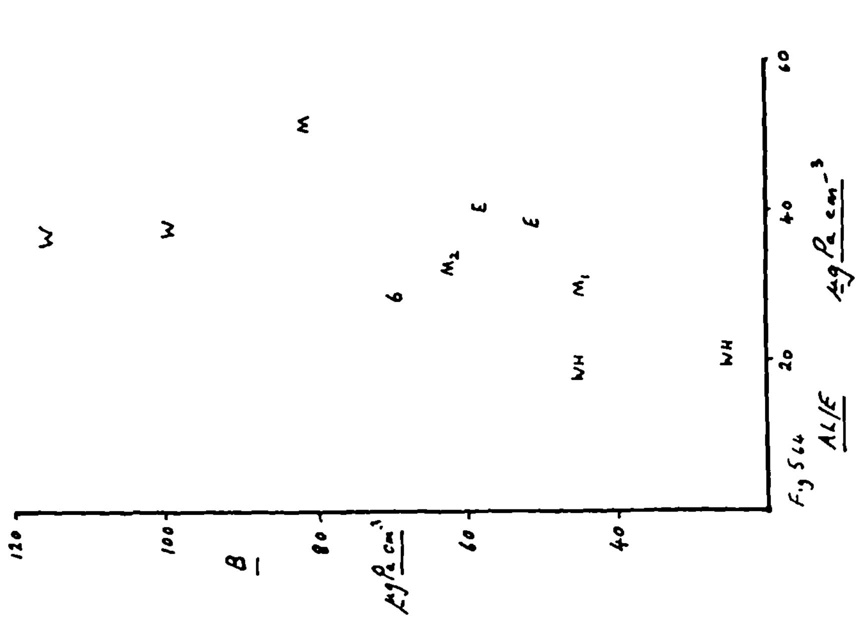
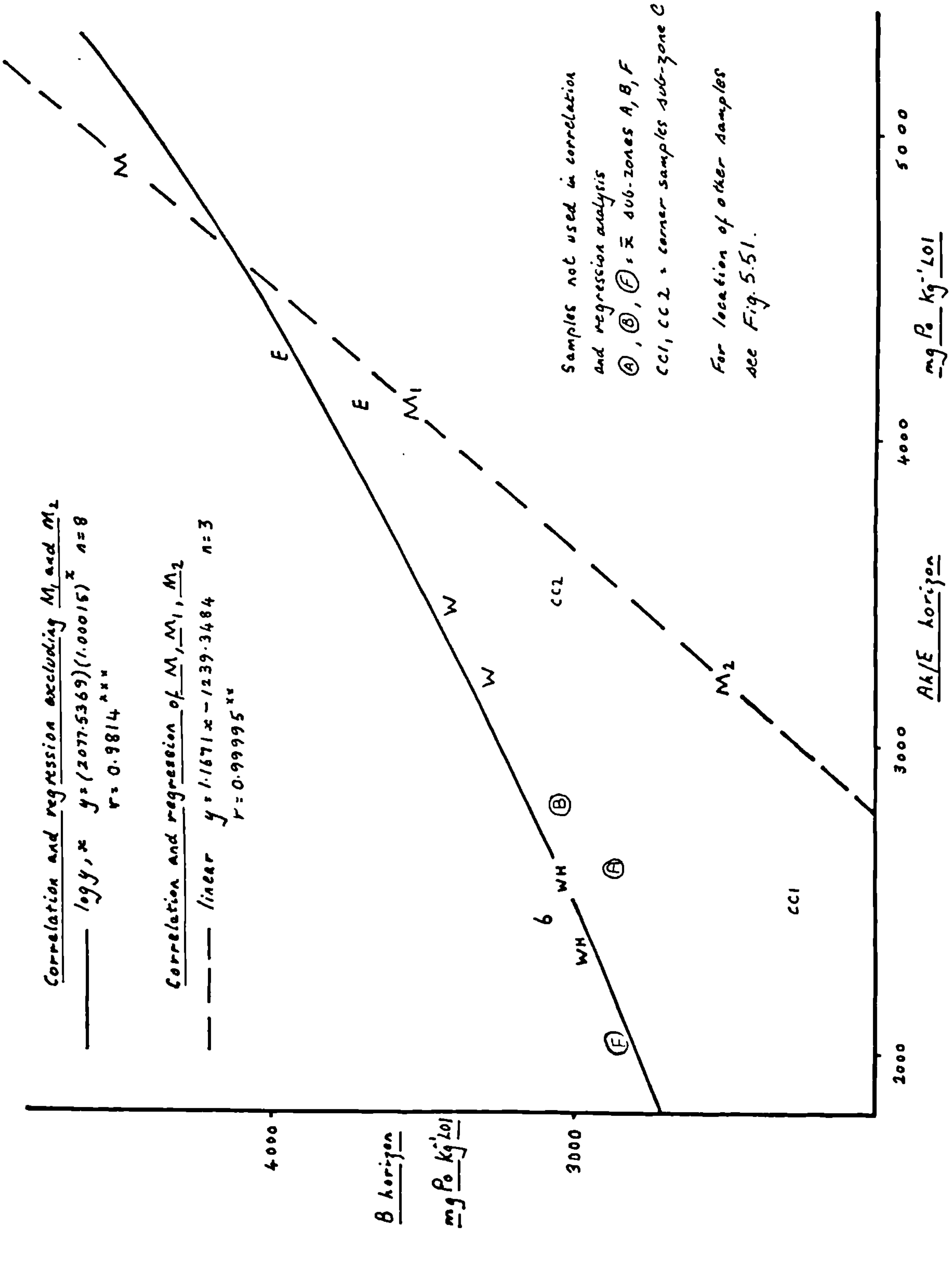


Fig. 5.66 Site F - Scattergram: mgPo kg^{-1} LOI in Ah/E horizon / mgPo kg^{-1} LOI in B horizon



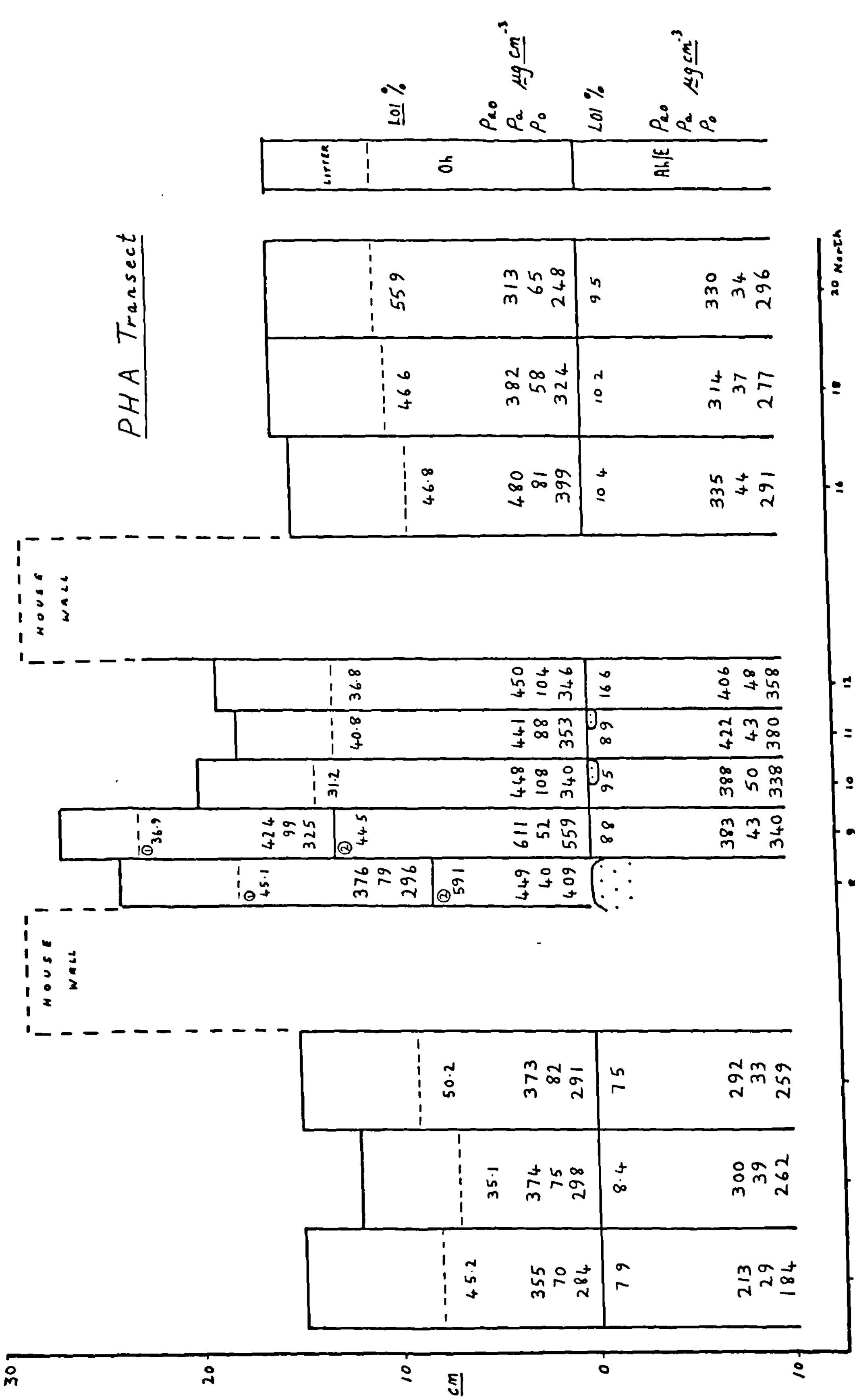
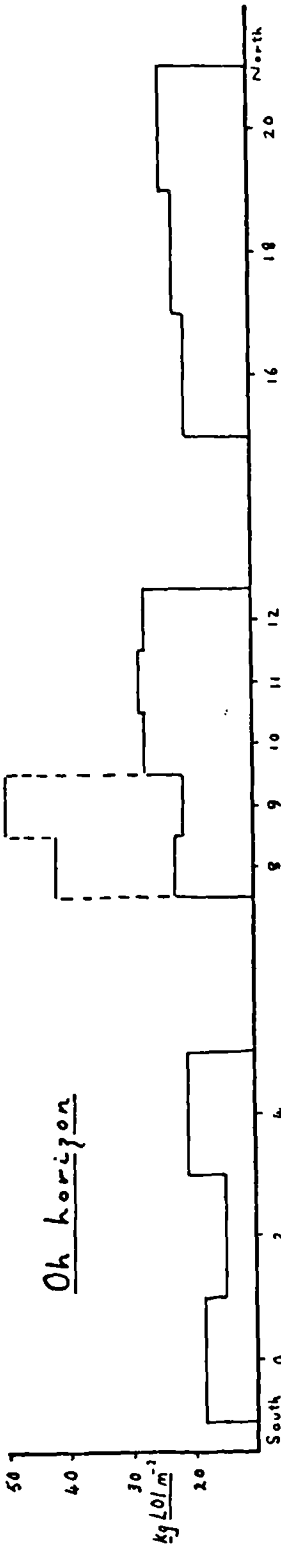


Fig. 5.67 PHA Transect - Phosphorus and LOI values in samples along a transect through a prehistoric house



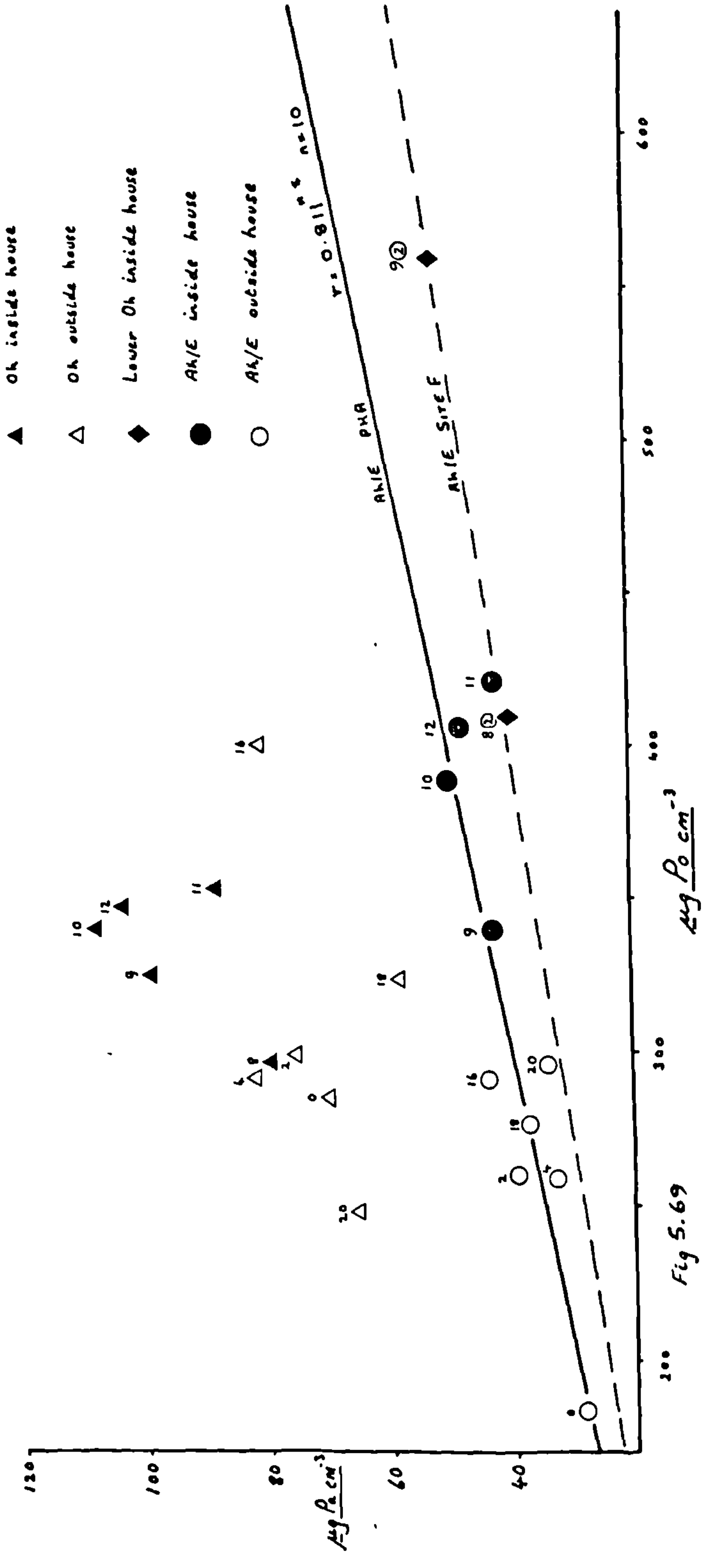


Fig. 5.68 PHA Transect - Lateral distribution: kg LOI m^{-2}

Fig. 5.69 PHA Transect - Scattergram: μgPo cm^{-3} in Oh and Ah/E horizon / μgPa cm^{-3} in Oh and Ah/E horizon

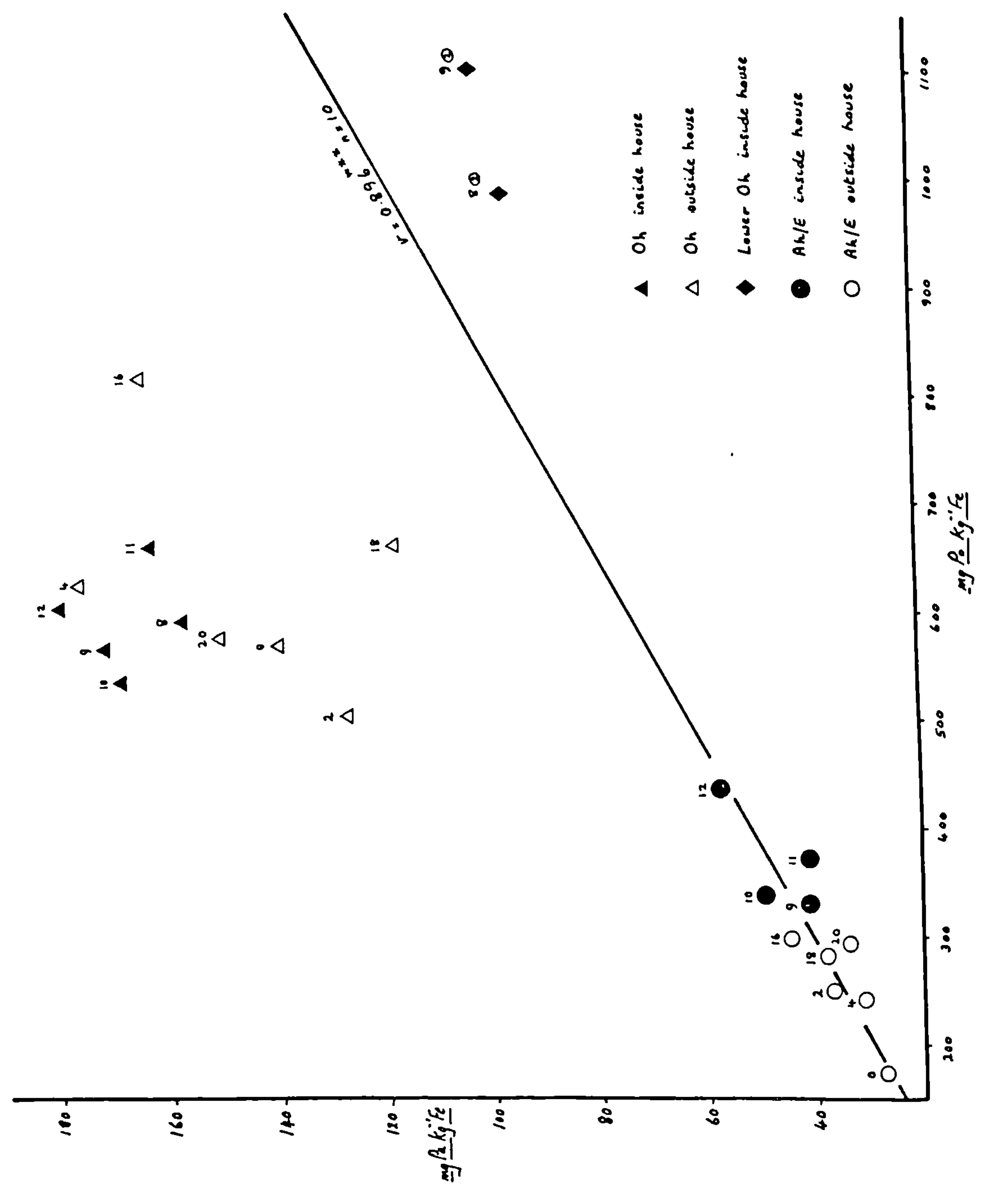
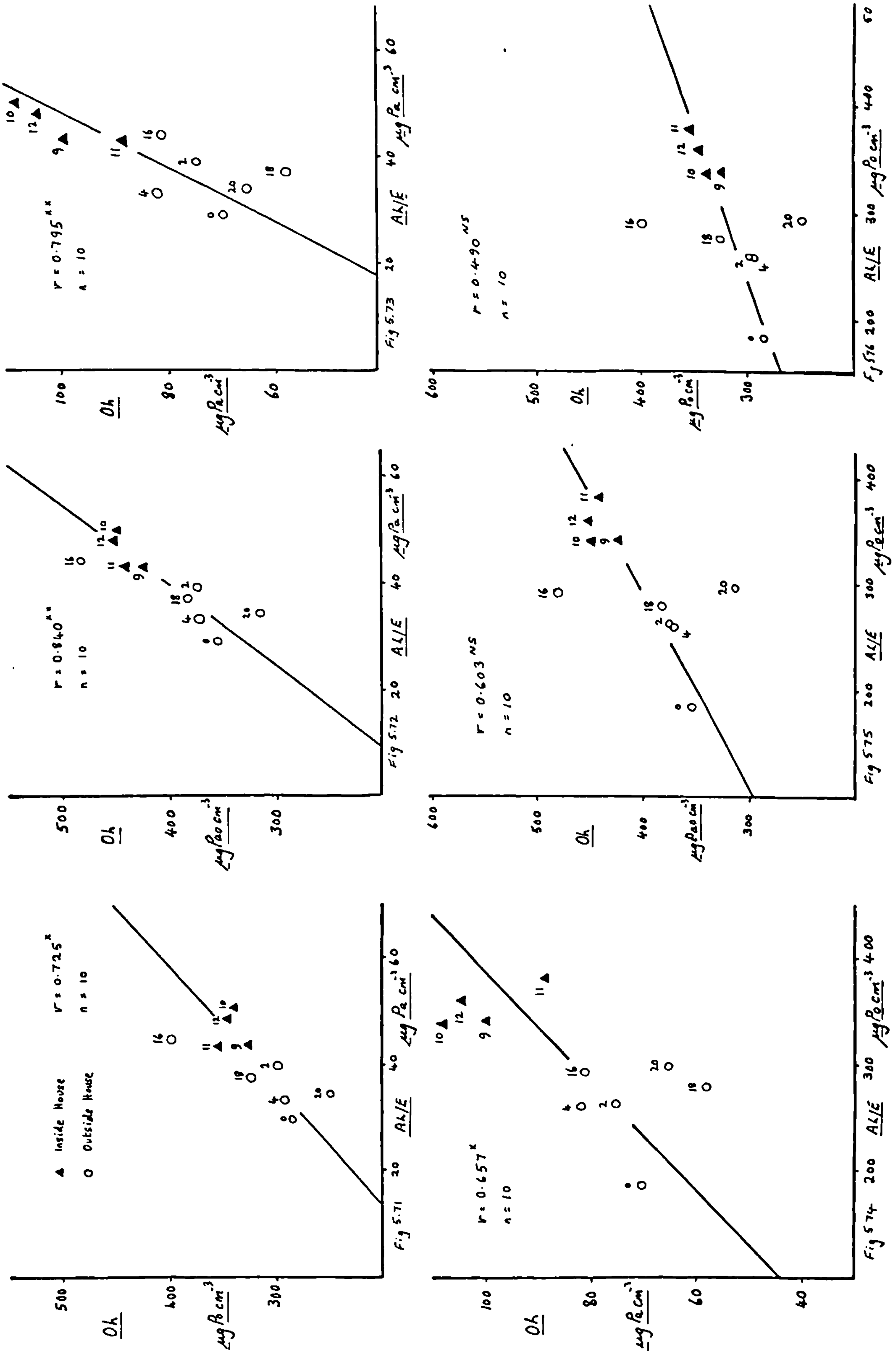
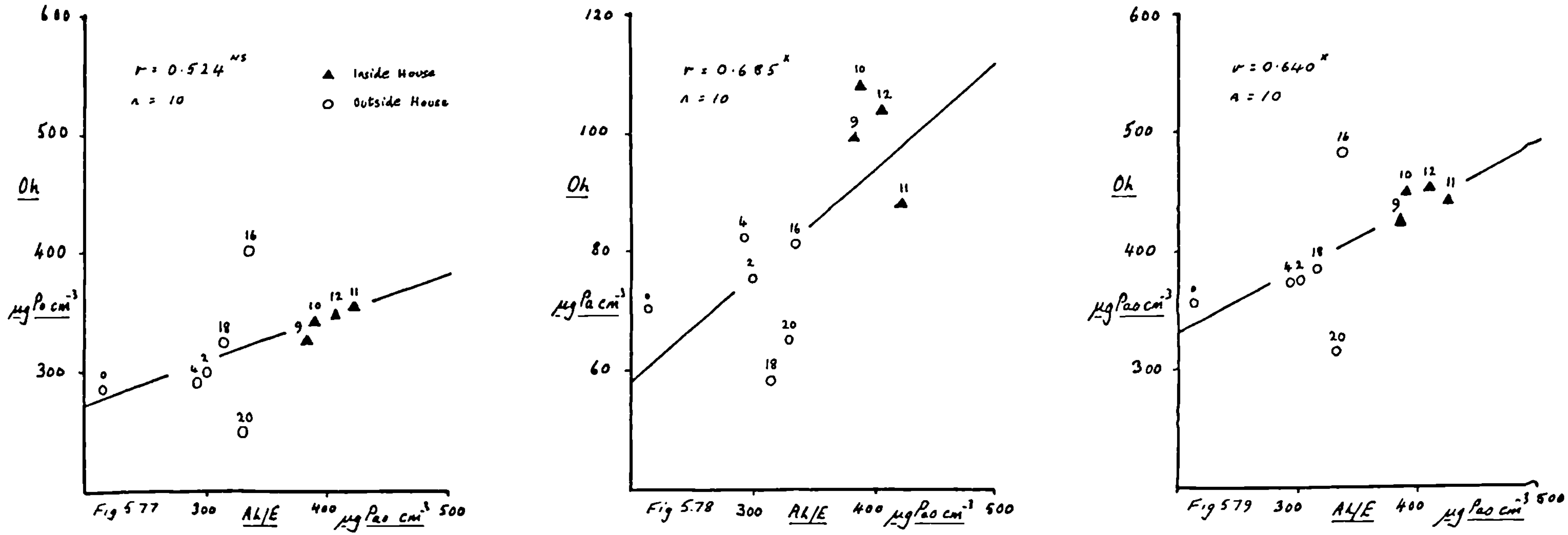


Fig. 5.70 PHA Transect - Scattergram: mgPo kg^{-1} Fe in Oh and Ah/E horizon / mgPa kg^{-1} Fe in Oh and Ah/E horizon



Figs. 5.71 - 5.76 PHA Transect - Scattergrams



Figs. 5.77 - 5.79 PHA Transect - Scattergrams

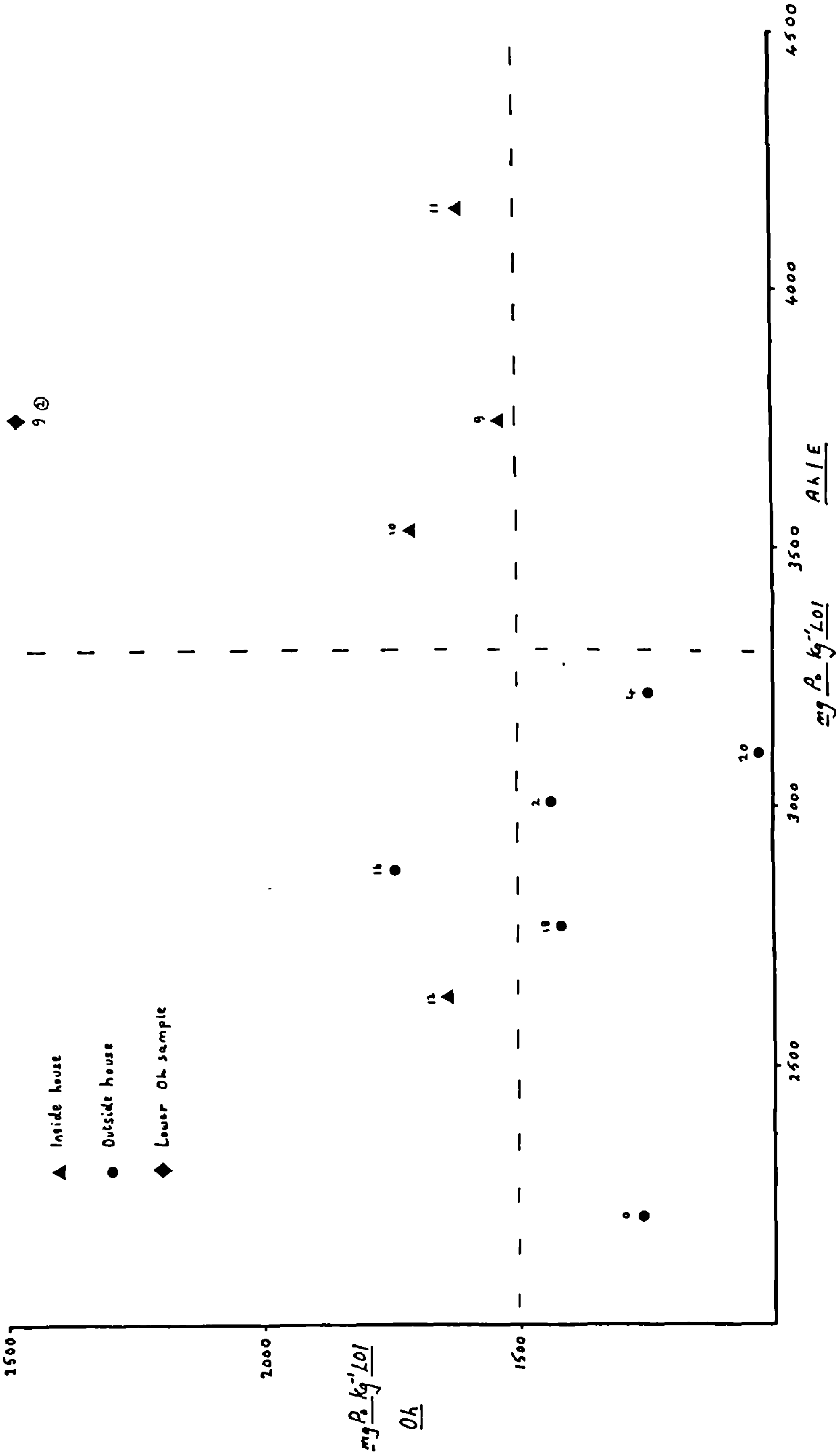


Fig. 5.80 PHA Transect - Scattergram: mgPo kg^{-1} LOI in Ah/E horizon / mgPo kg^{-1} LOI in Oh horizon

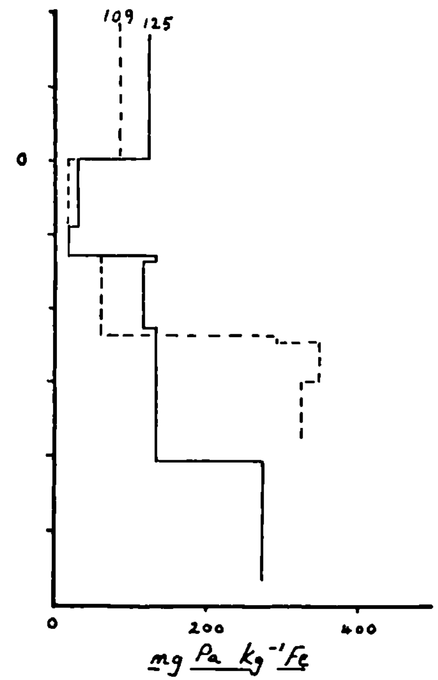


Fig. 5.81

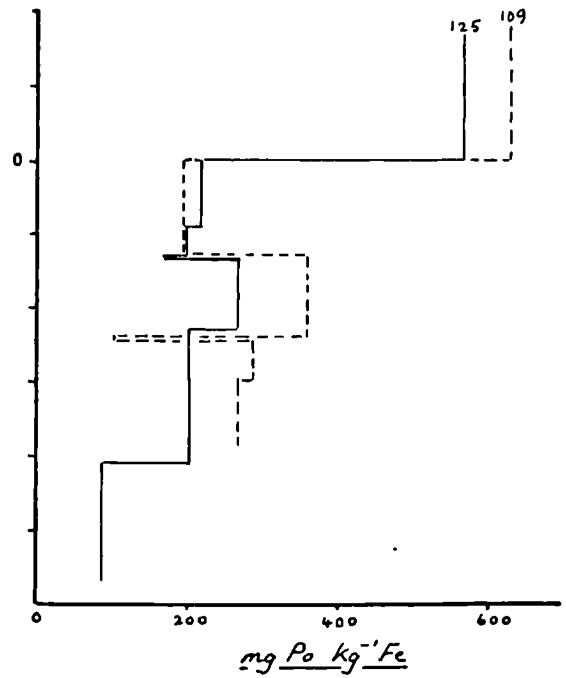


Fig. 5.82

Figs. 5.81 and 5.82 Stone Row - Vertical distribution of Pa and Po in profiles 109 and 125 (Row Transect)

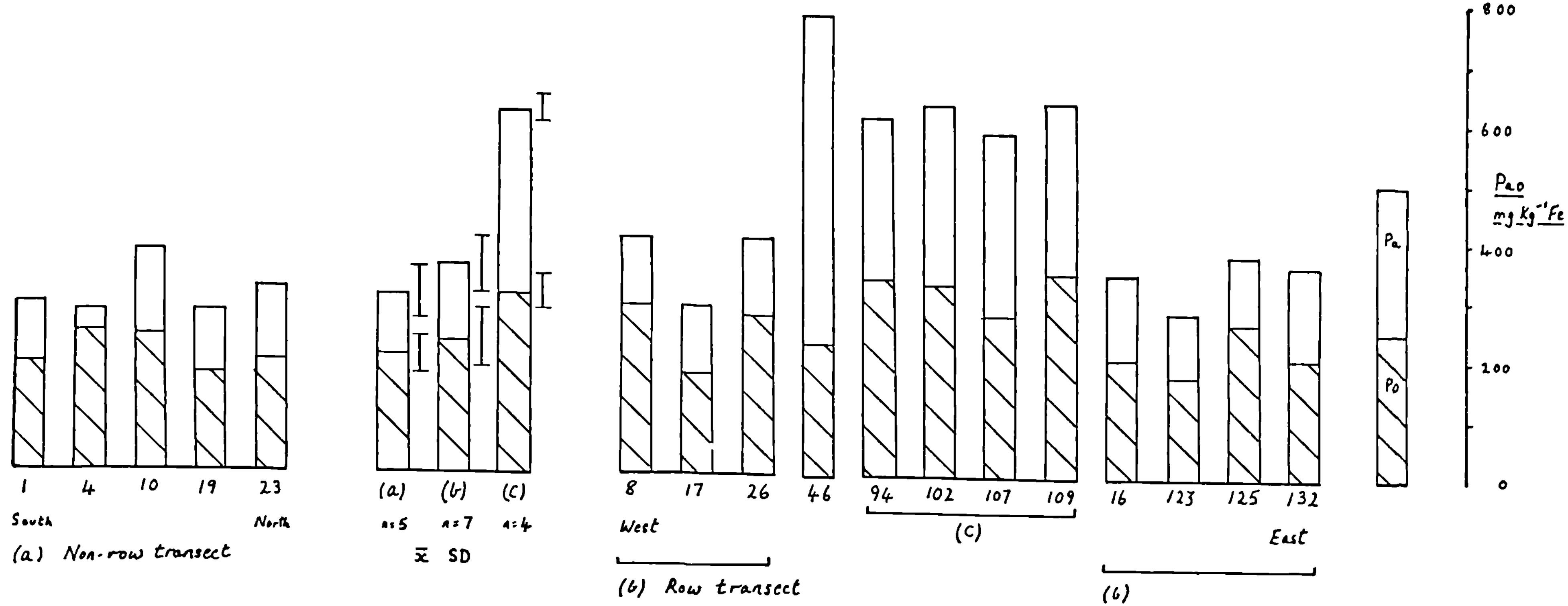


Fig. 5.83 Stone Row - Bar chart: the concentration of phosphorus in Non-row and Row Transect B horizon samples

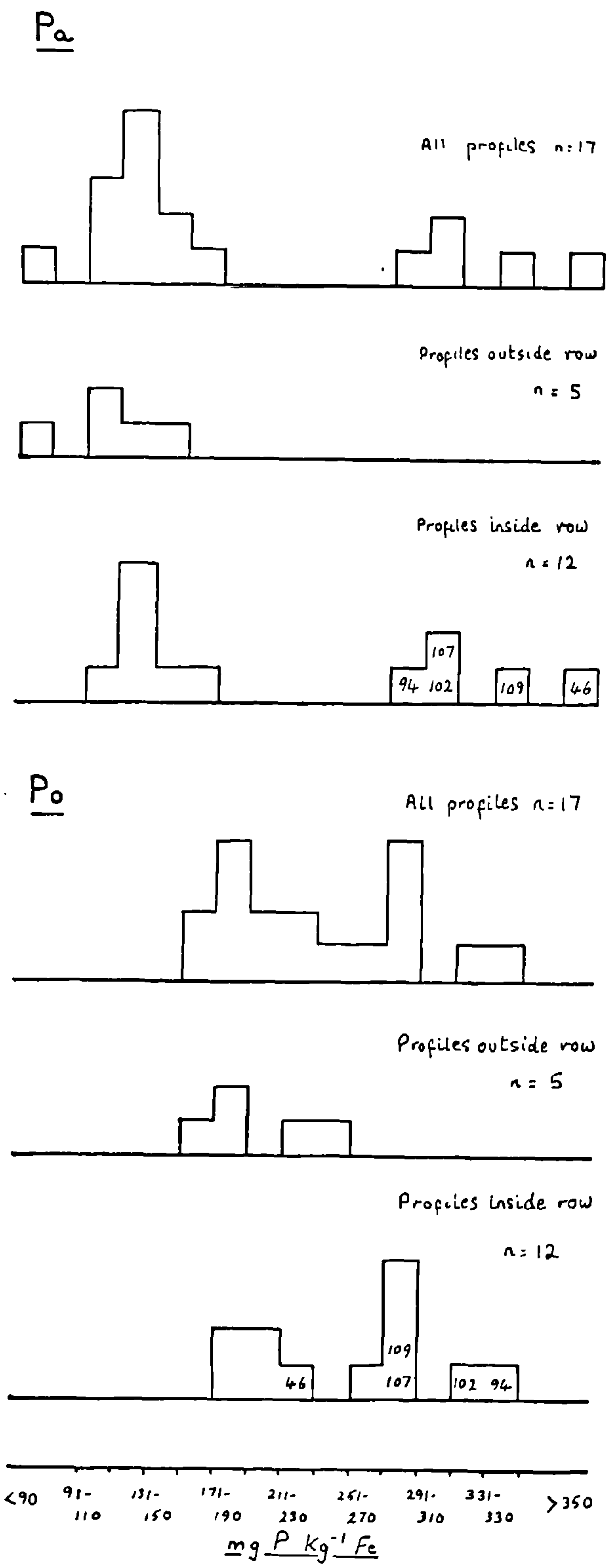


Fig. 5.84 Stone Row - Histograms: the concentration of phosphorus in Non-row and Row Transect B horizon samples

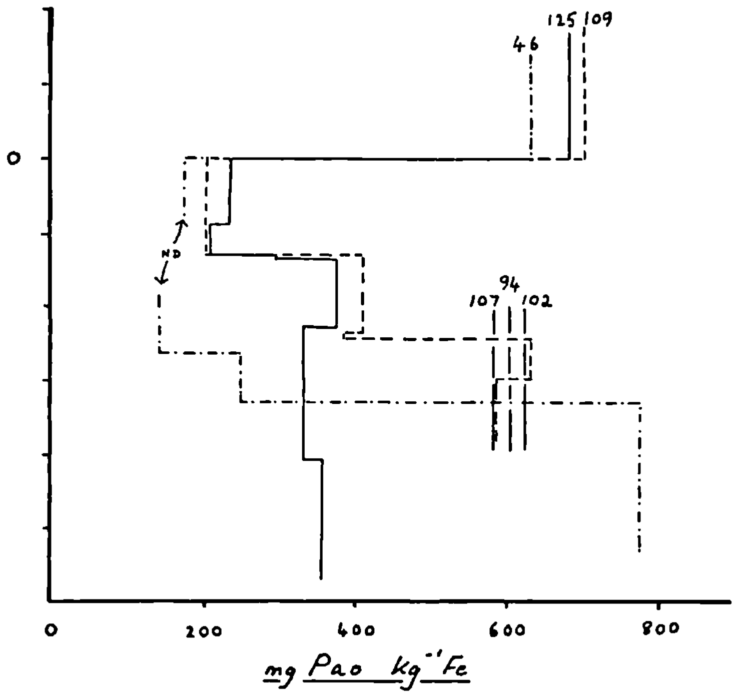


Fig. 5.85 Stone Row - Vertical distribution of Pao in profiles 46, 109, 125

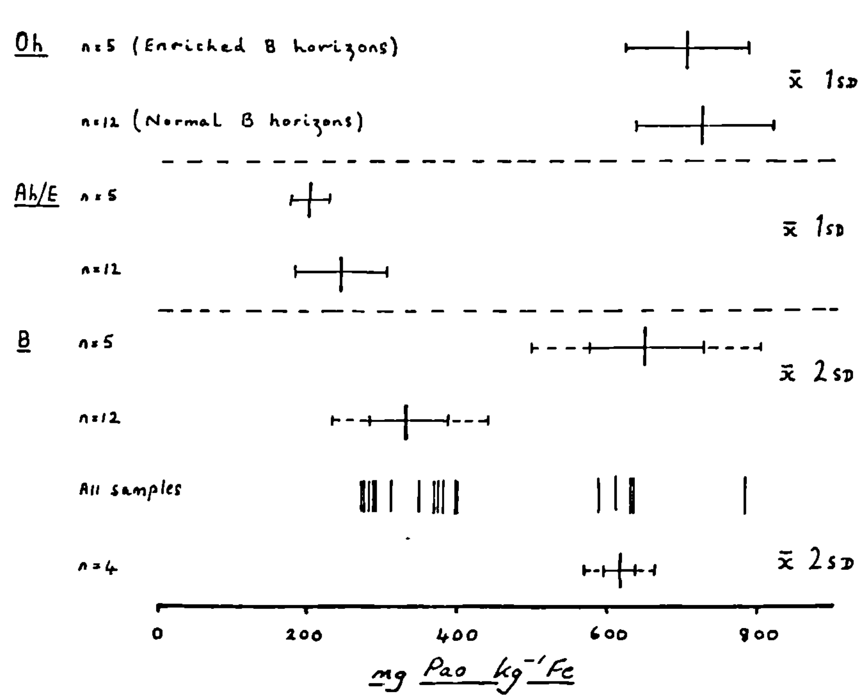


Fig. 5.86 Stone Row - Diagram showing the mean concentration of phosphorus in Oh, Ah/E and B horizon samples

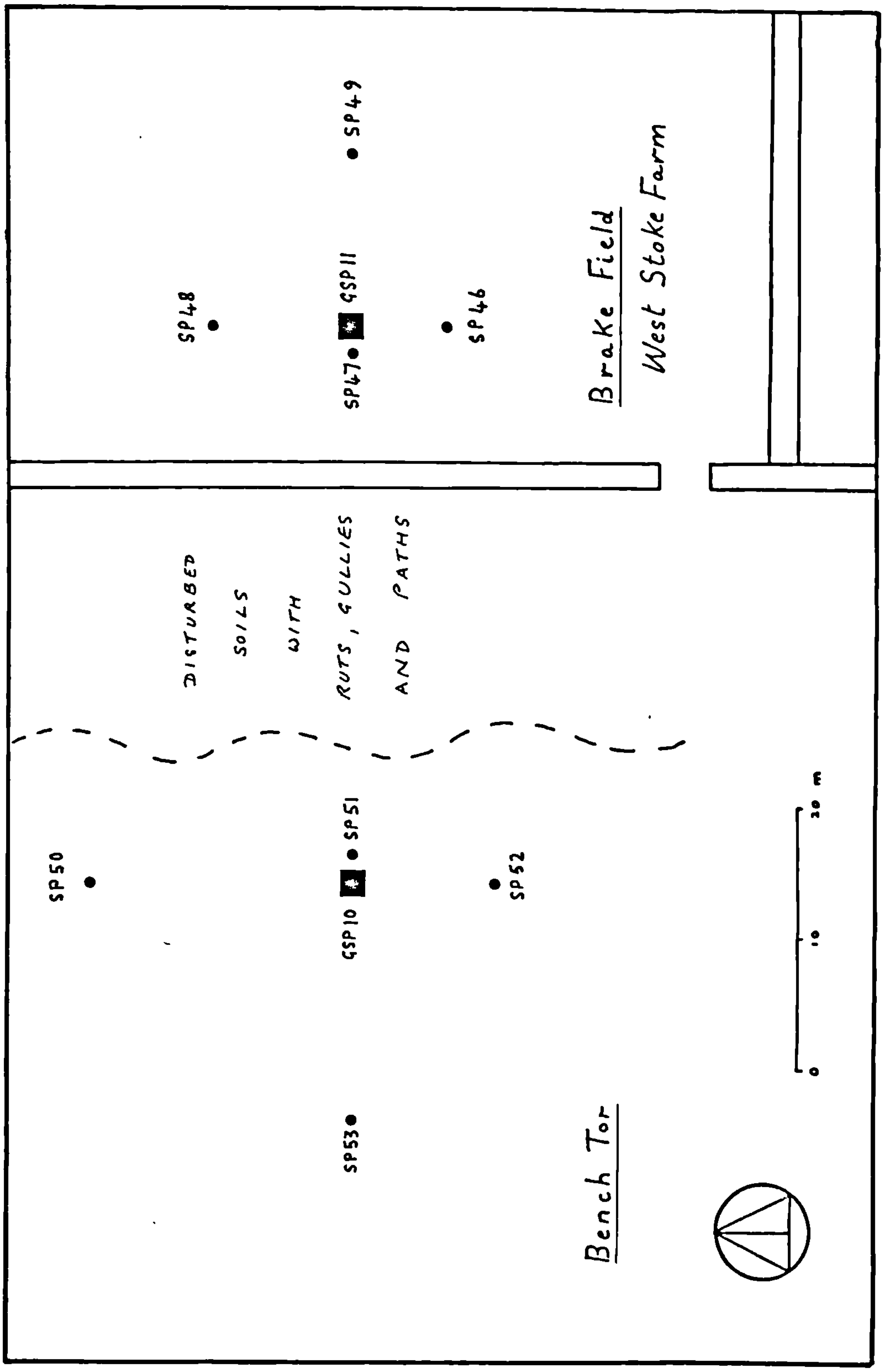


Fig. 5.87 West Stoke Farm and Bench Tor - Location of sampled profiles and cultural features

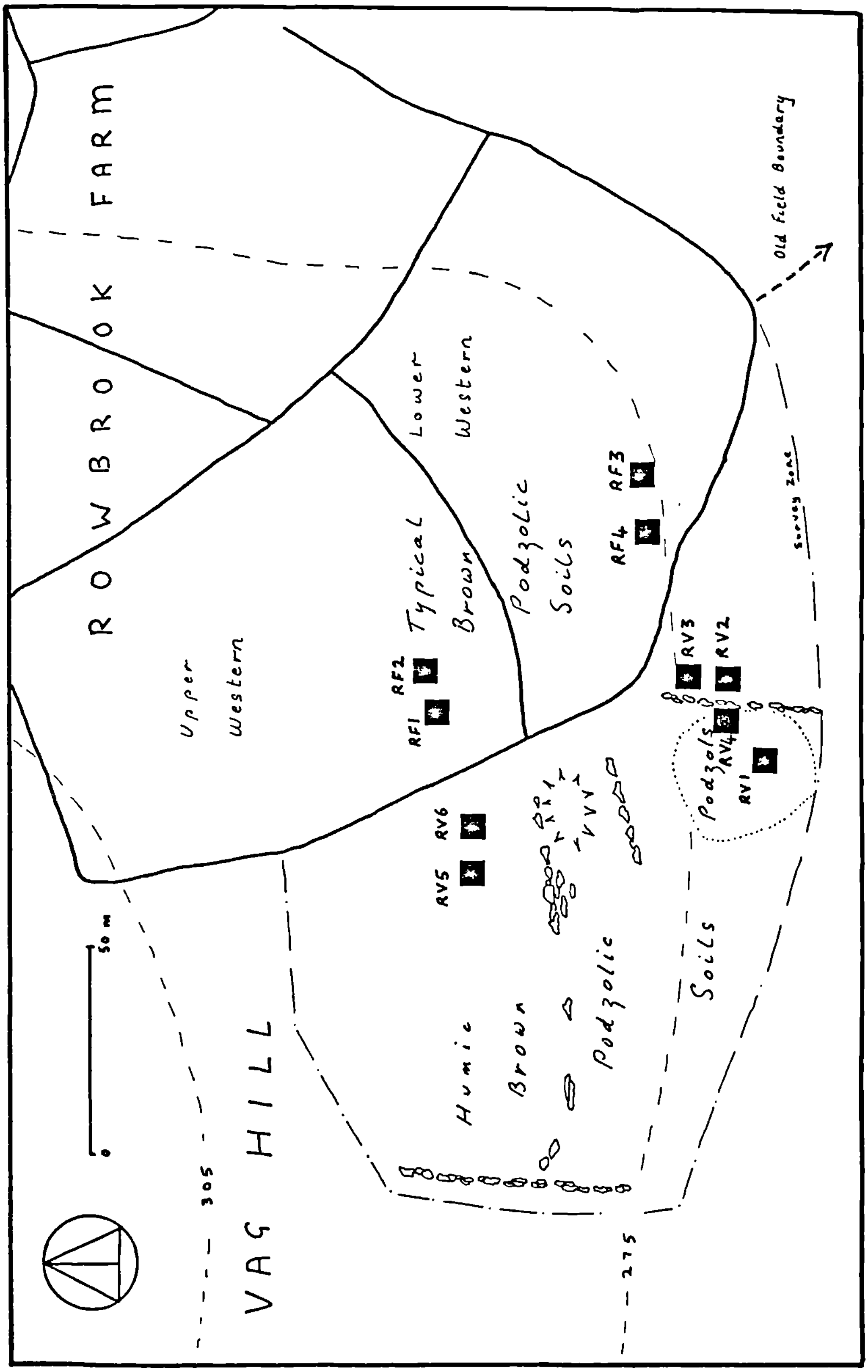
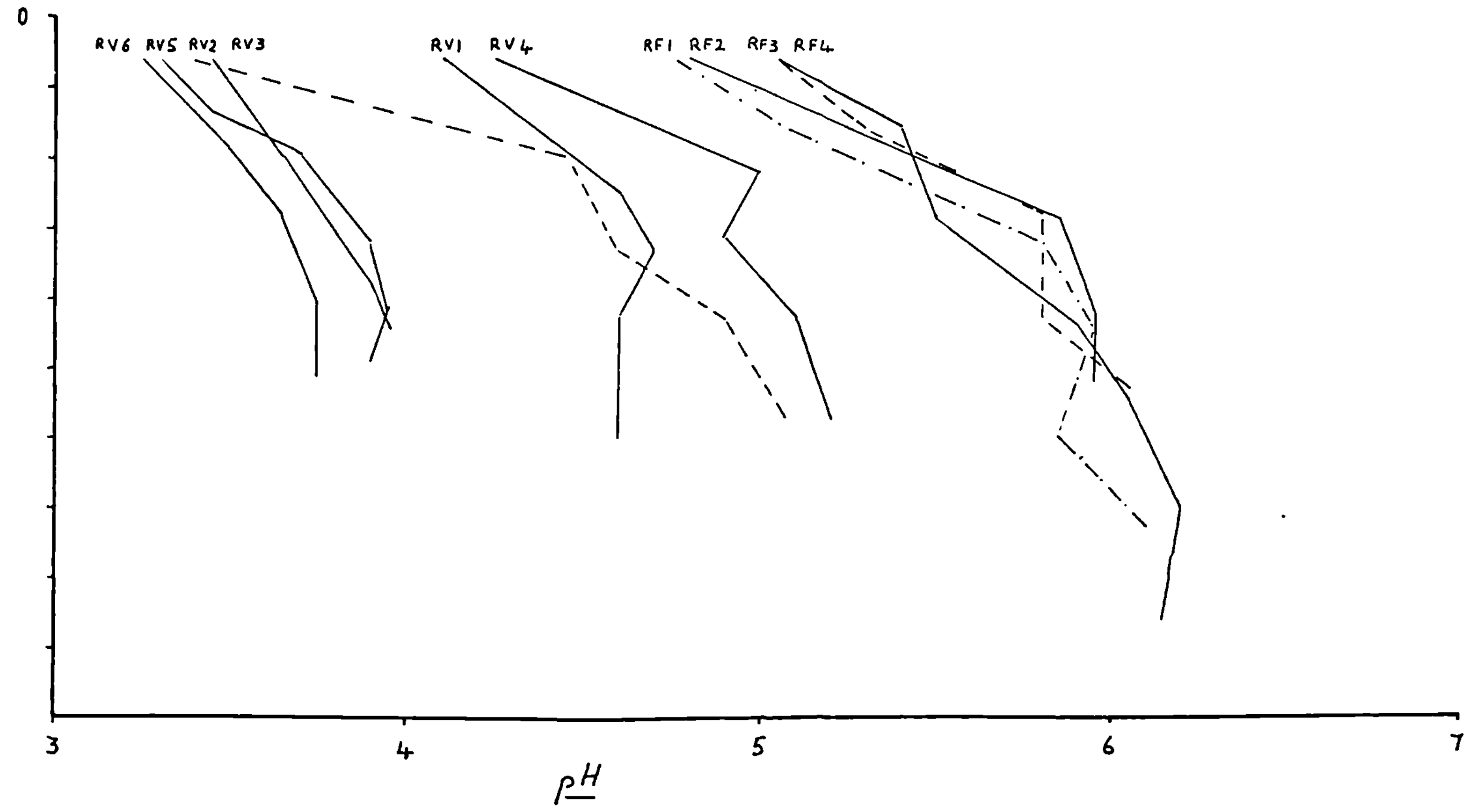
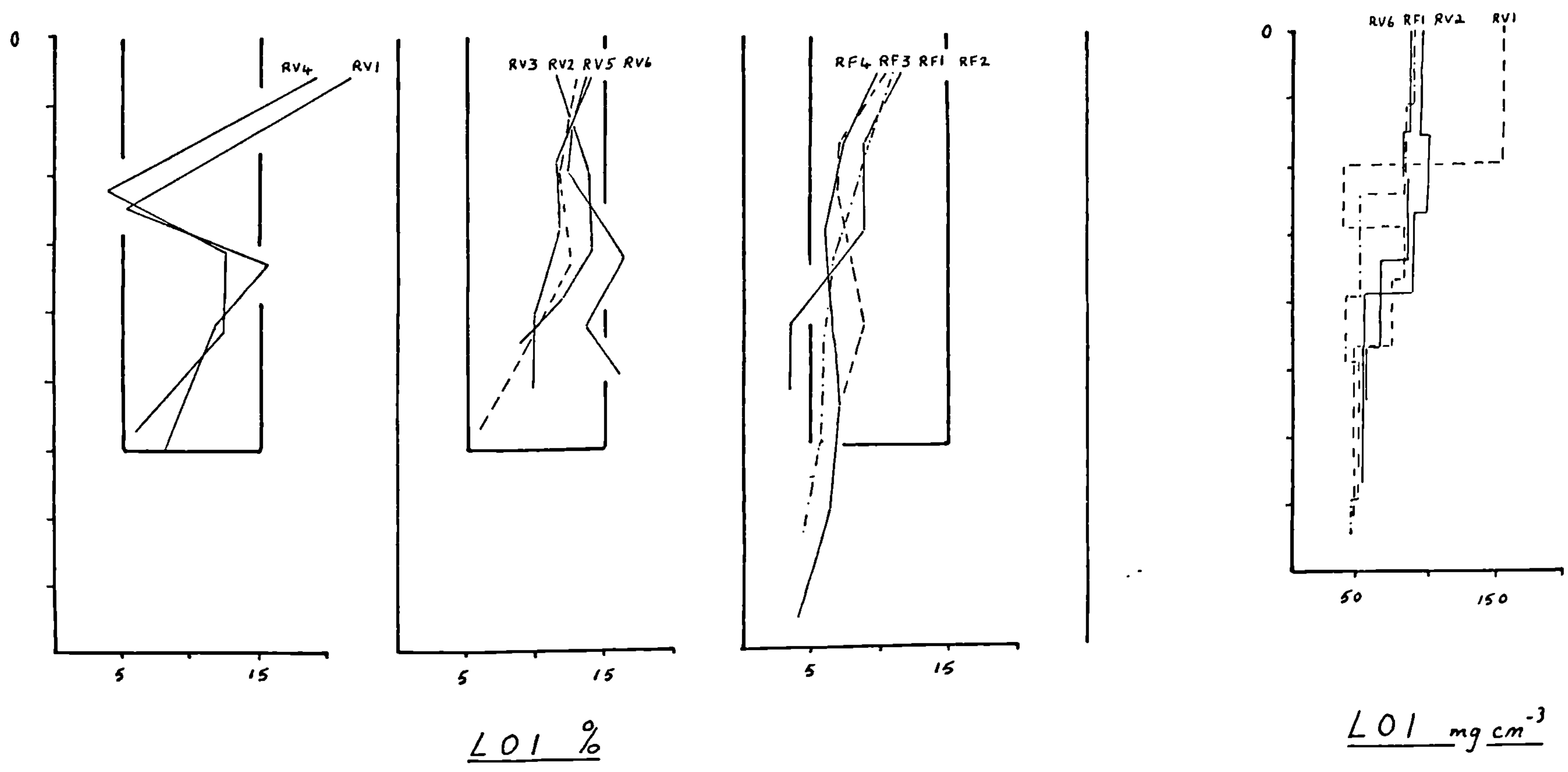


Fig. 5.88 Rowbrook Farm and Vag Hill - Location of sampled profiles, and the distribution of soil types and cultural features

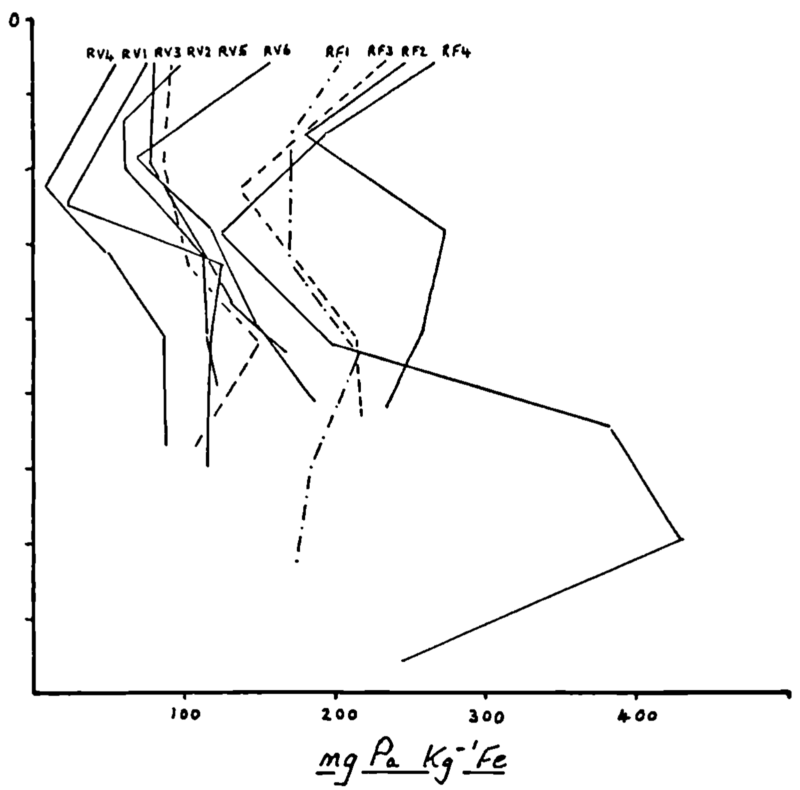
Fig. 5.89 Rowbrook Farm and Vag Hill - Vertical distributions

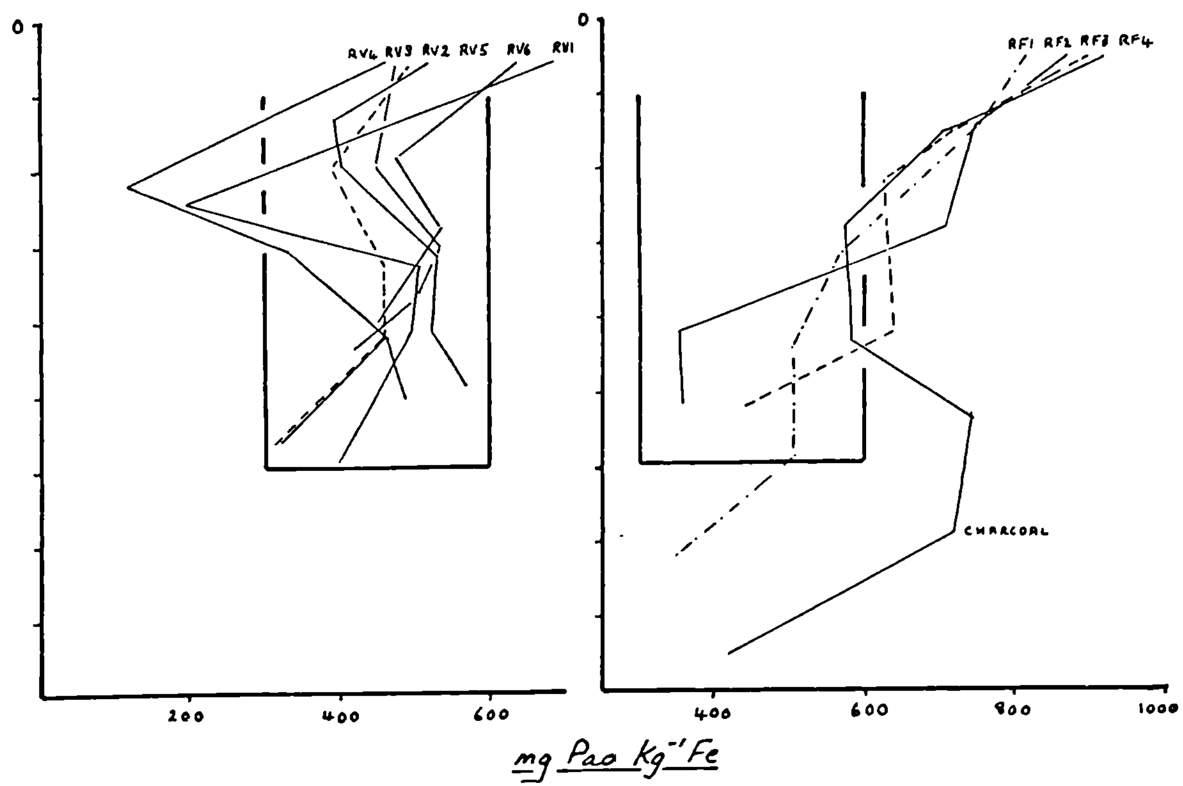


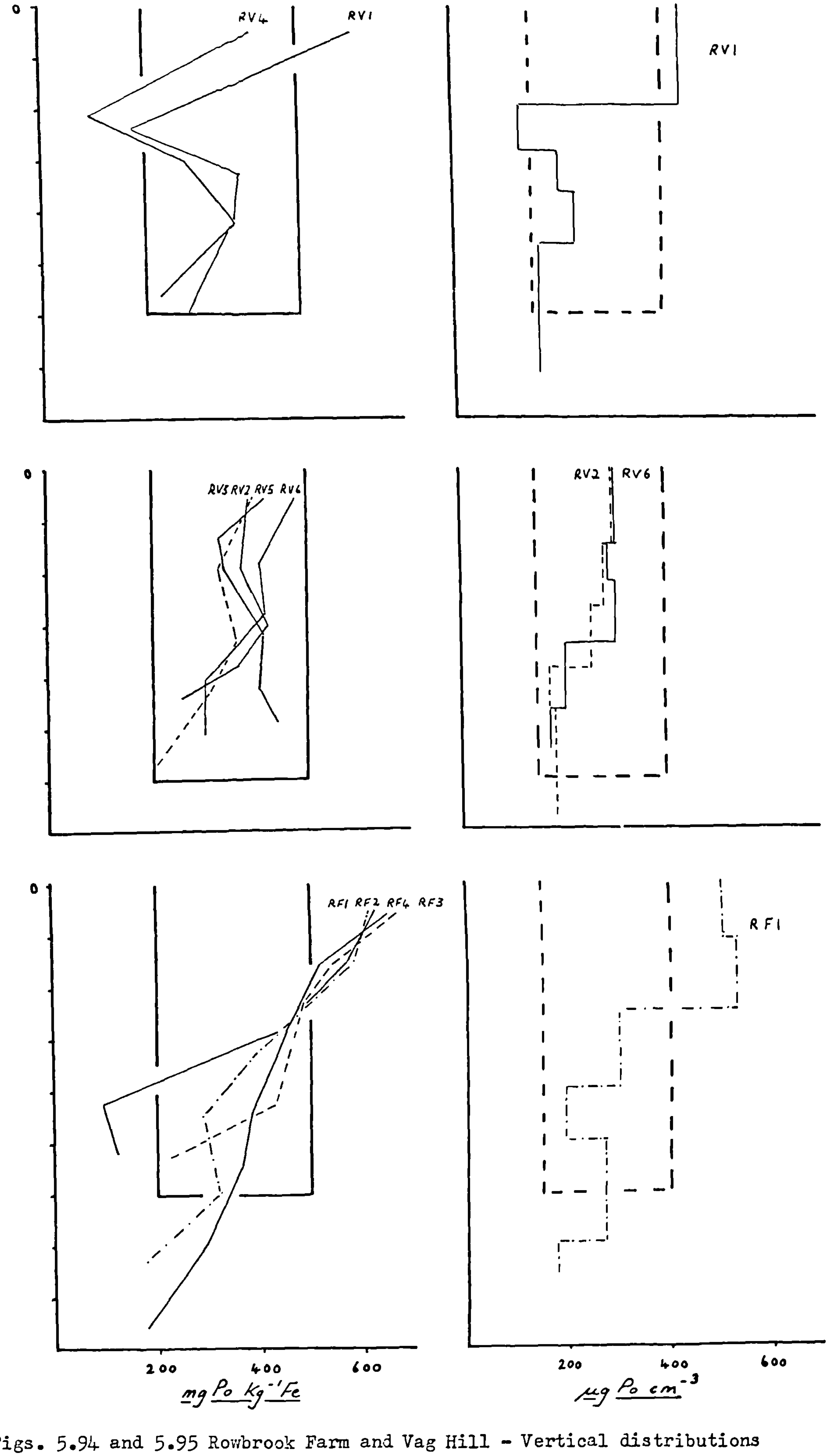
Figs. 5.90 and 5.91 Rowbrook Farm and Vag Hill - Vertical distributions



Figs. 5.92 and 5.93 Rowbrook Farm and Vag Hill - Vertical distributions







Figs. 5.94 and 5.95 Rowbrook Farm and Vag Hill - Vertical distributions

Fig. 5.96 Rowbrook Farm and Vag Hill - Vertical distributions

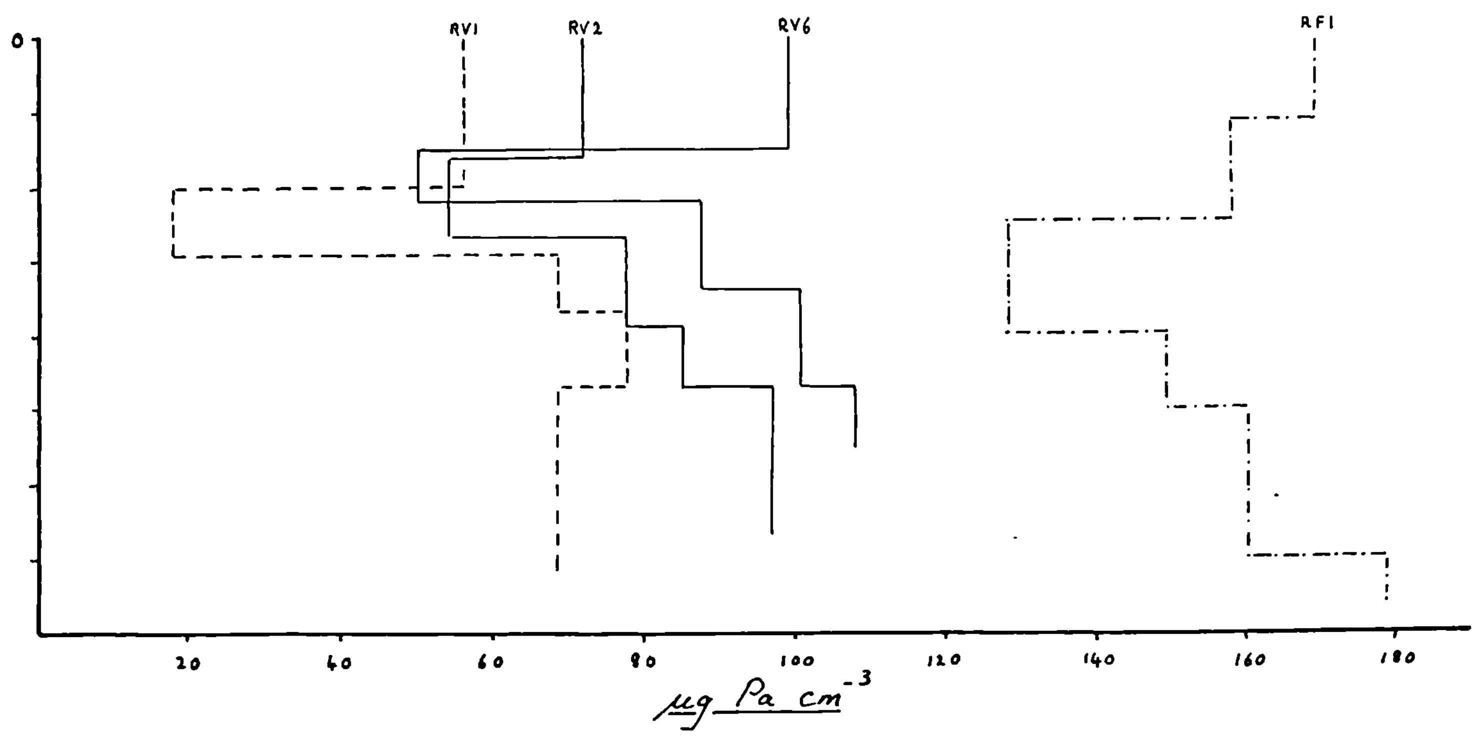
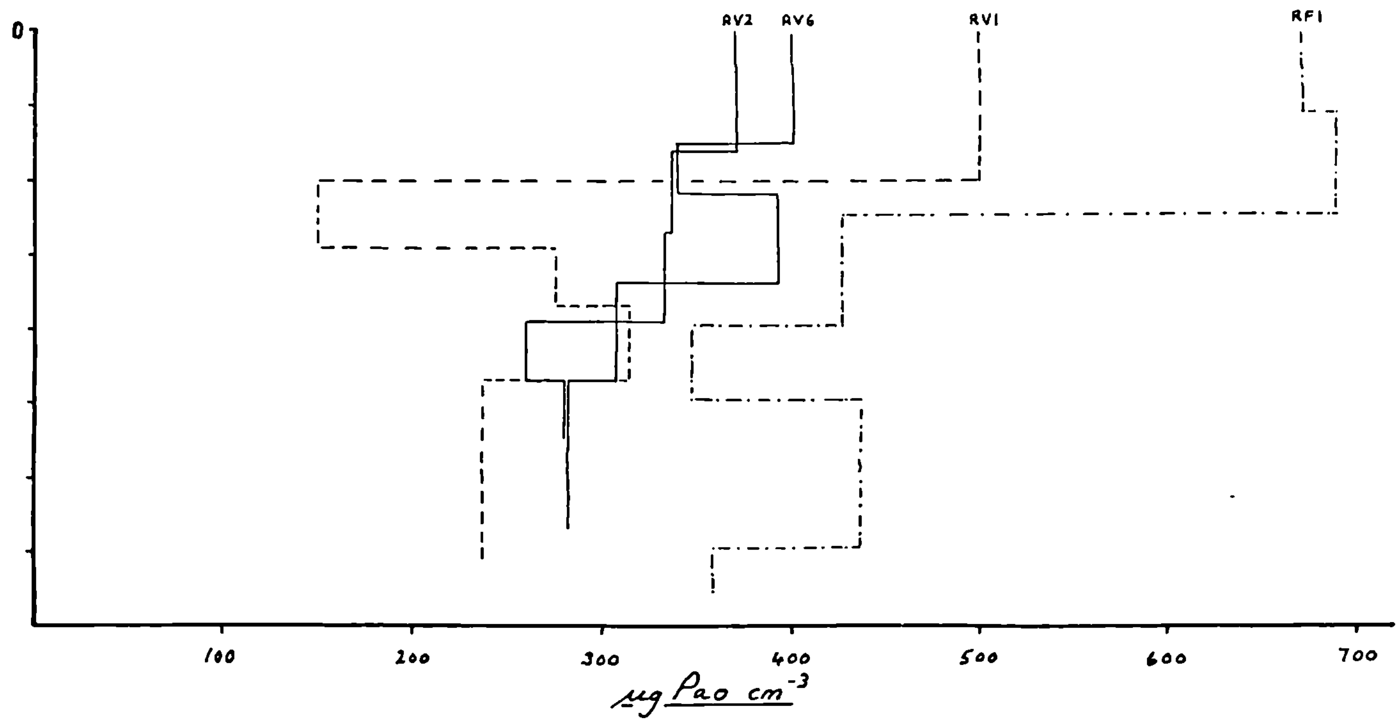
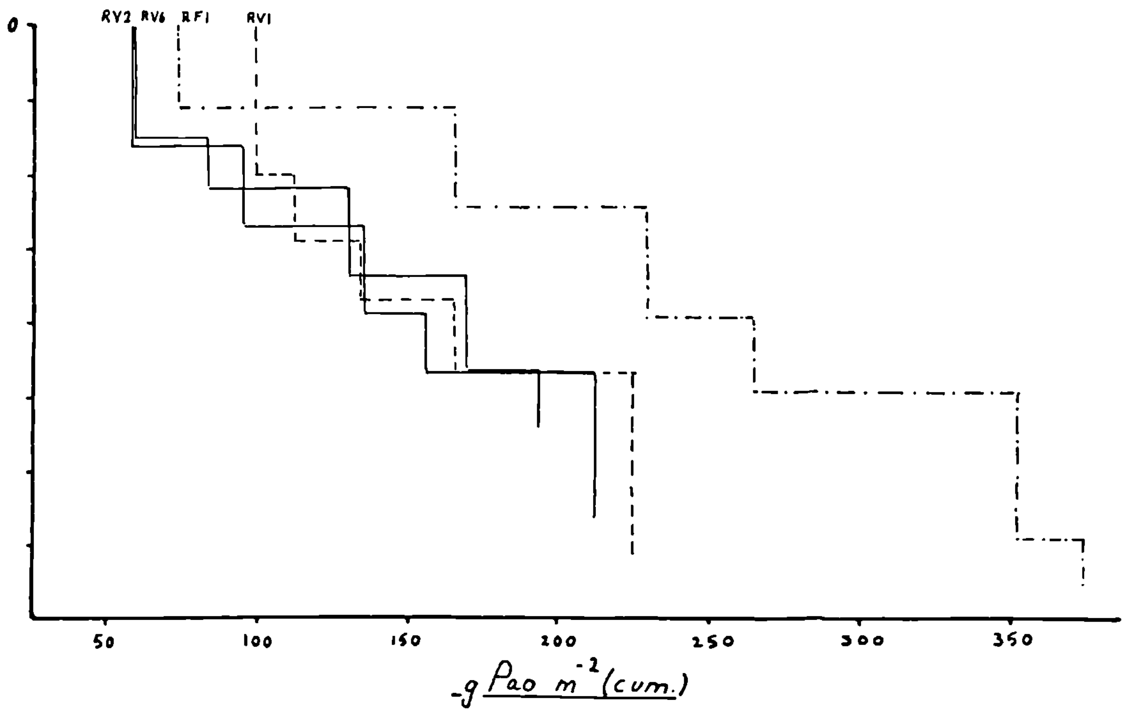
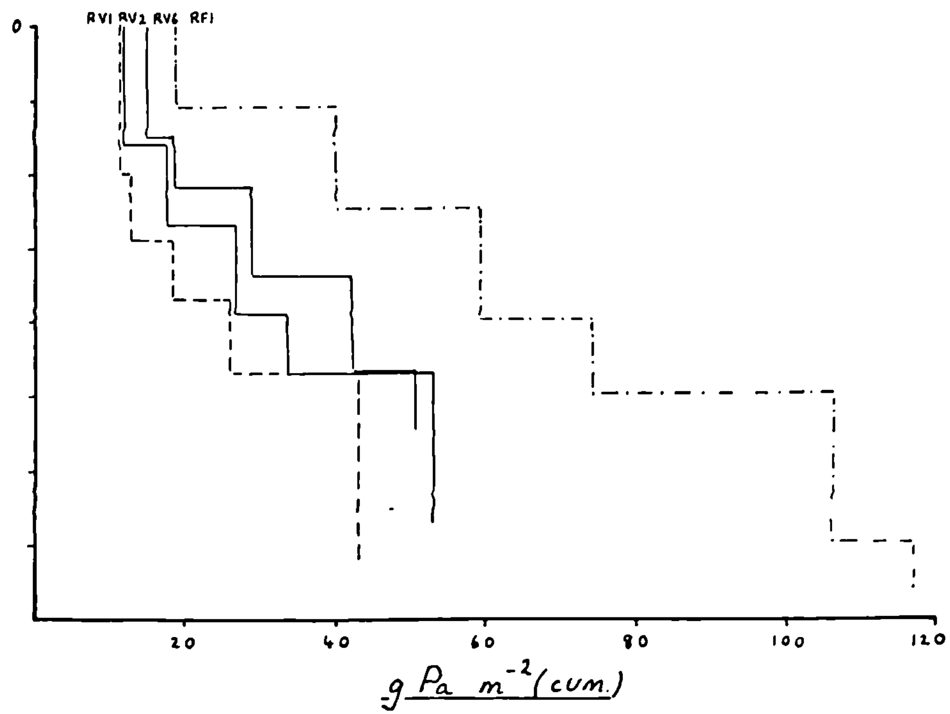


Fig. 5.97 Rowbrook Farm and Vag Hill - Vertical distributions



Figs. 5.98 and 5.99 Rowbrook Farm and Vag Hill - Vertical distributions





Figs. 5.100, 5.101 and 5.102 Rowbrook Farm and Vag Hill - Vertical distributions

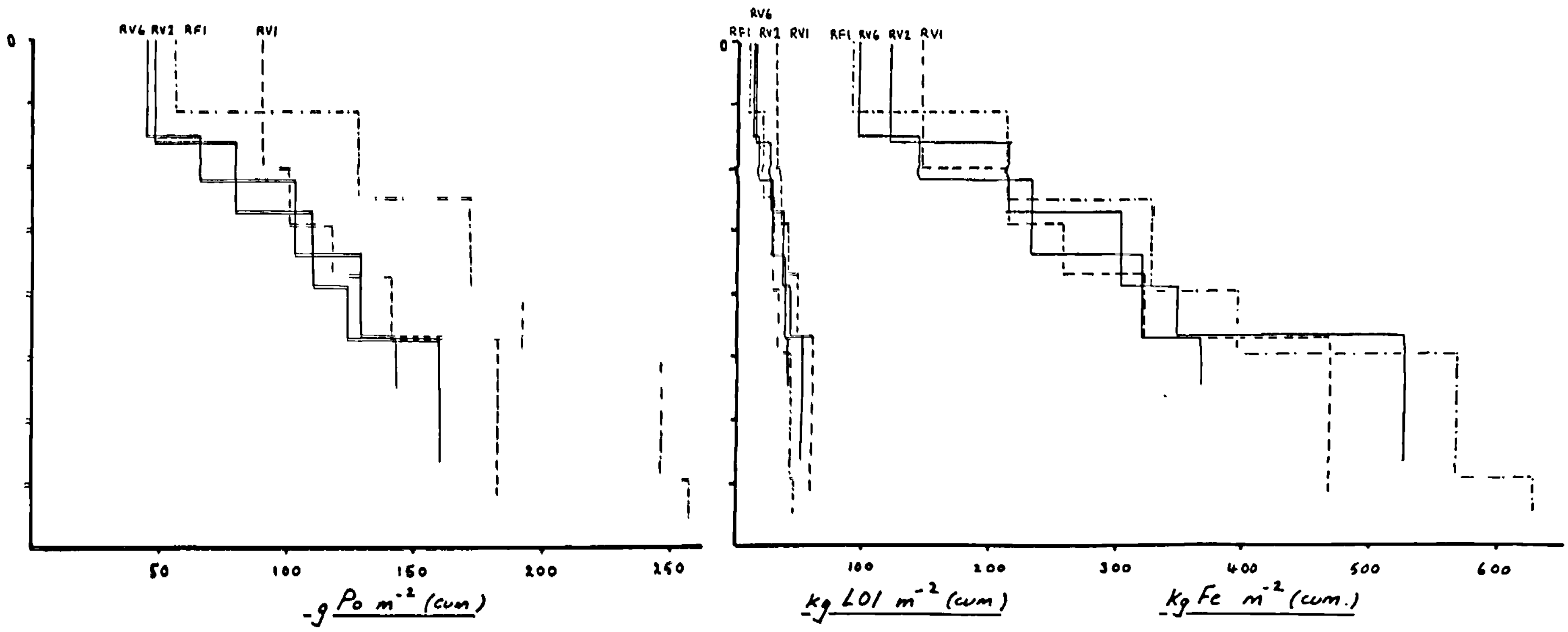


Fig. 5.103 Rowbrook Farm and Vag Hill - Vertical distributions

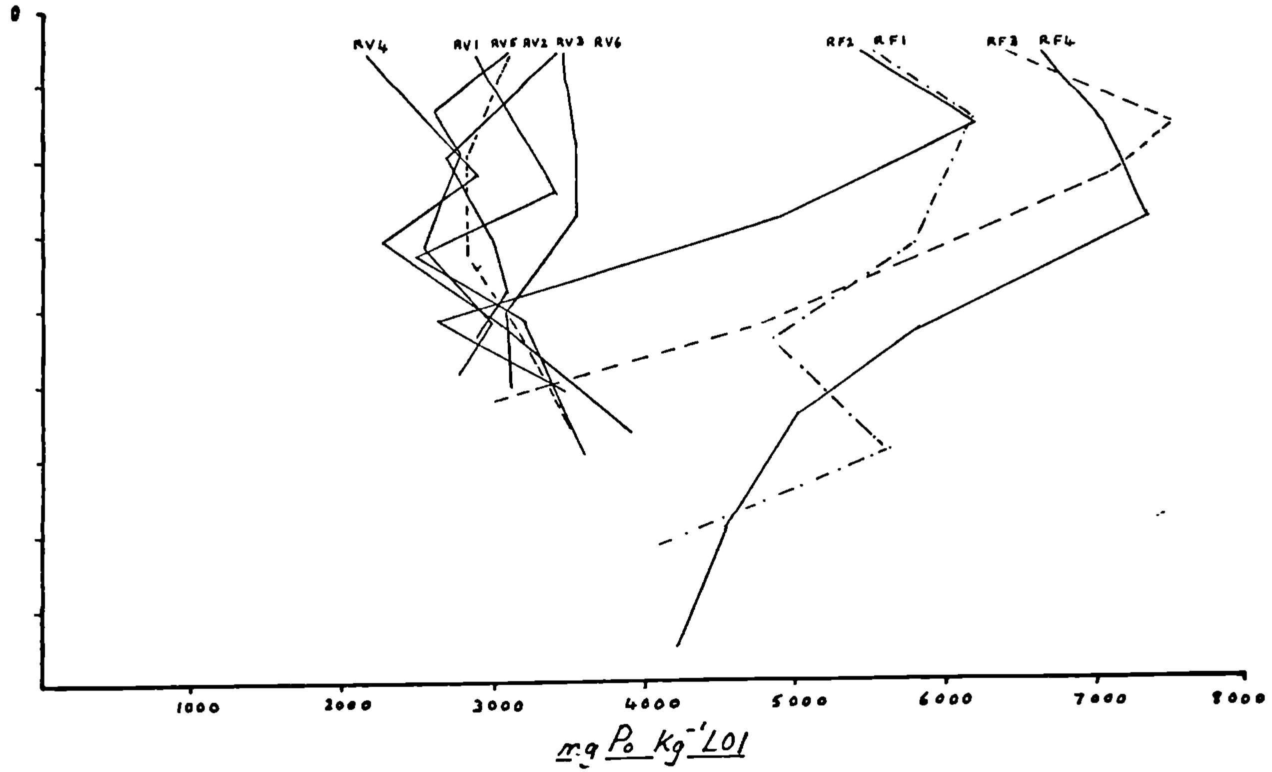
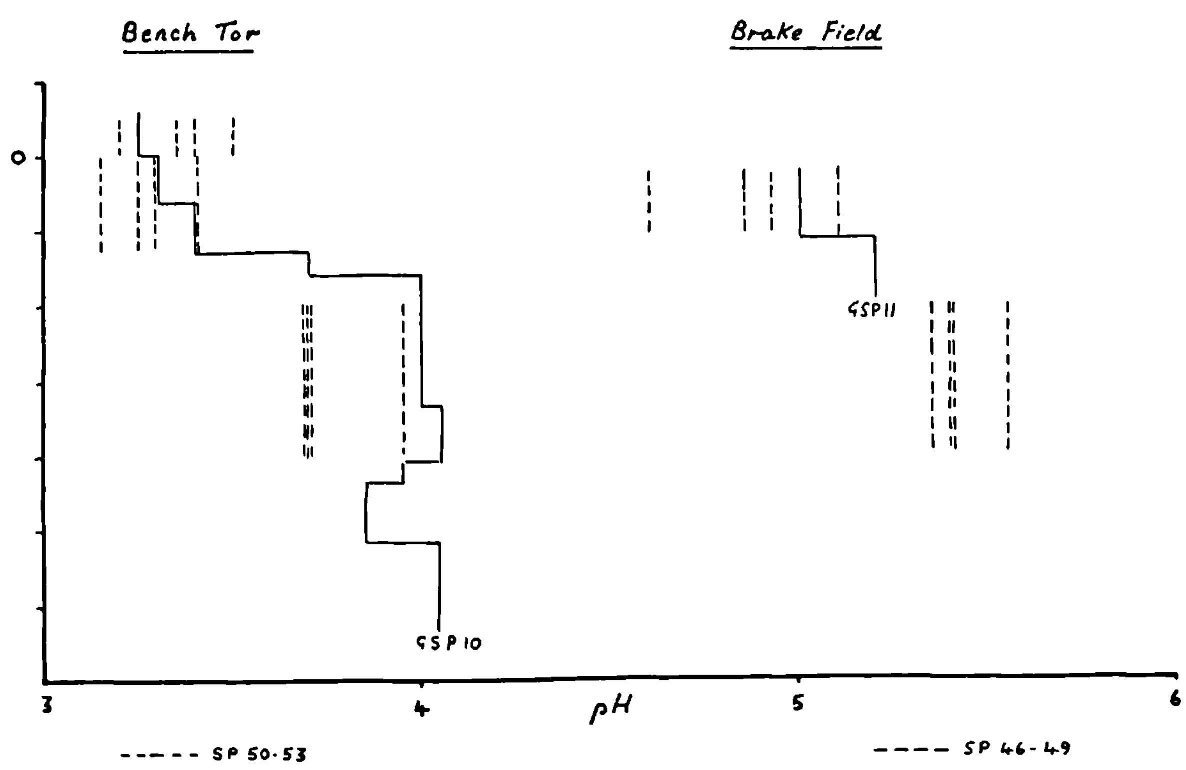
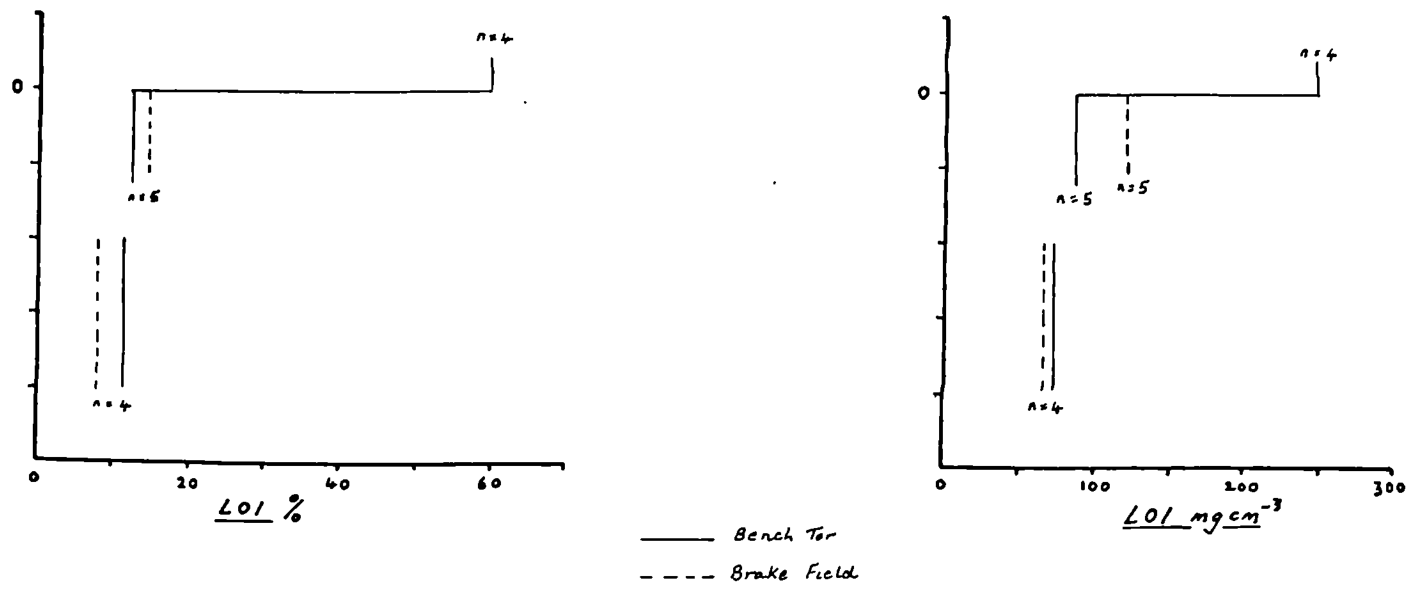


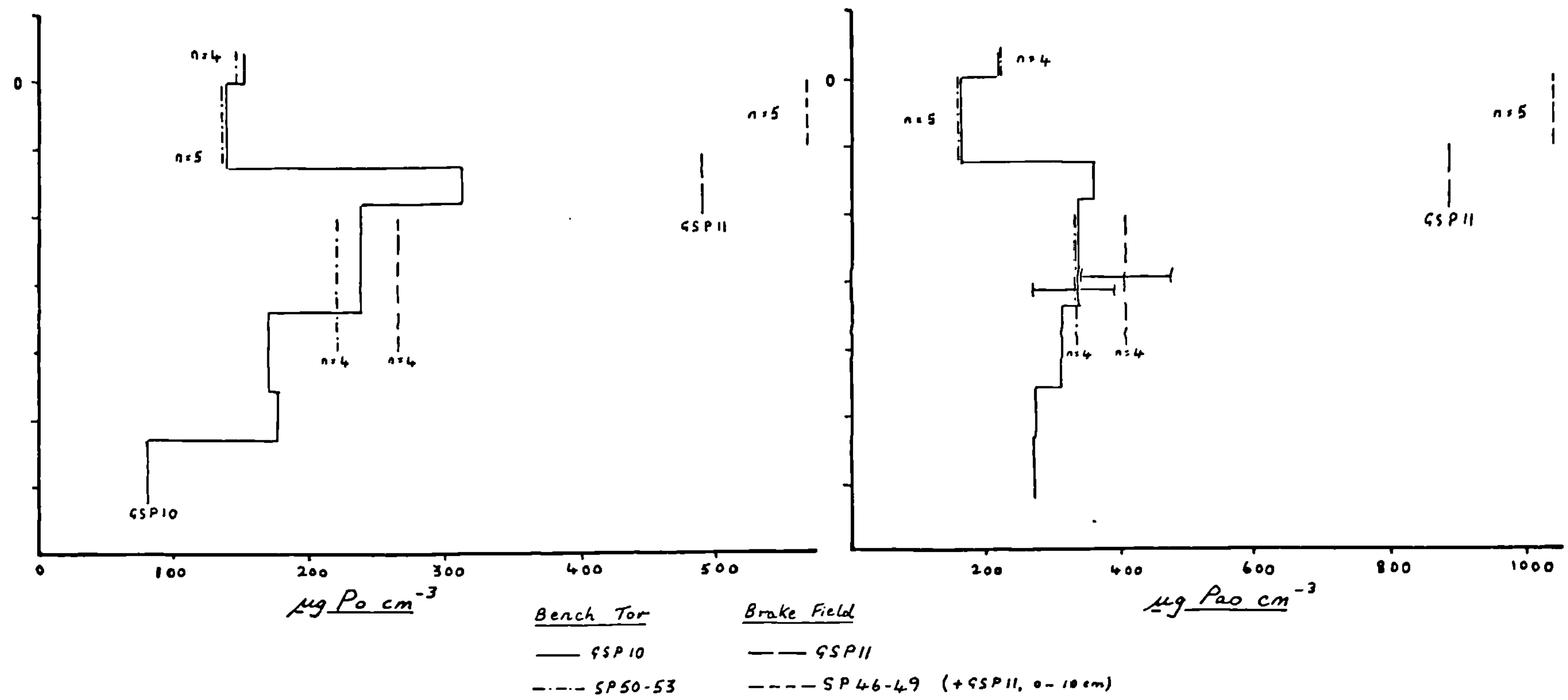
Fig. 5.104 West Stoke Farm and Bench Tor - Vertical distributions



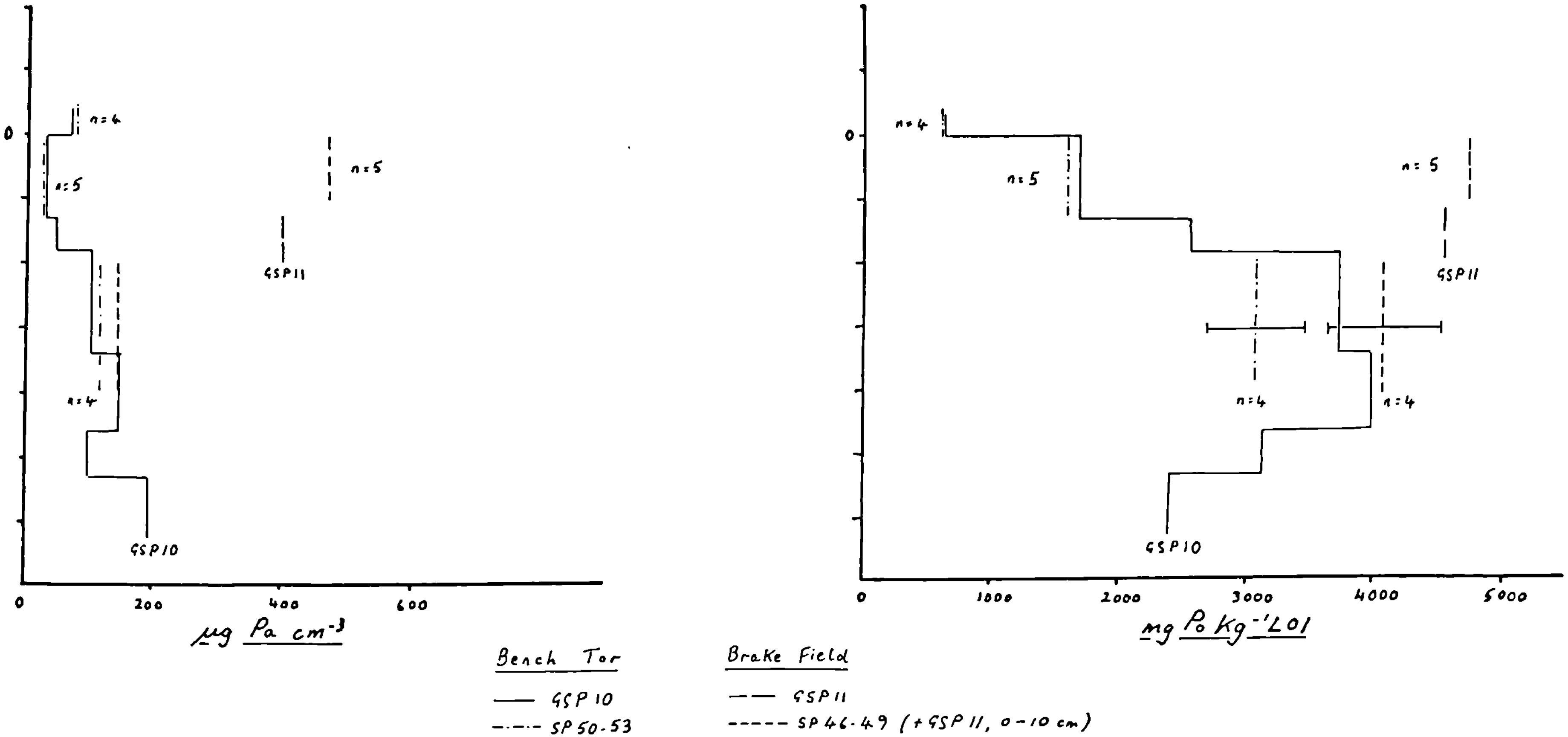
Figs. 5.105 and 5.106 West Stoke Farm amd Bench Tor - Vertical distributions



Figs. 5.107 and 5.108 West Stoke Farm and Bench Tor - Vertical distributions



Figs. 5.109 and 5.110 West Stoke Farm and Bench Tor - Vertical distributions



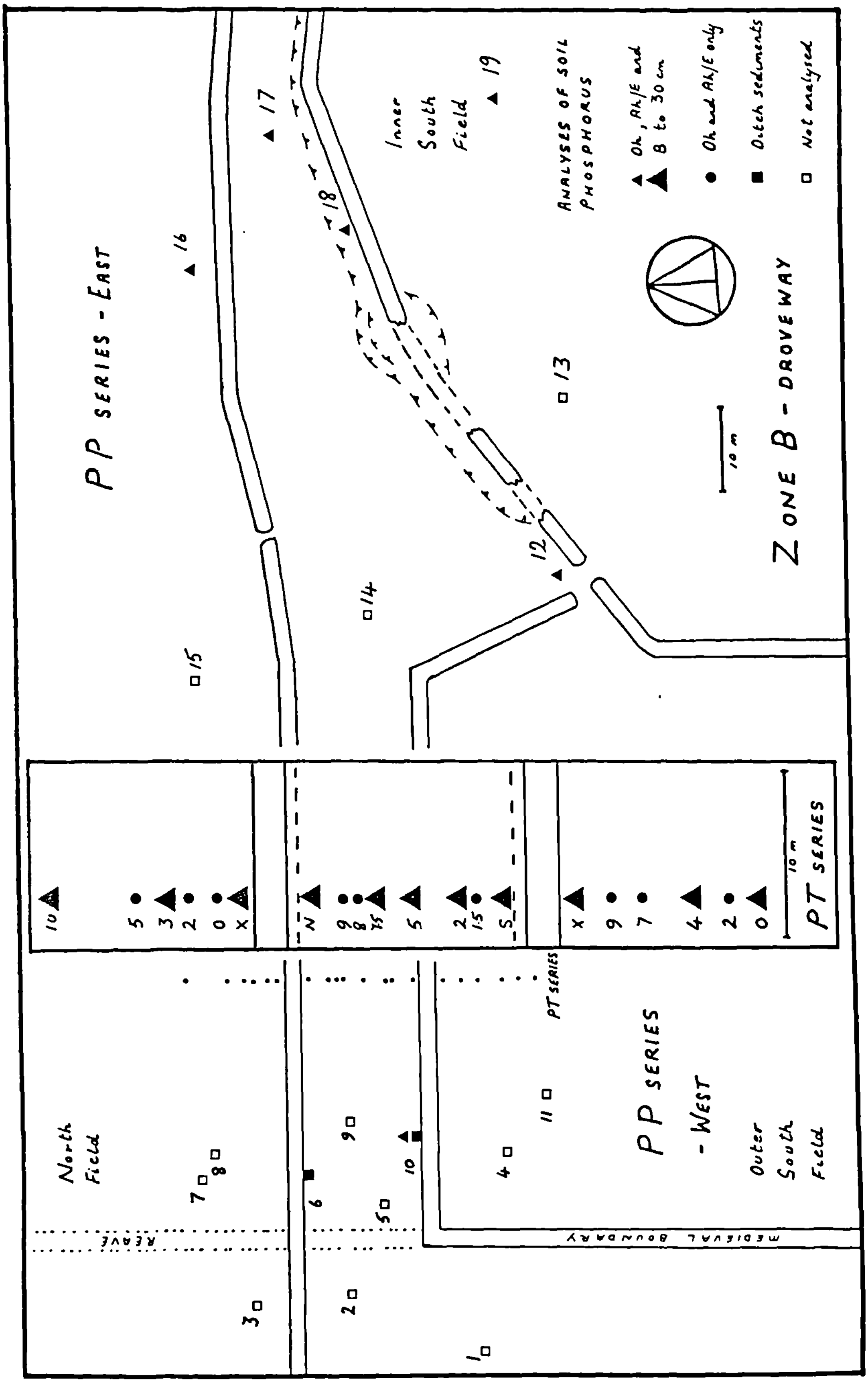


Fig. 5.111 Zone B - The location of sampled profiles and cultural features

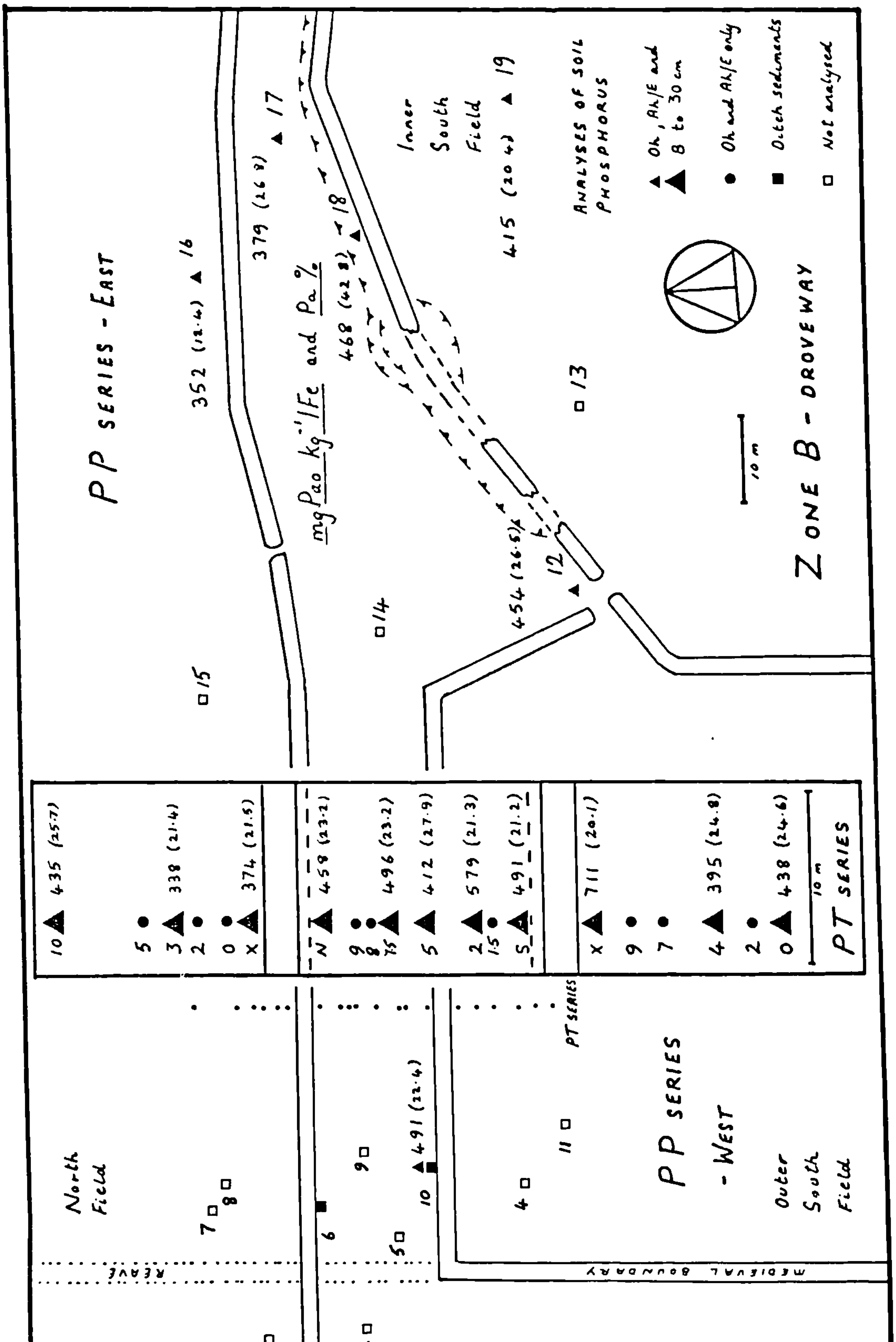


Fig. 5.112 Zone B - Lateral distribution: mgPao kg^{-1} IFe and Pa % in profiles sampled to 30 cm below the mineral soil surface

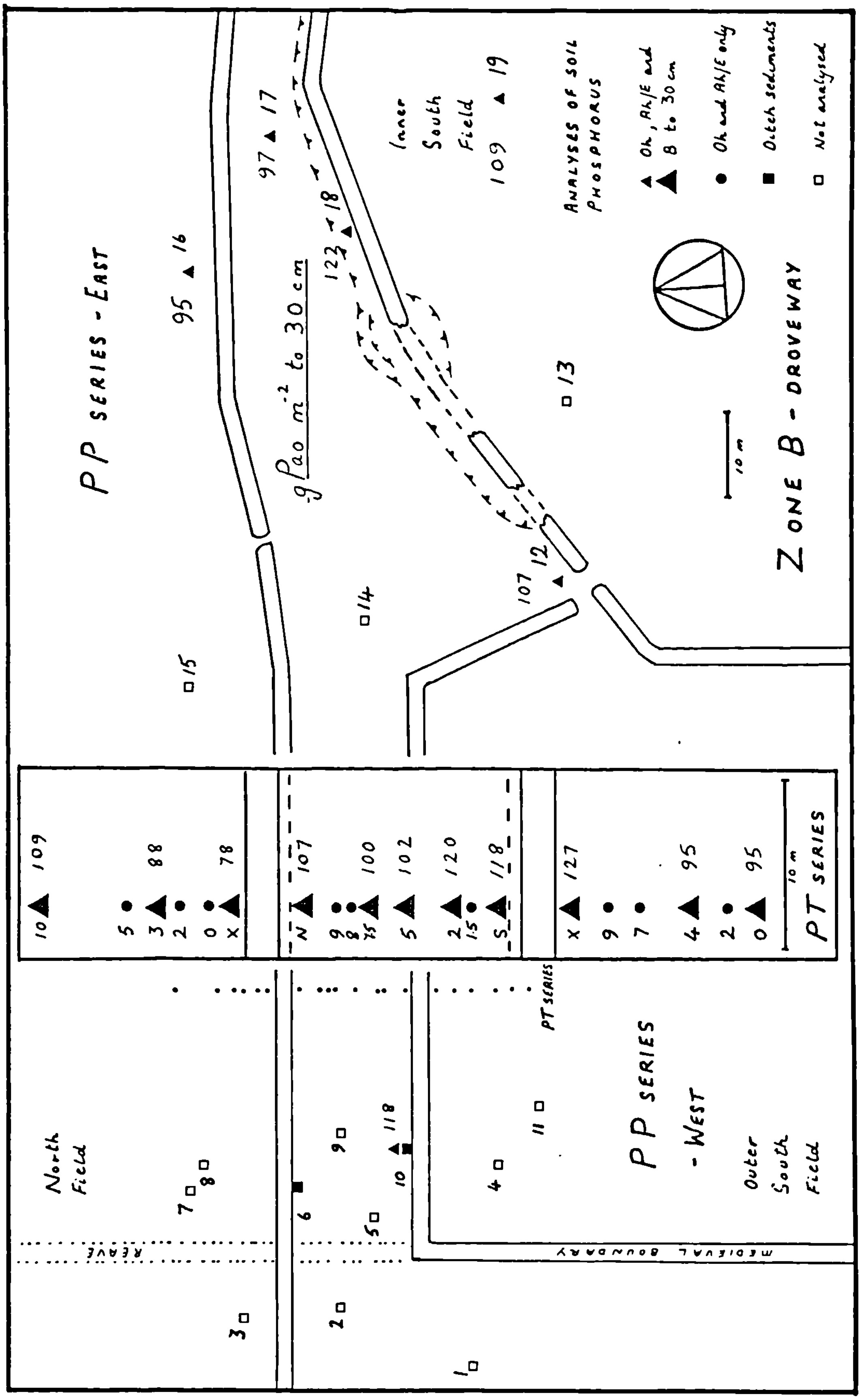


Fig. 5.113 Zone B - Lateral distribution: gPao m^{-2} in profiles sampled to 30 cm below the mineral soil surface

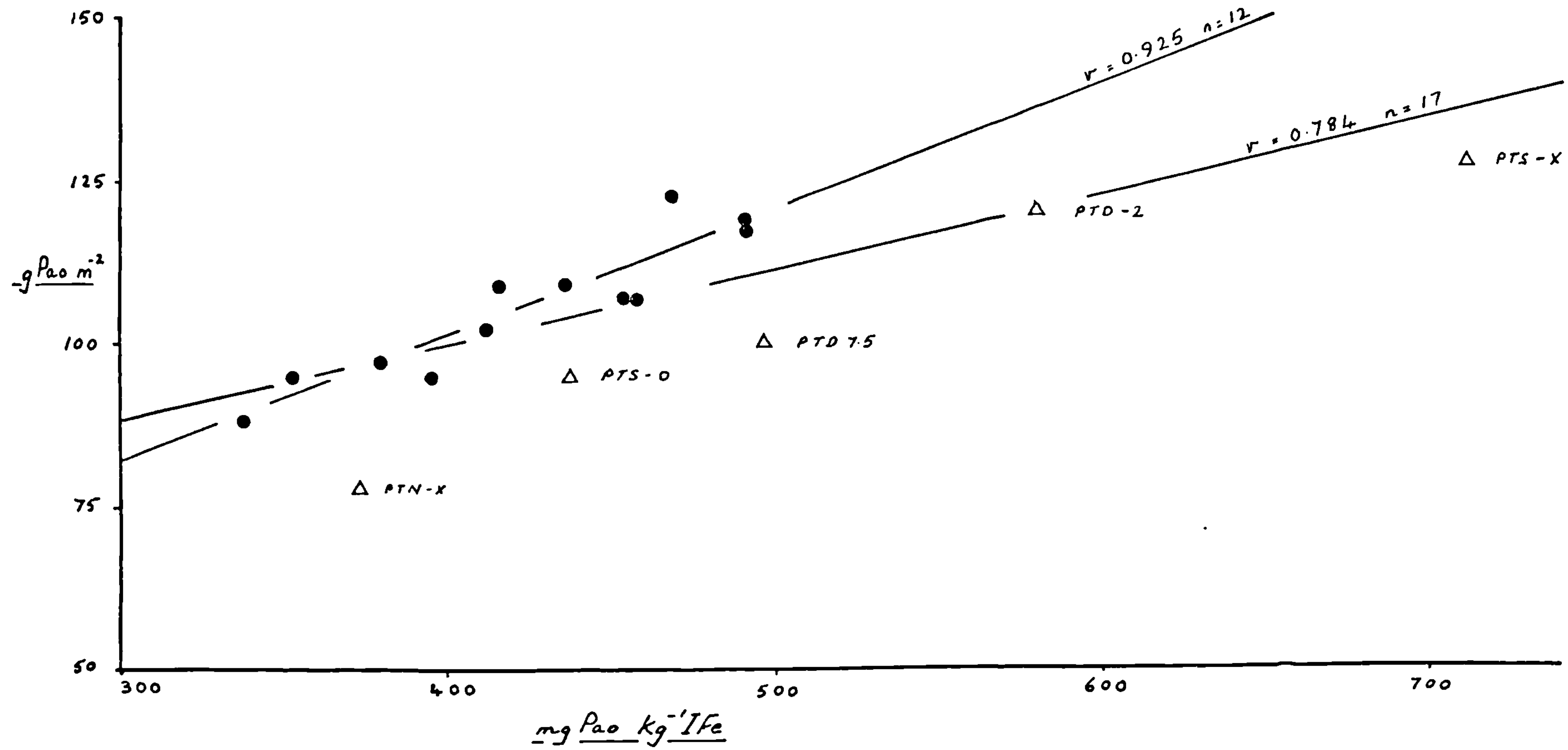
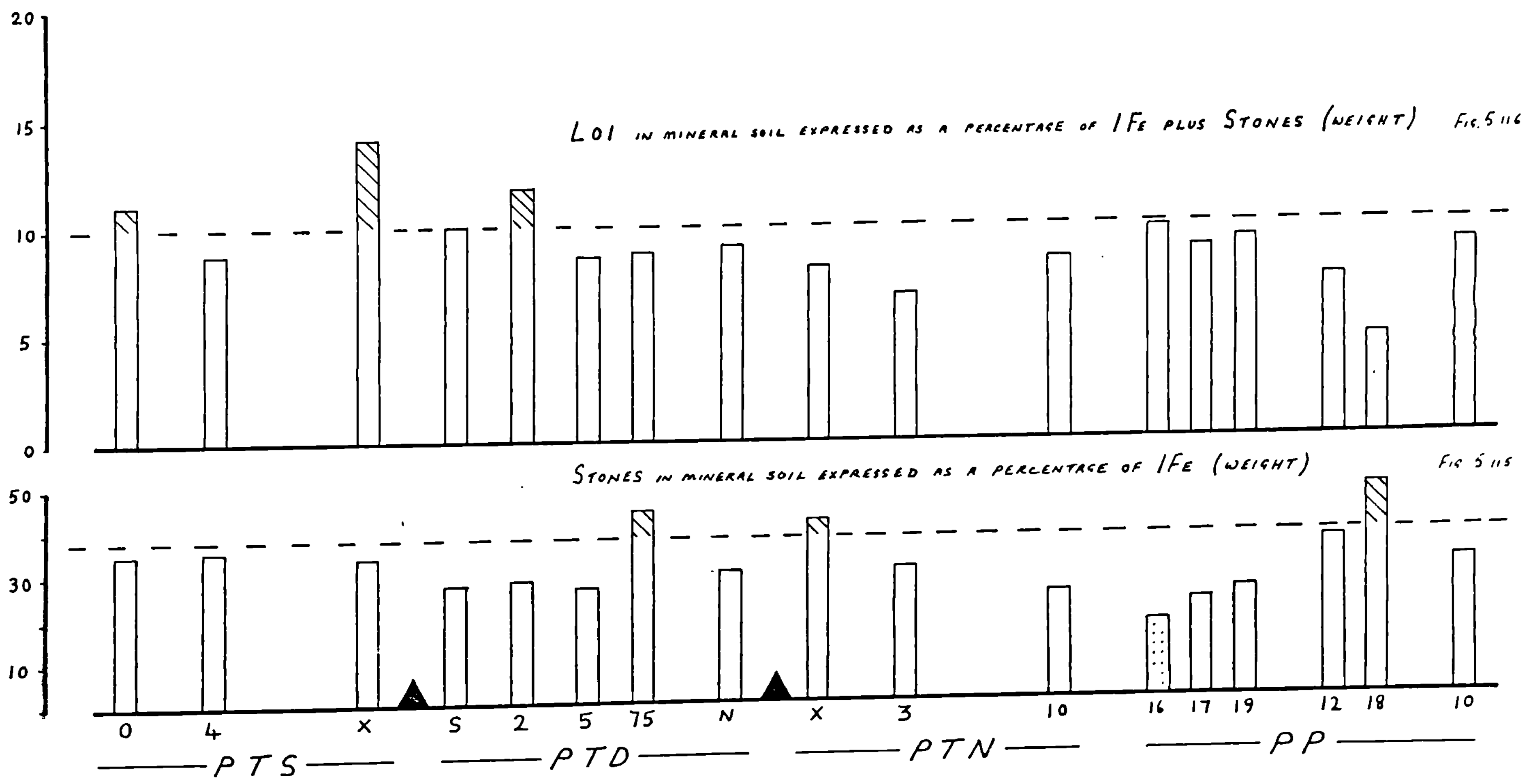


Fig. 5.114 Zone B - Scattergram: mgPao kg^{-1}IFe in profiles / gPao m^{-2} in profiles

Figs. 5.115 and 5.116 Zone B - Bar charts



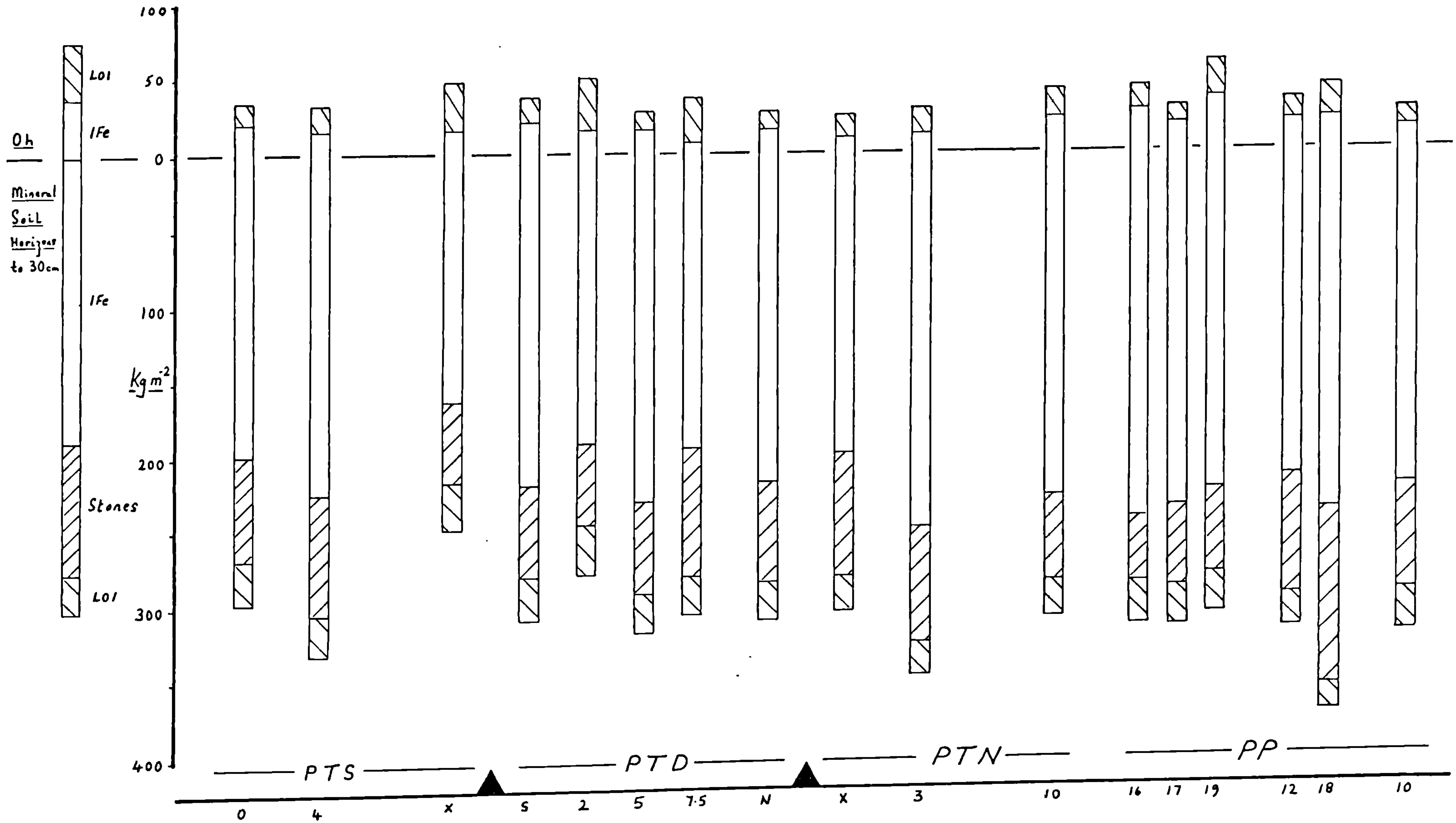


Fig. 5.117 Zone B - Bar chart: kg LOI, Stones, IFe m^{-2} in profiles sampled to 30 cm below the mineral soil surface

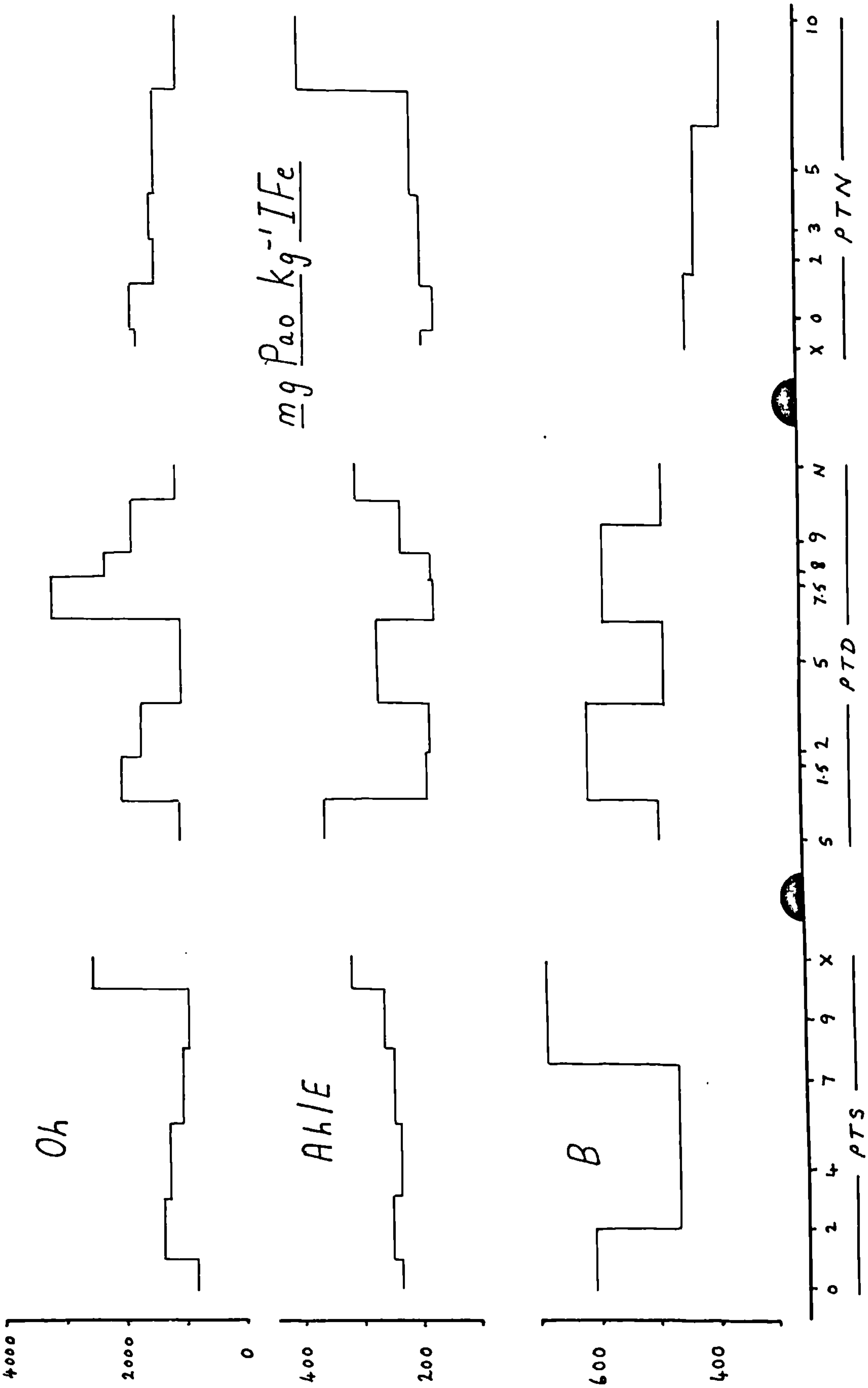


Fig. 5.118 Zone B - Transect

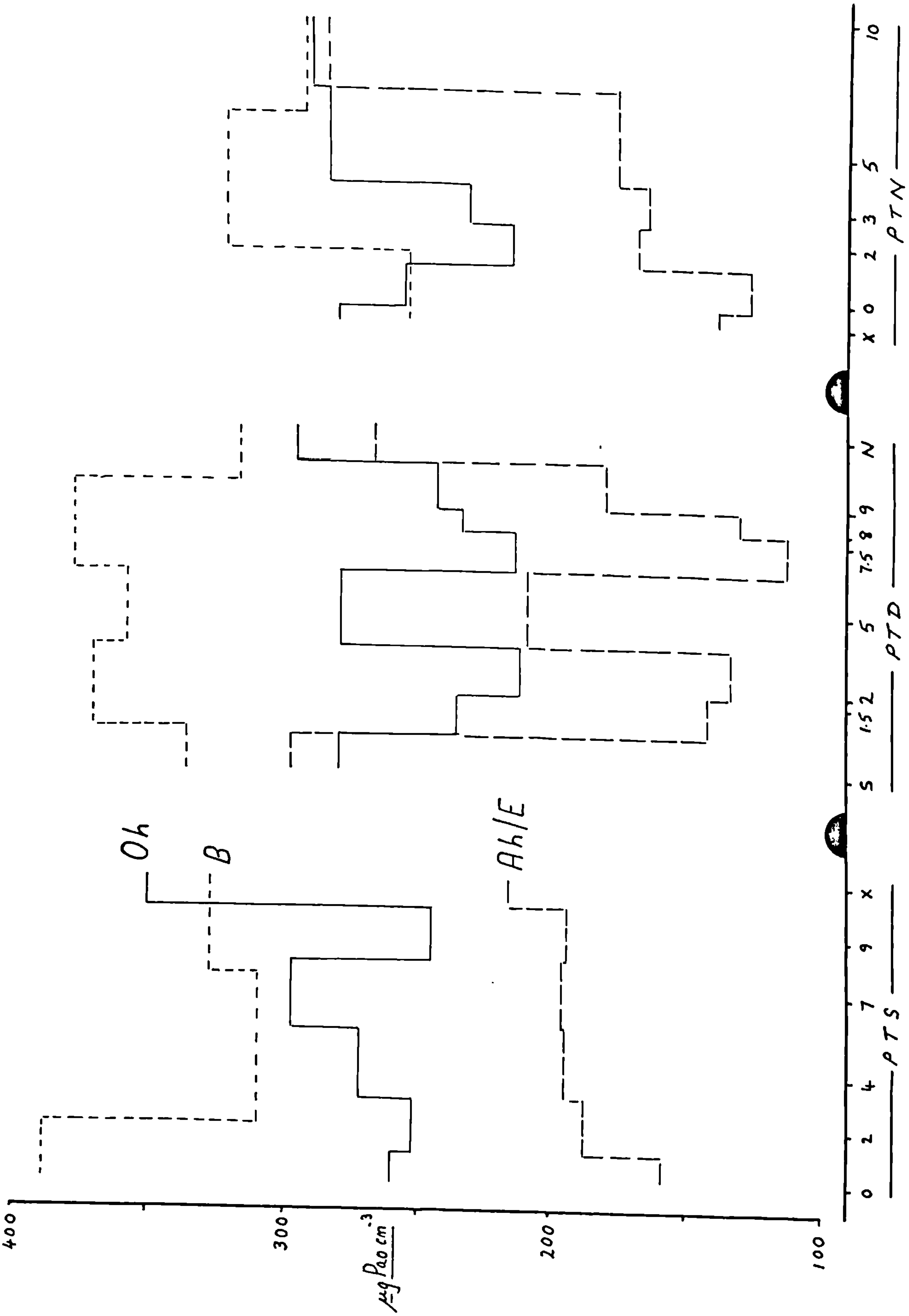


Fig. 5.119 Zone B - Transect

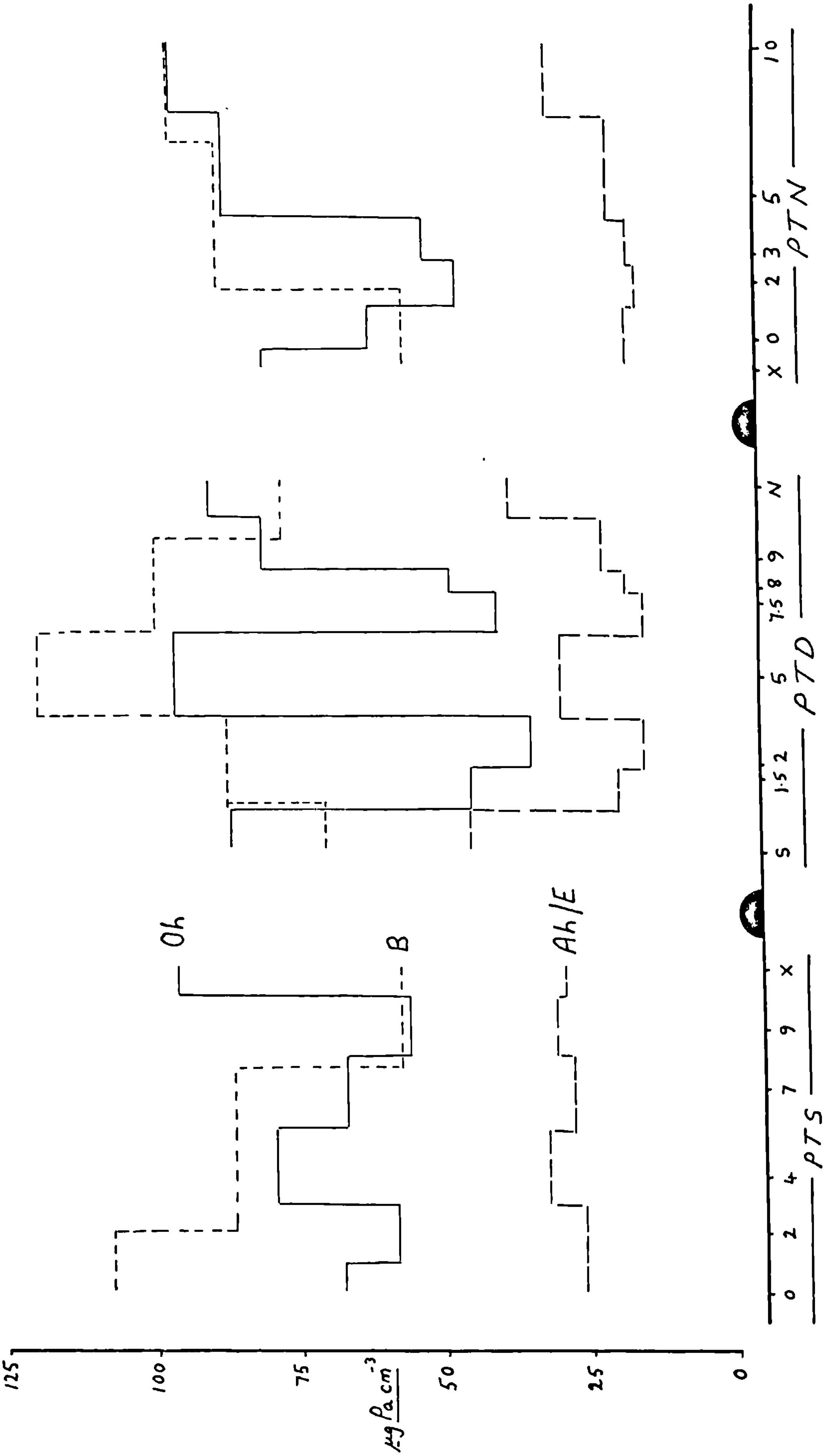


Fig. 5.120 Zone B - Transect

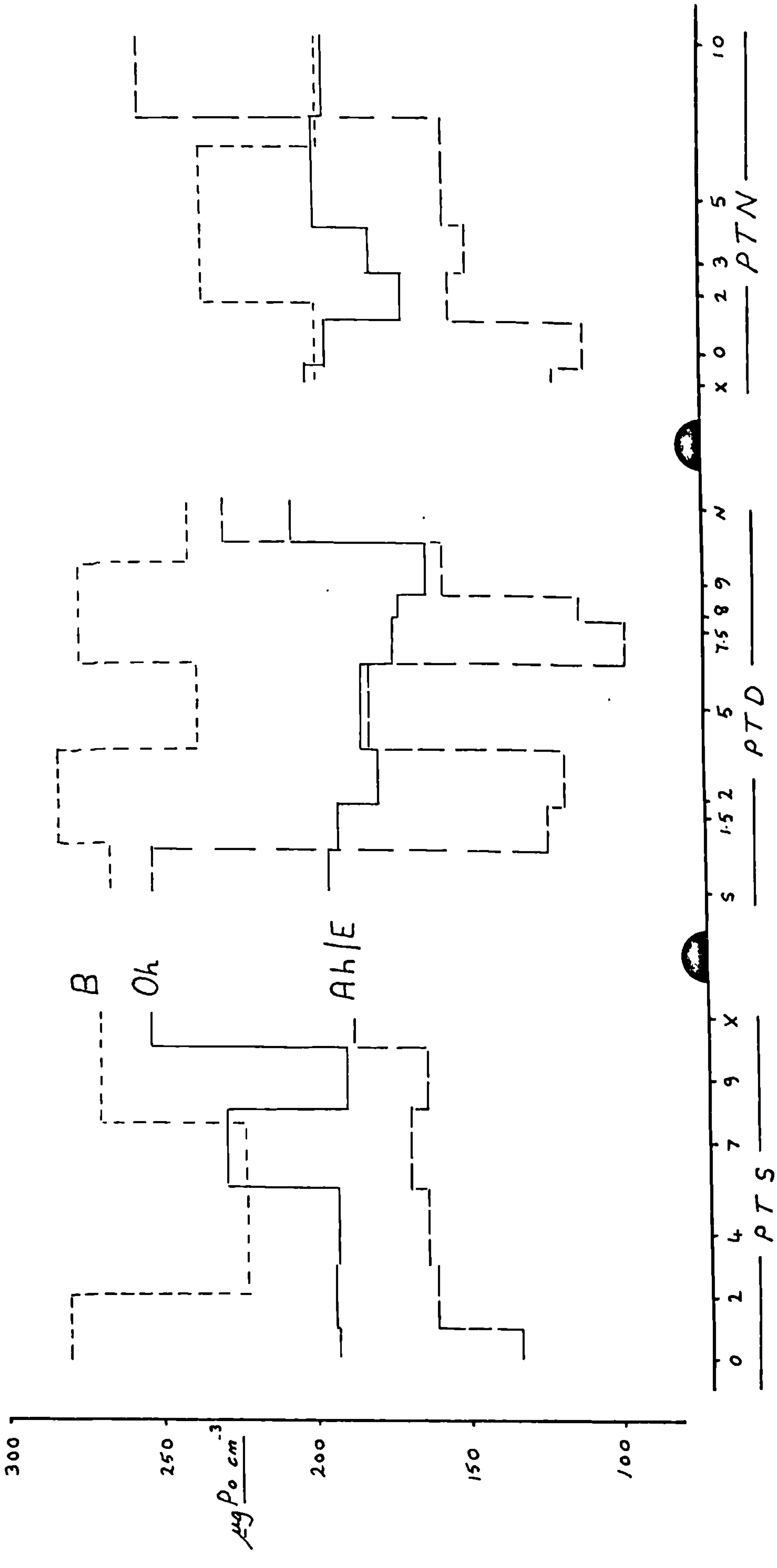
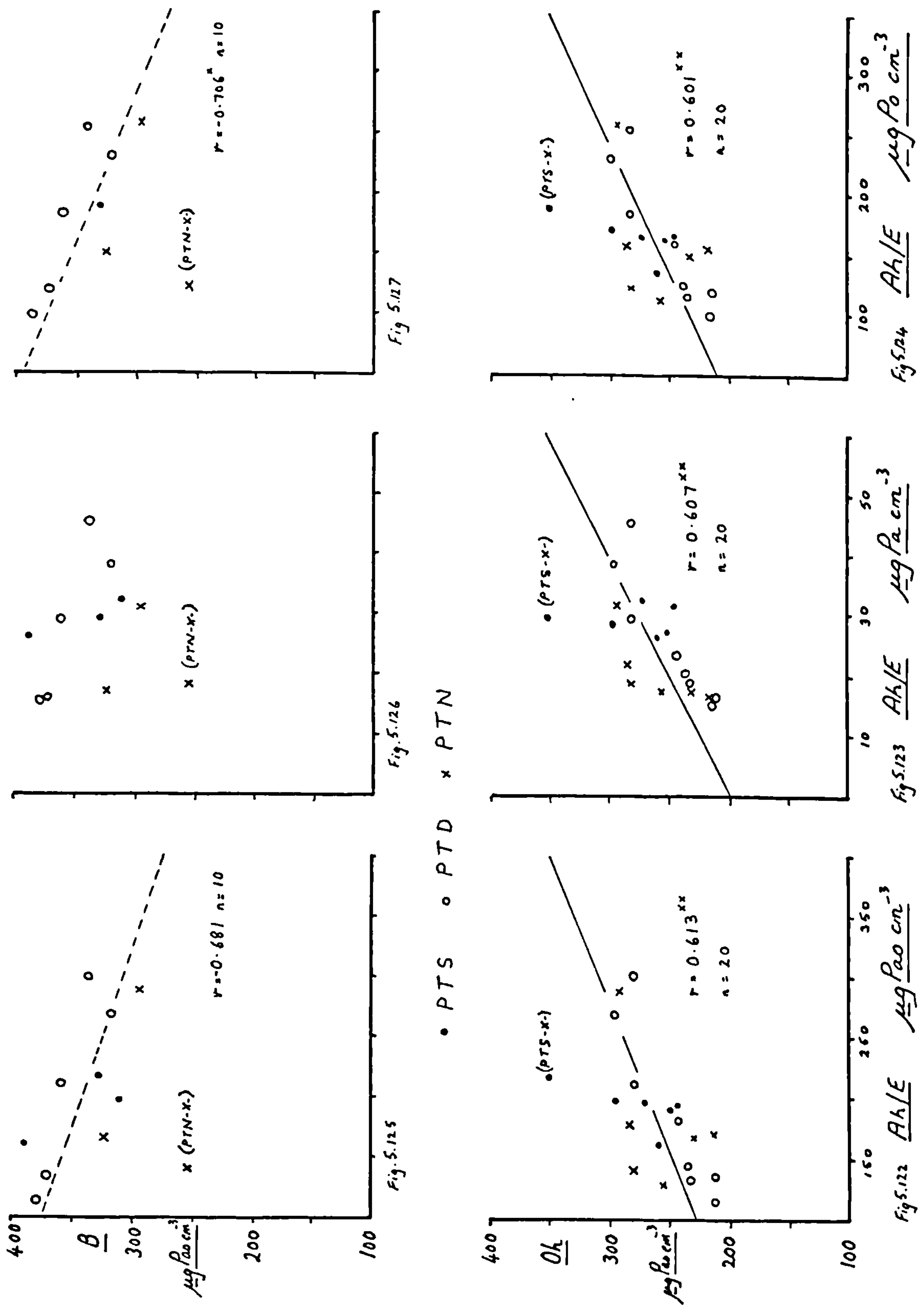
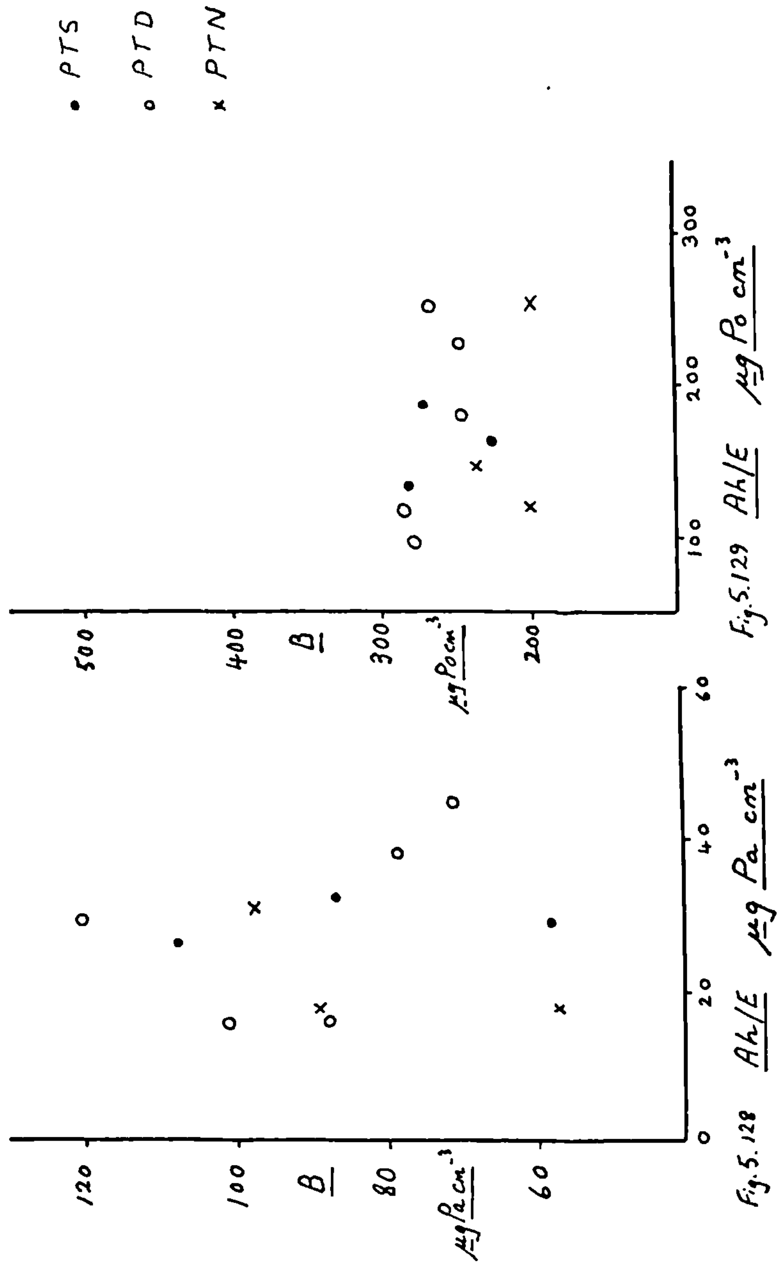


Fig. 5.121 Zone B - Transect



Figs. 5.122 - 5.127 Zone B - Transect Scattergrams



Figs. 5.128 and 5.129 Zone B - Transect Scattergrams

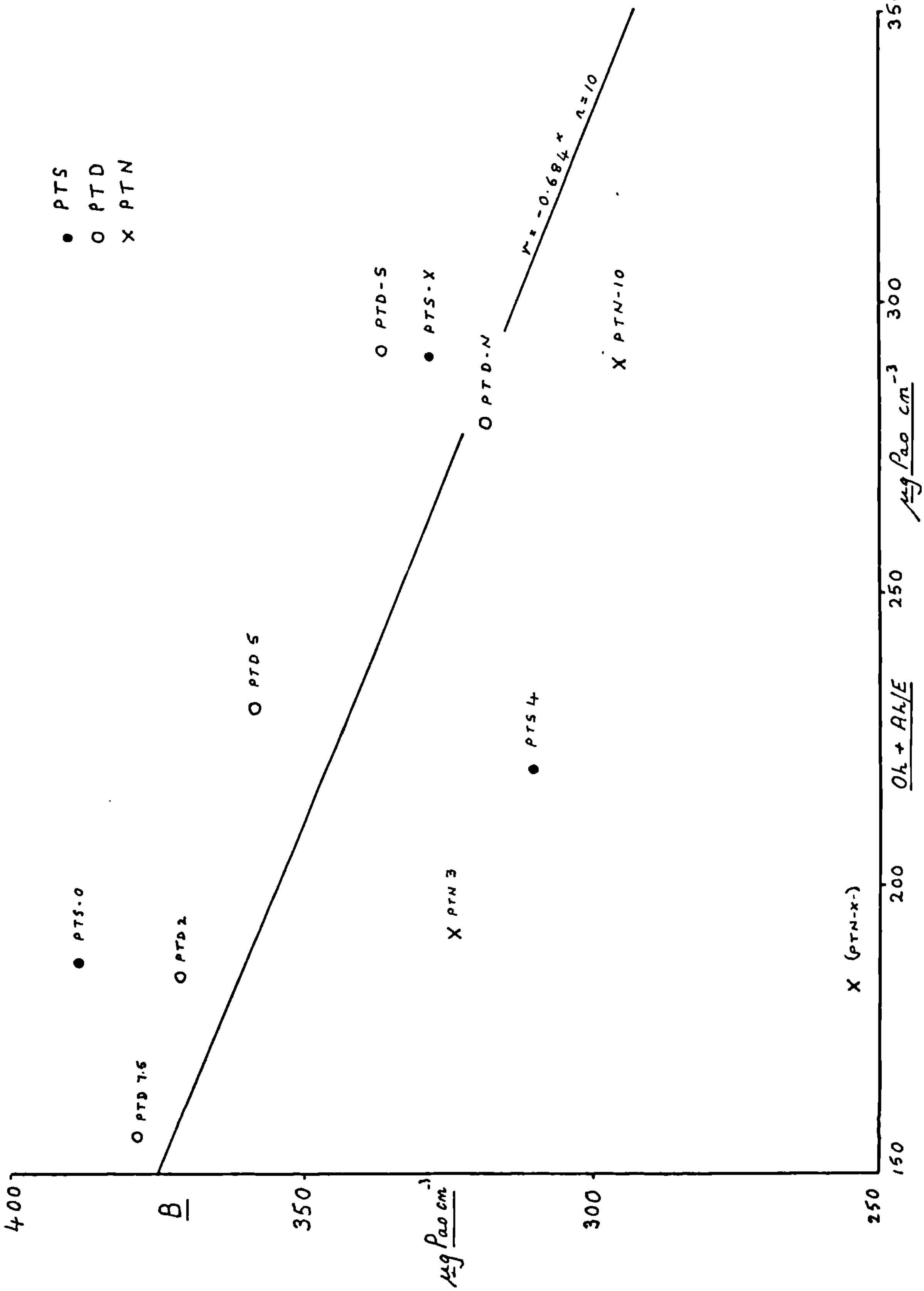


Fig. 5.130 Zone B - Transect scattergram: µgPao cm^{-3} in Oh + Ah/E horizon / µgPao cm^{-3} in B horizon

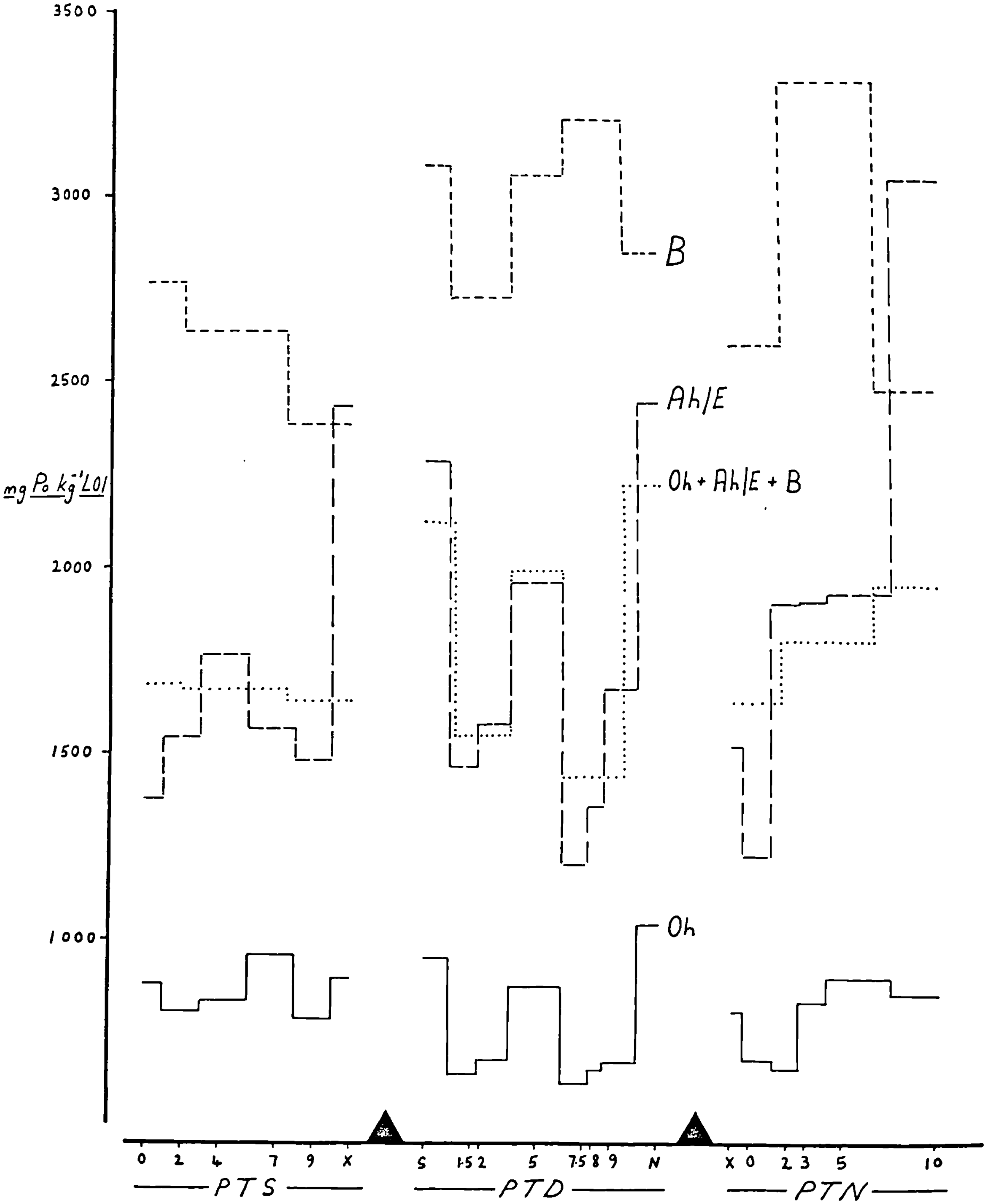
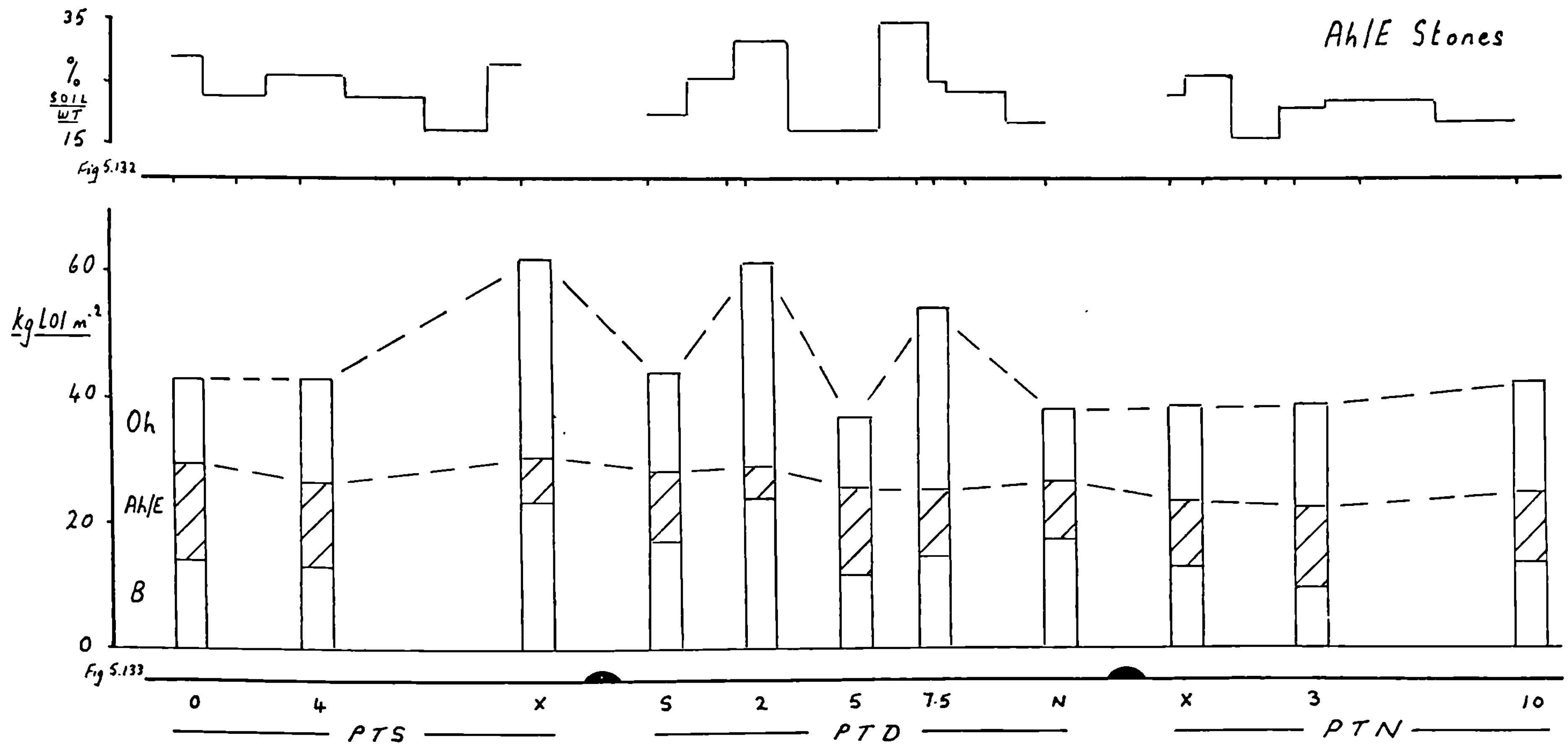


Fig. 5.131 Zone B - Transect



Figs. 5.132 and 5.133 Zone B - Transect

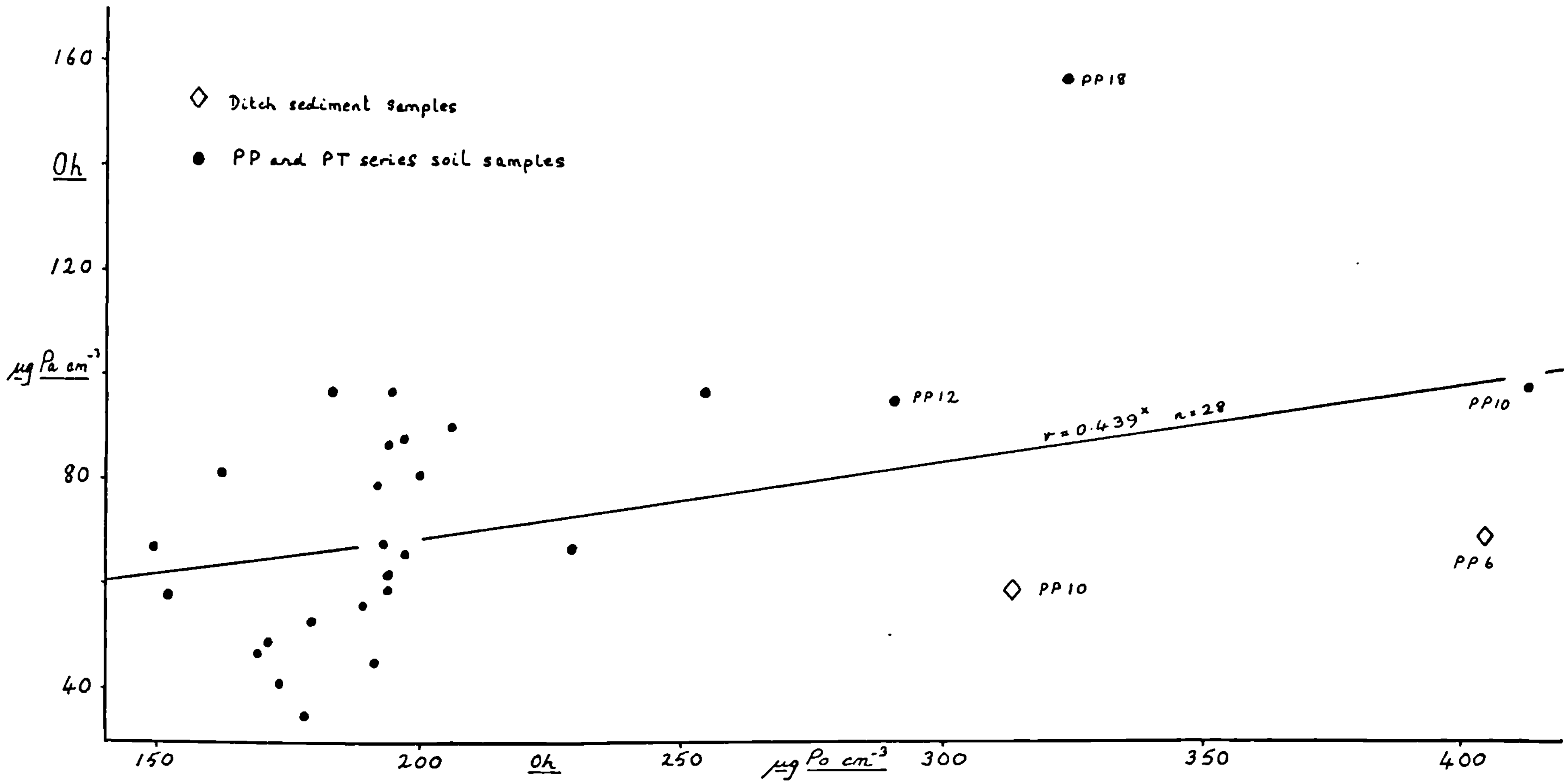


Fig. 5.134 Zone B - Scattergram: µgPo cm^{-3} in Oh horizon / µgPa cm^{-3} in Oh horizon

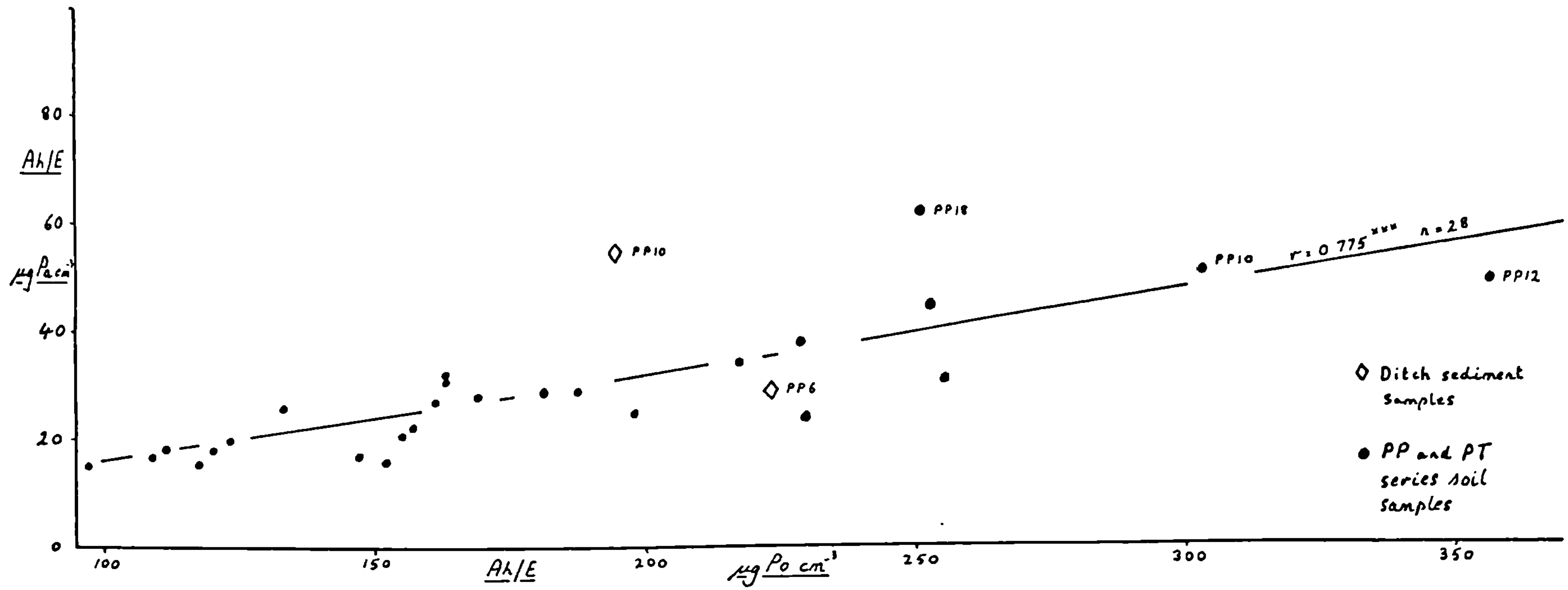
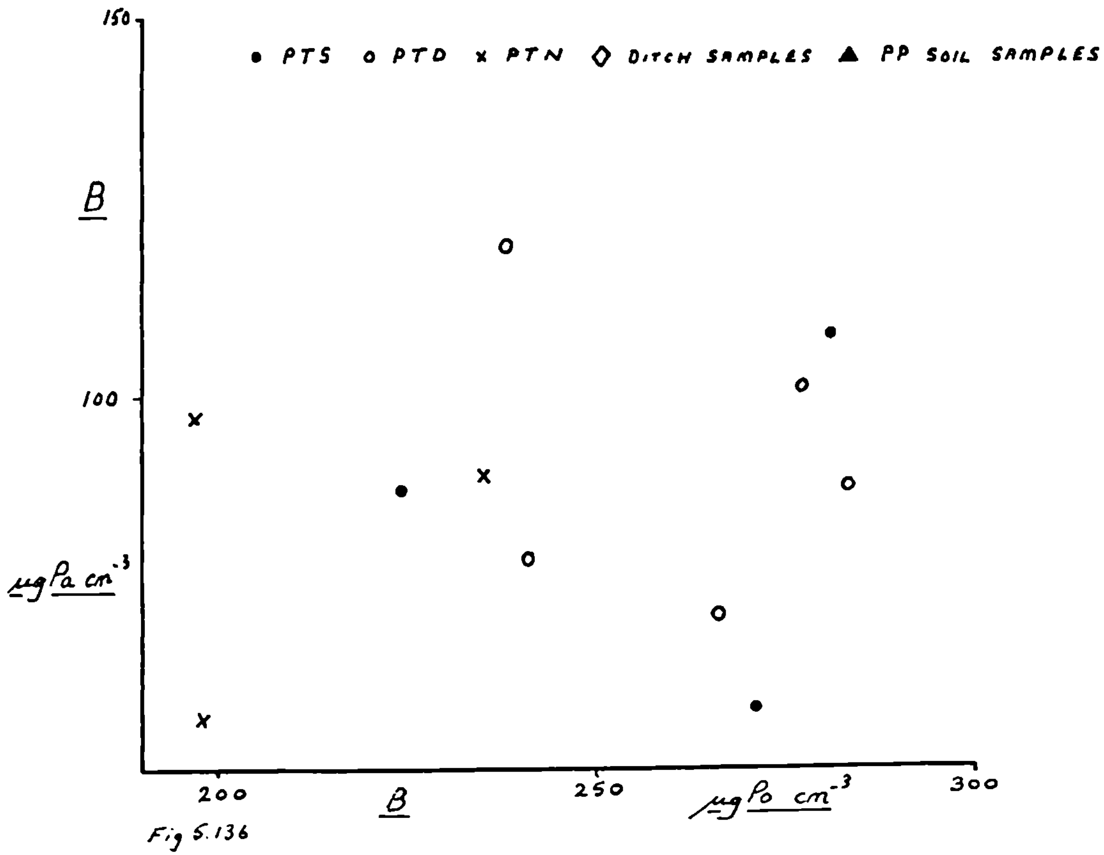
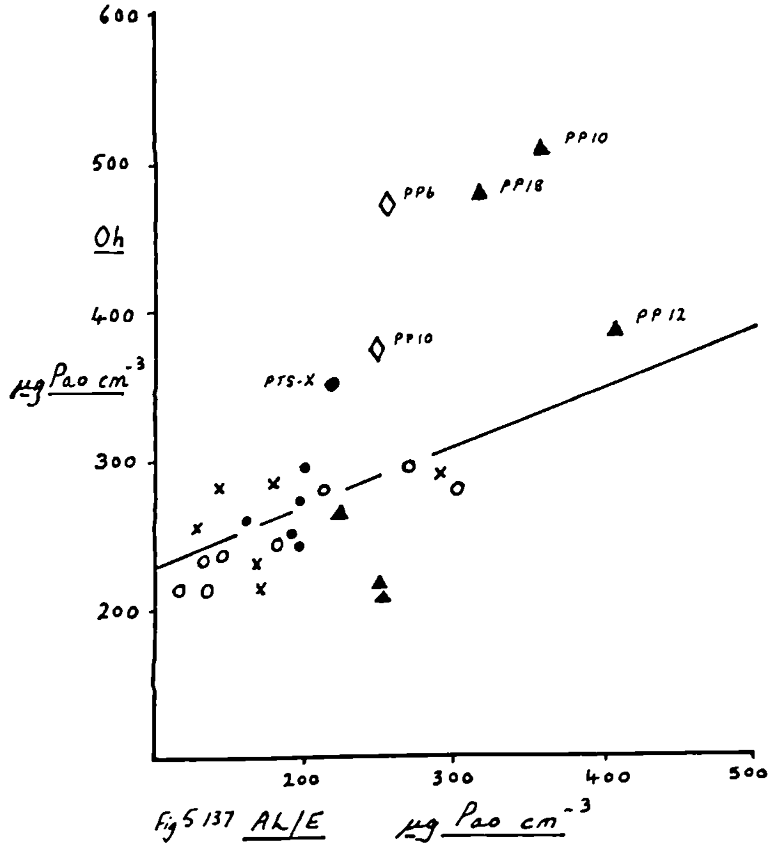
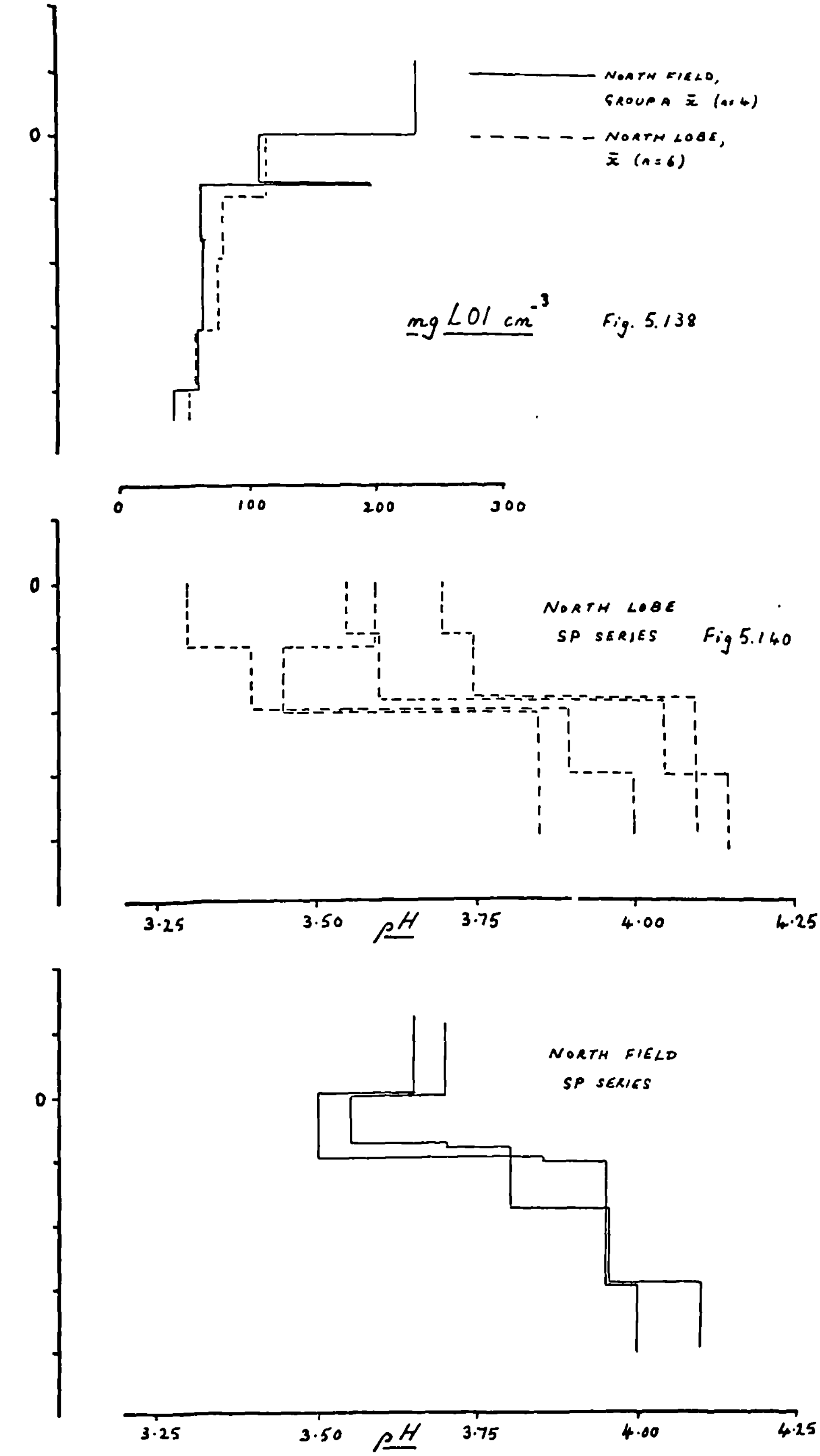


Fig 5.135 Zone B - Scattergram: μgPo cm^{-3} in Ah/E horizon / μgPa cm^{-3} in Ah/E horizon





Figs. 5.136 and 5.137 Zone B - Scattergrams



Figs. 5.138 and 5.140 Zone C - Vertical distributions

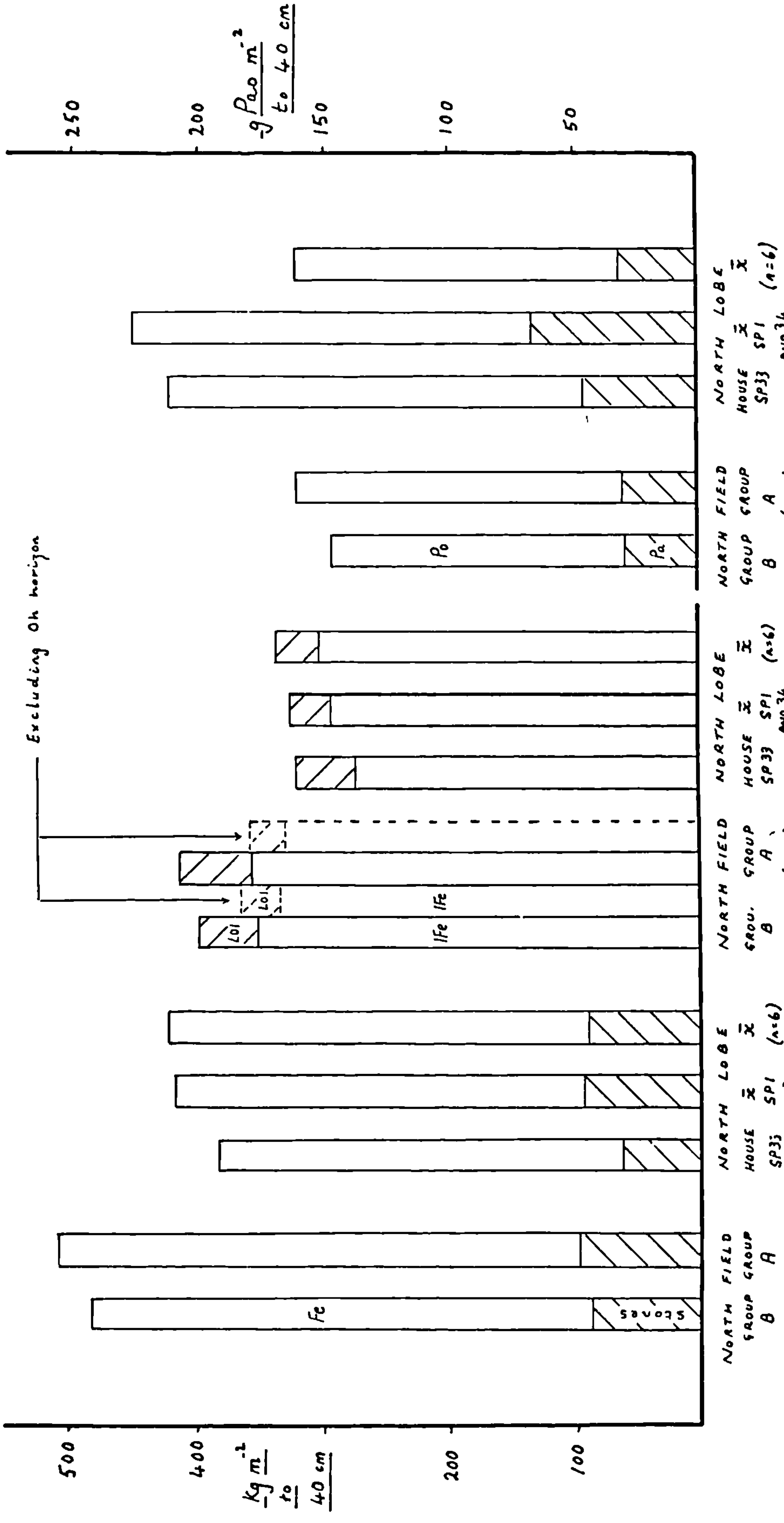
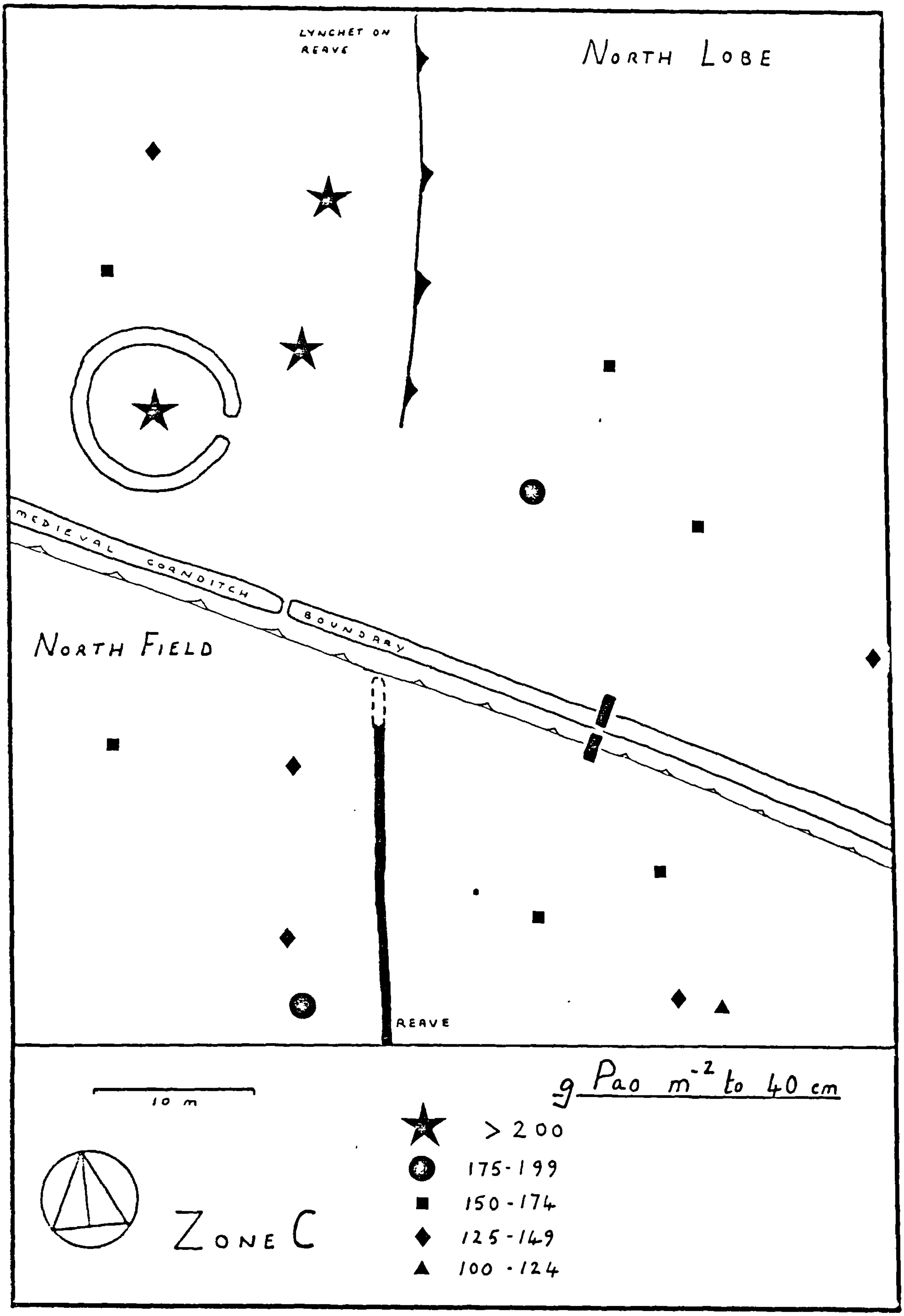


Fig. 5.139 Zone C - Bar chart



LYNCHET ON REAVE
NORTH LOBE
MEDIEVAL CORNDITCH BOUNDARY
NORTH FIELD
REAVE
10 m
g Pao m-2 to 40 cm
> 200
175-199
150-174
125-149
100-124
ZONE C

Fig. 5.141

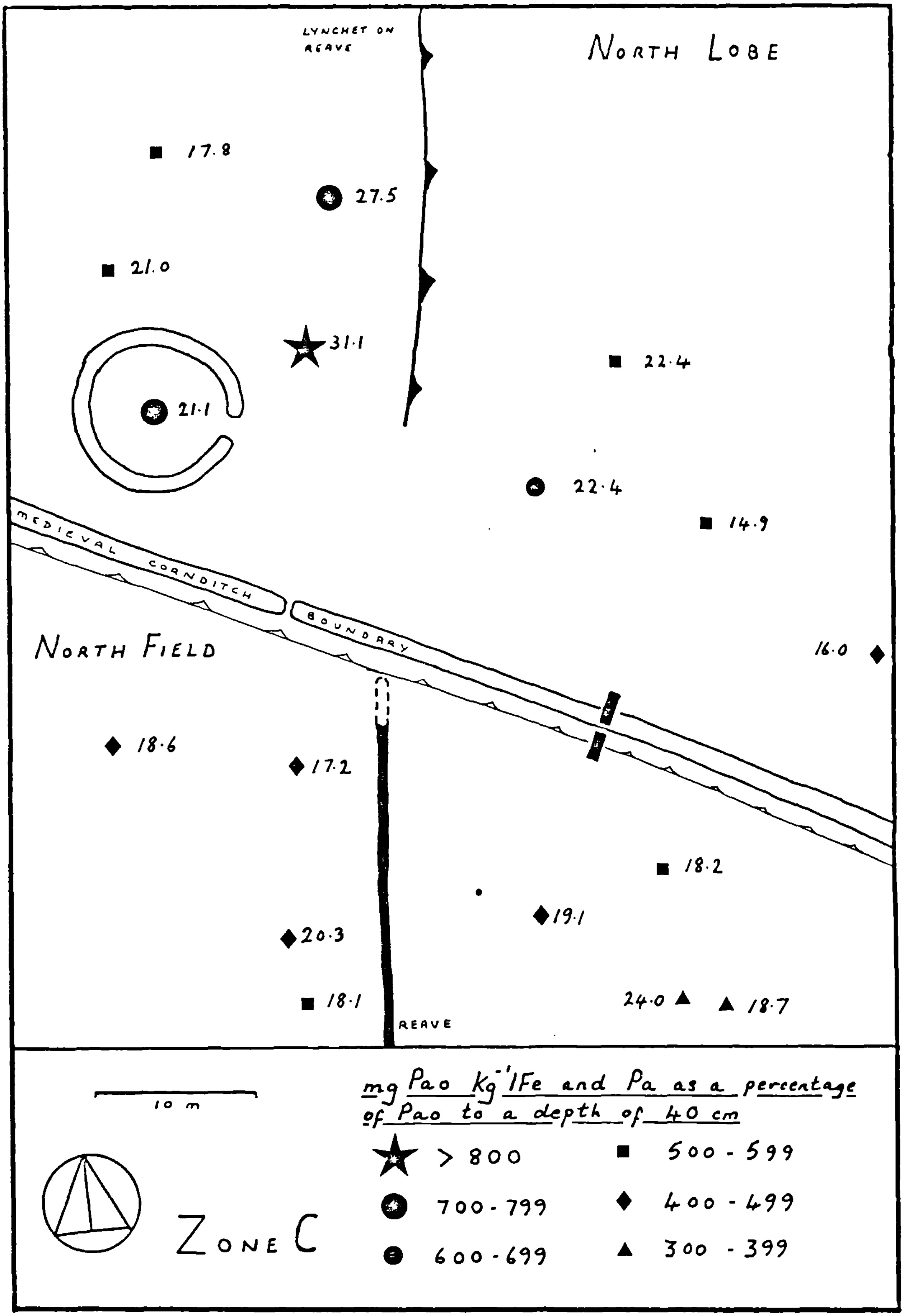
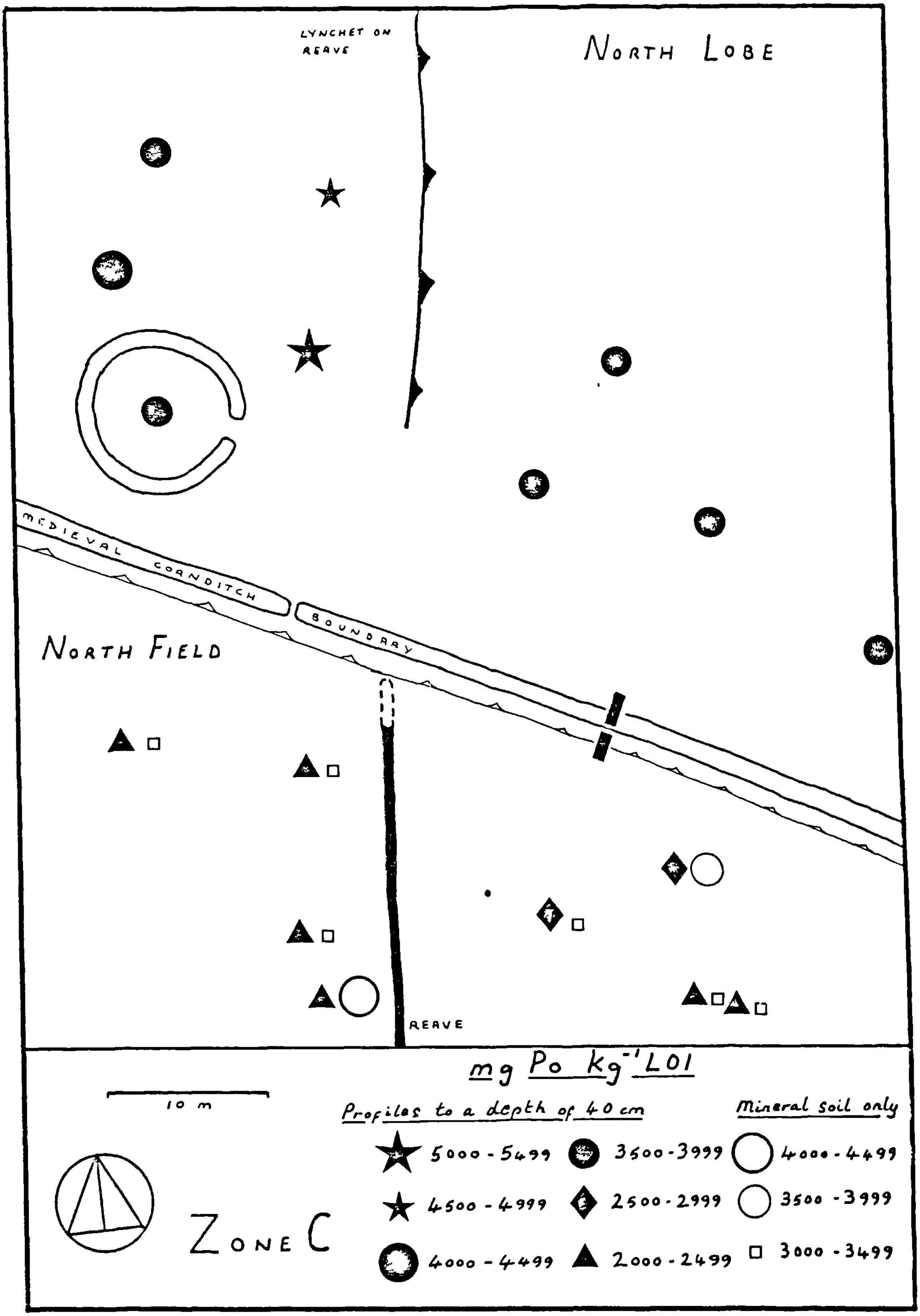

LYNCHET ON REAVE
NORTH LOBE
17.8
27.5
21.0
31.1
22.4
21.1
22.4
14.9
MEDIEVAL CORNDITCH BOUNDARY
NORTH FIELD
16.0
18.6
17.2
18.2
19.1
20.3
24.0
18.7
18.1
REAVE
10 m
mg Pao Kg⁻¹ IFe and Pa as a percentage of Pao to a depth of 40 cm
> 800
500 - 599
700 - 799
400 - 499
600 - 699
300 - 399
ZONE C

Fig. 5.142



LYNCHET ON REAVE
NORTH LOBE
MEDIEVAL CORNDITCH BOUNDARY
NORTH FIELD
REAVE
mg Po kg⁻¹ LOI
10 m
Profiles to a depth of 40 cm
Mineral soil only
5000 - 5499
3500 - 3999
4000 - 4499
4500 - 4999
2500 - 2999
3500 - 3999
ZONE C
4000 - 4499
2000 - 2499
3000 - 3499

Fig. 5.143

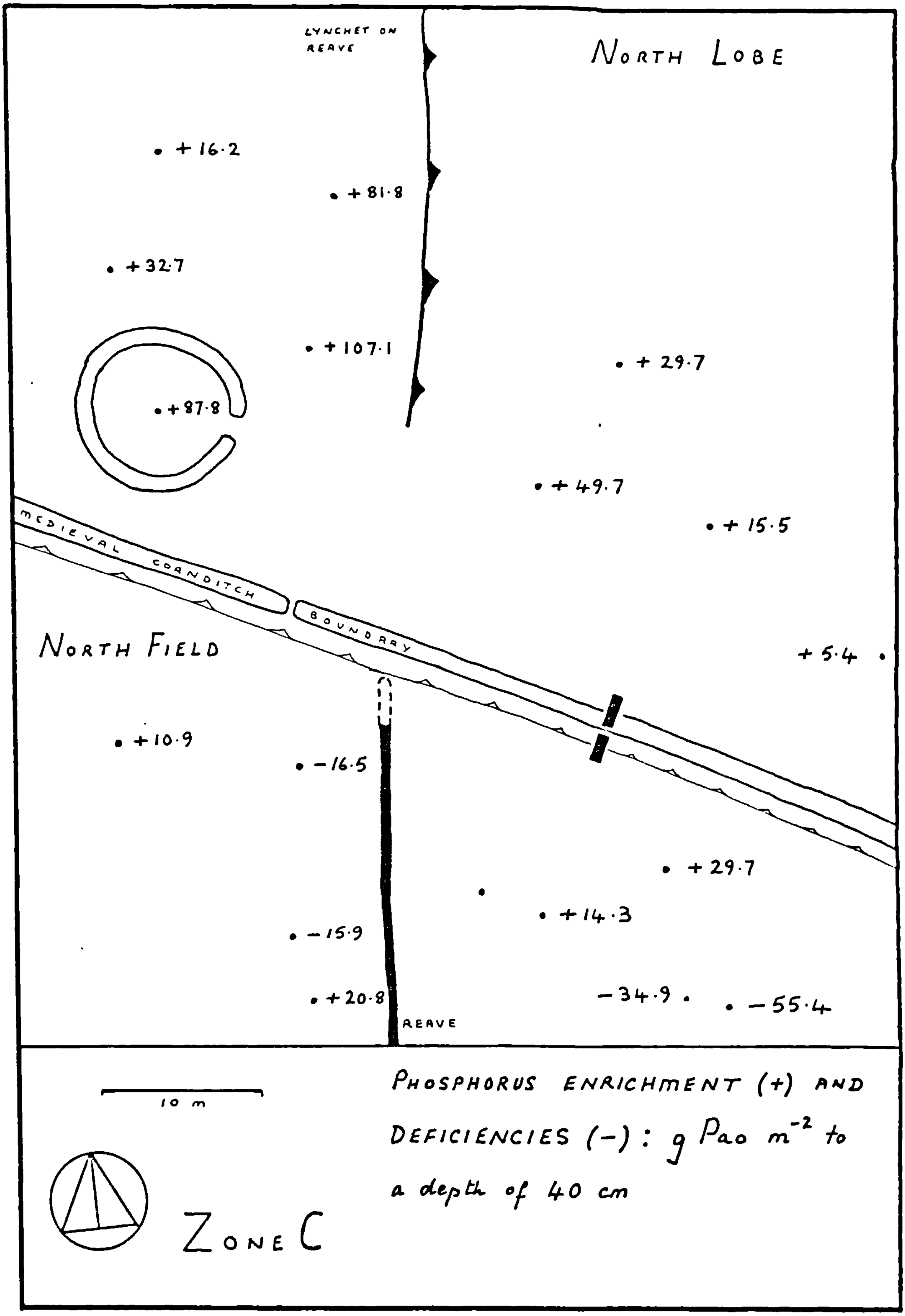
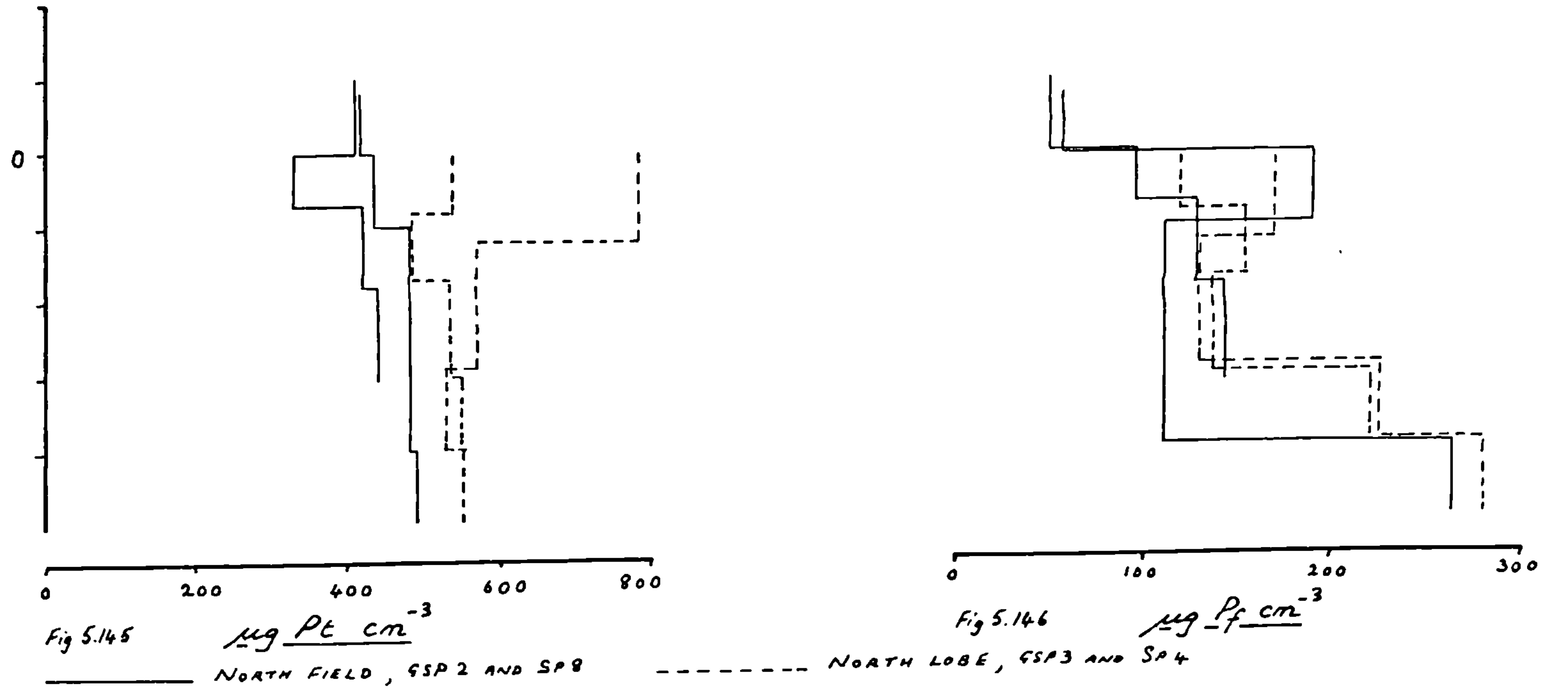
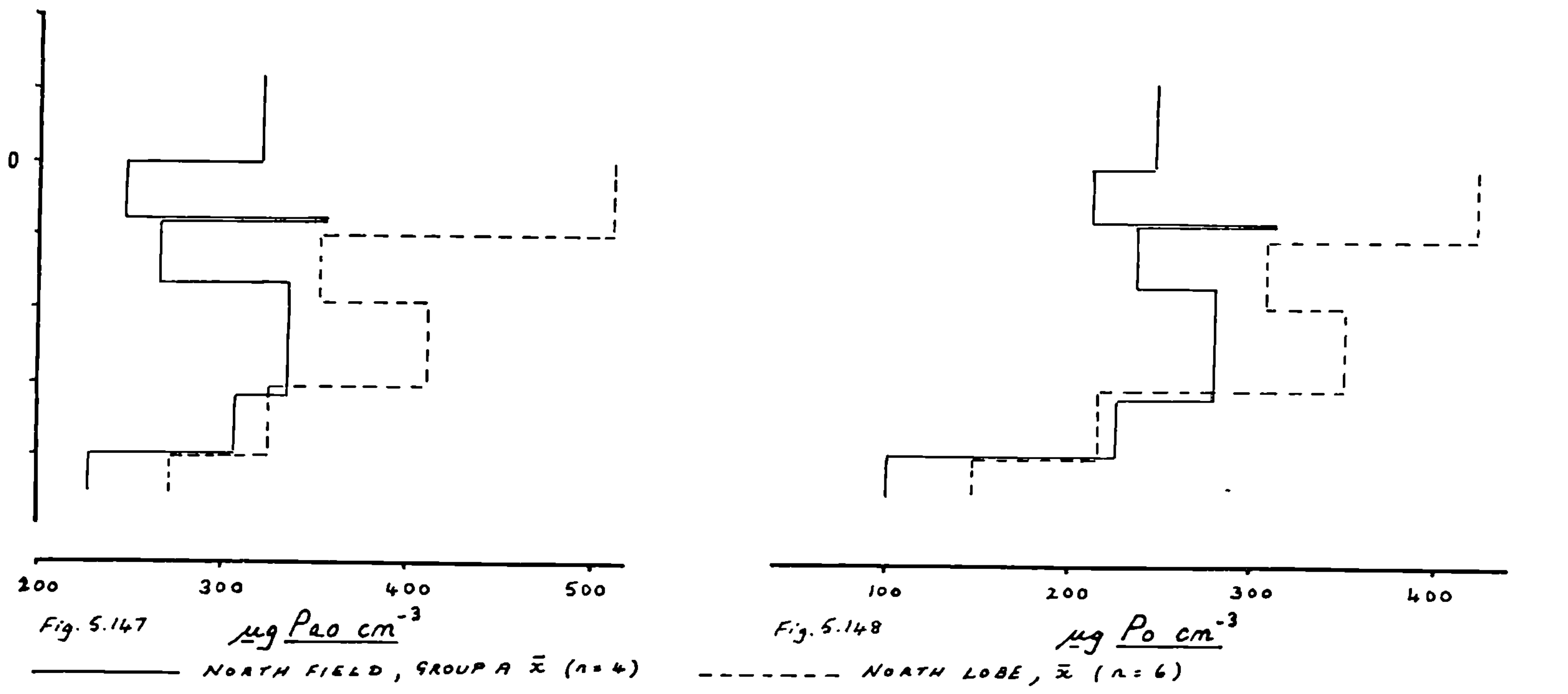

LYNCHET ON REAVE
NORTH LOBE
+16.2
+81.8
+32.7
+107.1
+87.8
+29.7
+49.7
+15.5
MEDIEVAL CORNDITCH
BOUNDARY
NORTH FIELD
+5.4
+10.9
-16.5
+29.7
+14.3
-15.9
+20.8
-34.9
-55.4
REAVE
10 m
ZONE C
PHOSPHORUS ENRICHMENT (+) AND DEFICIENCIES (-): g Pao m⁻² to a depth of 40 cm

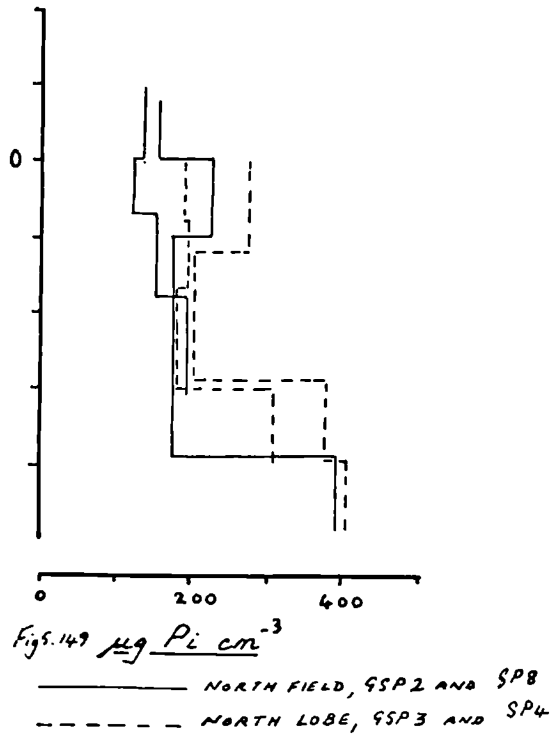
Fig. 5.144

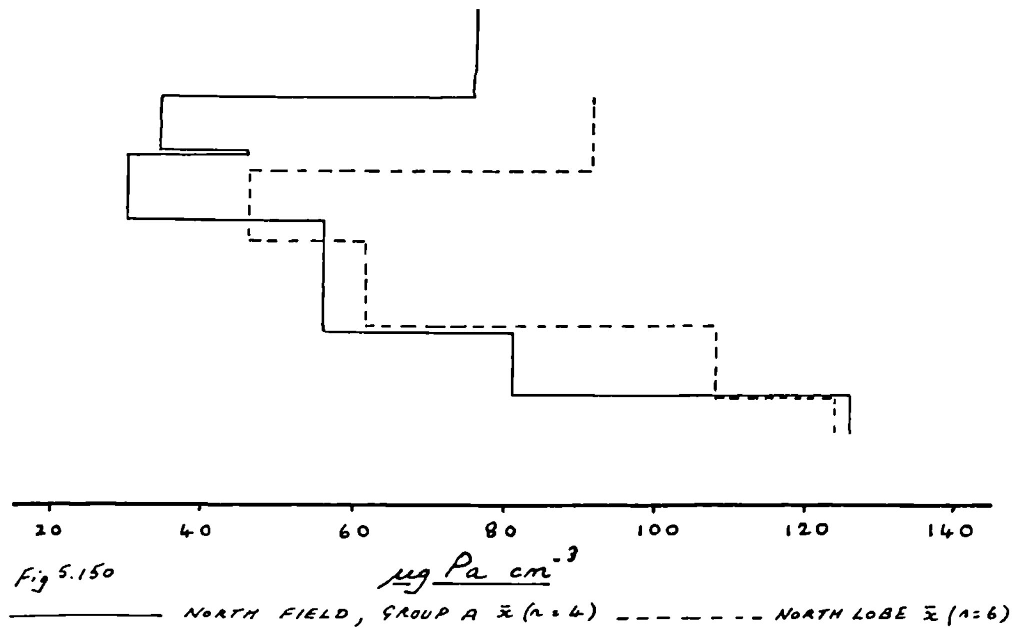


Figs. 5.145 and 5.146 Zone C - Vertical distributions

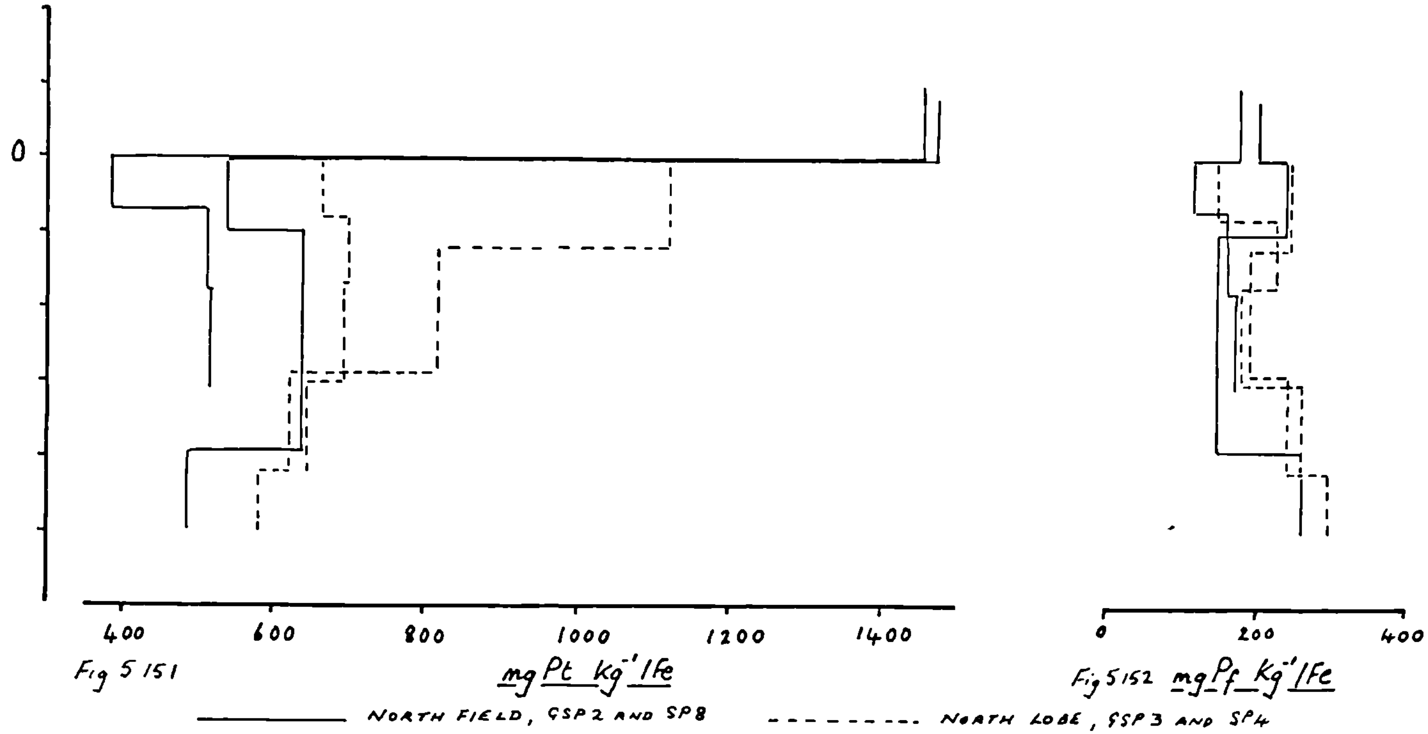


Figs. 5.147 and 5.148 Zone C - Vertical distributions

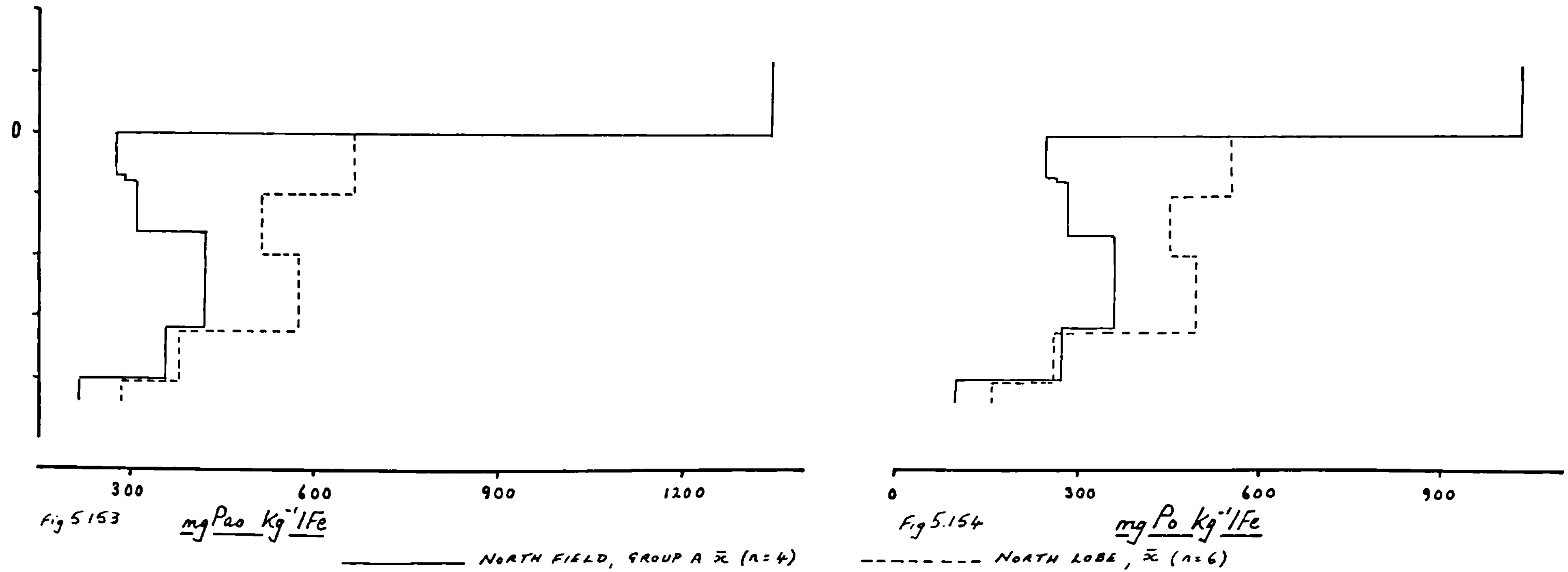




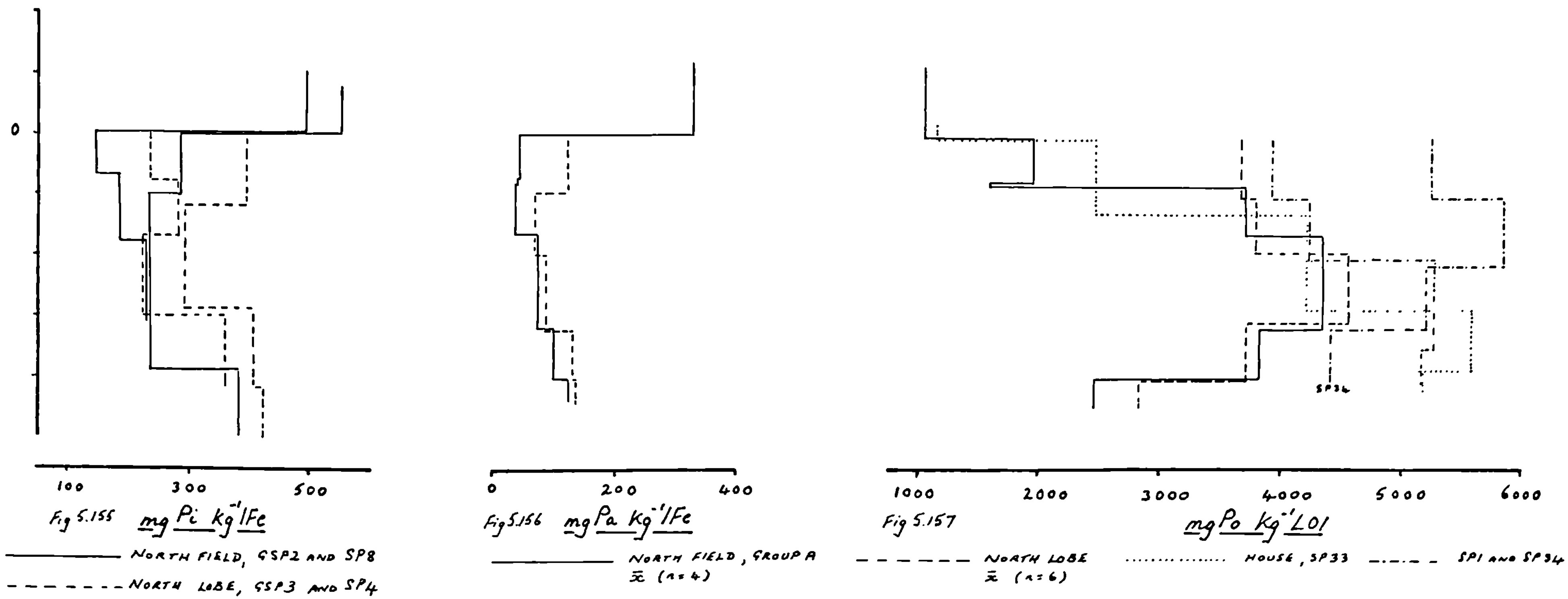
Figs. 5.149 and 5.150 Zone C - Vertical distributions



Figs. 5.151 and 5.152 Zone C - Vertical distributions



Figs. 5.153 and 5.154 Zone C - Vertical distributions



Figs. 5.155, 5.156 and 5.157 Zone C - Vertical distributions

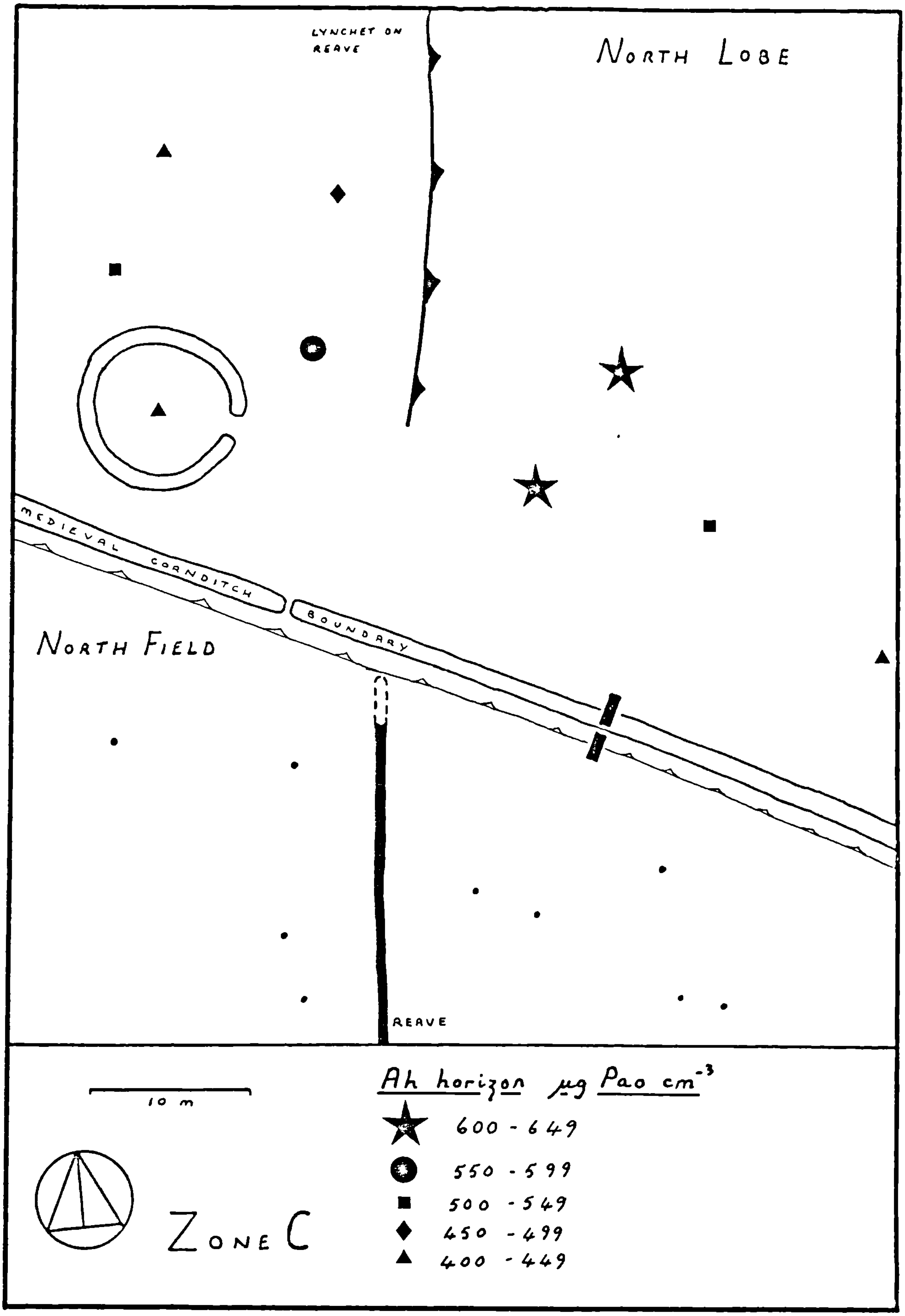

LYNCHET ON REAVE
NORTH LOBE
MEDIEVAL CORNDITCH BOUNDARY
NORTH FIELD
REAVE
10 m
Ah horizon µg Pao cm-3
600 - 649
550 - 599
500 - 549
450 - 499
400 - 449
ZONE C

Fig. 5.158

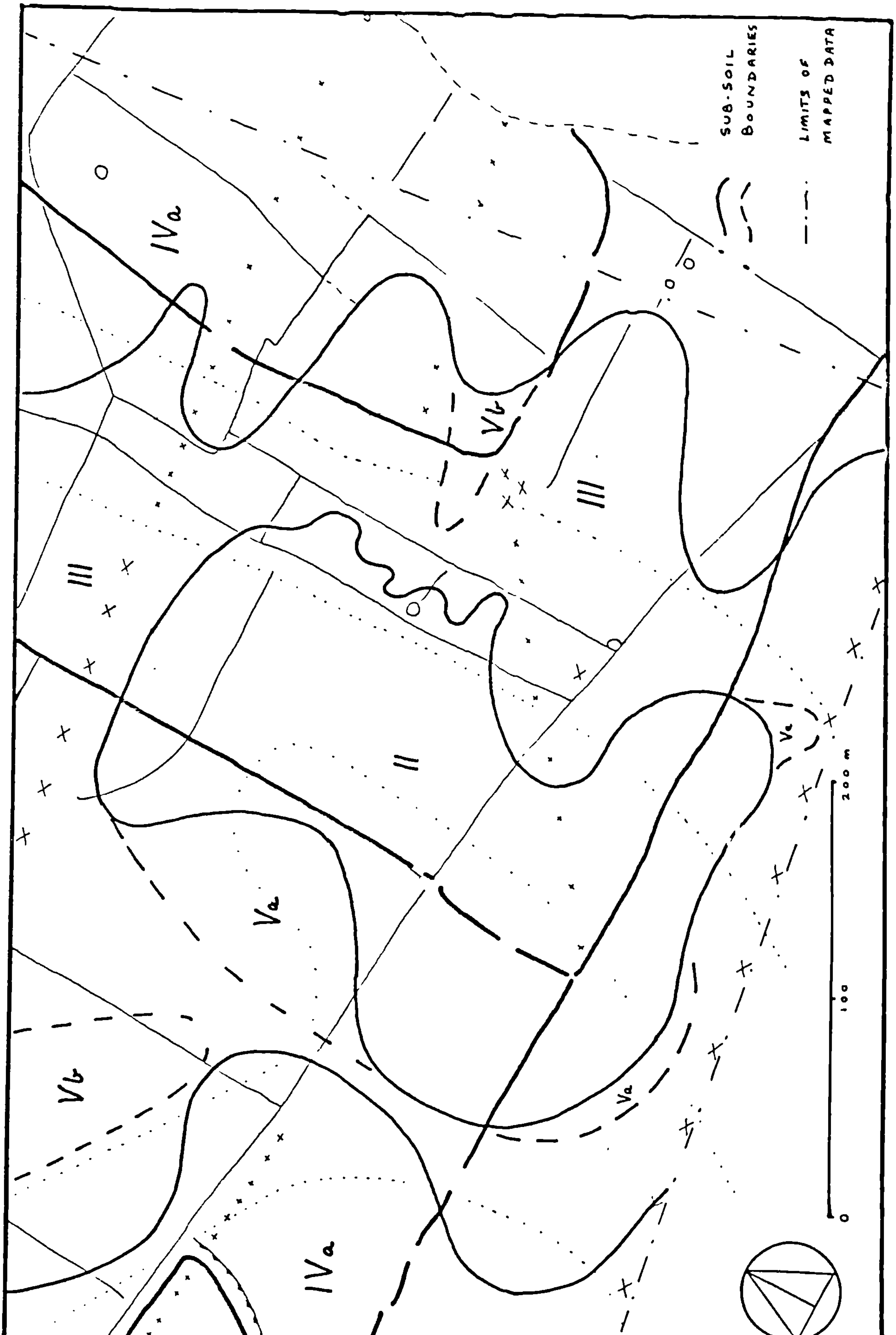


Fig. 5.159 Zone A - Distribution of sub-soil classification units (sub-soil classification units are described in sections 4.2.1.1 and 4.2.2.1)

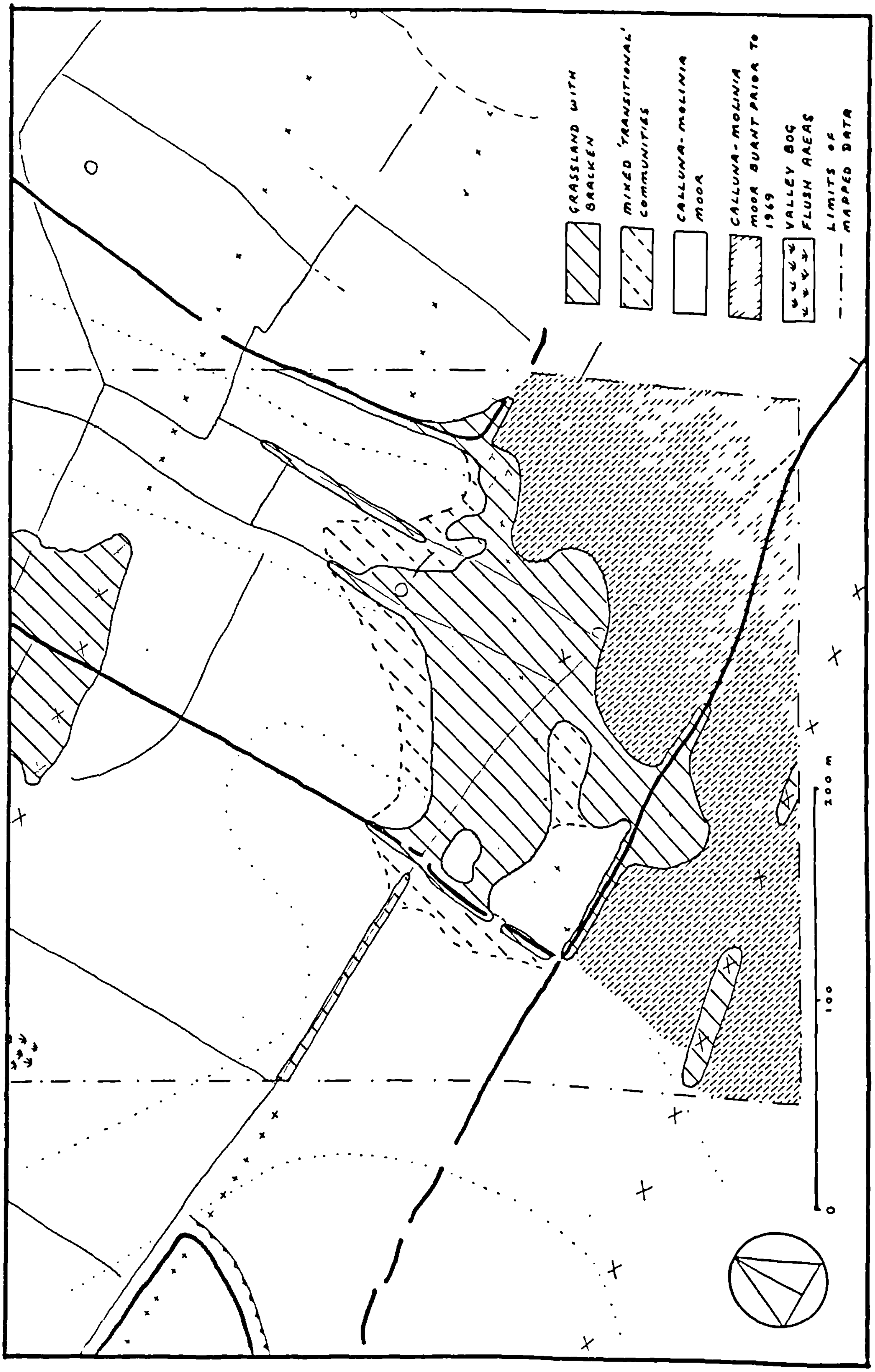
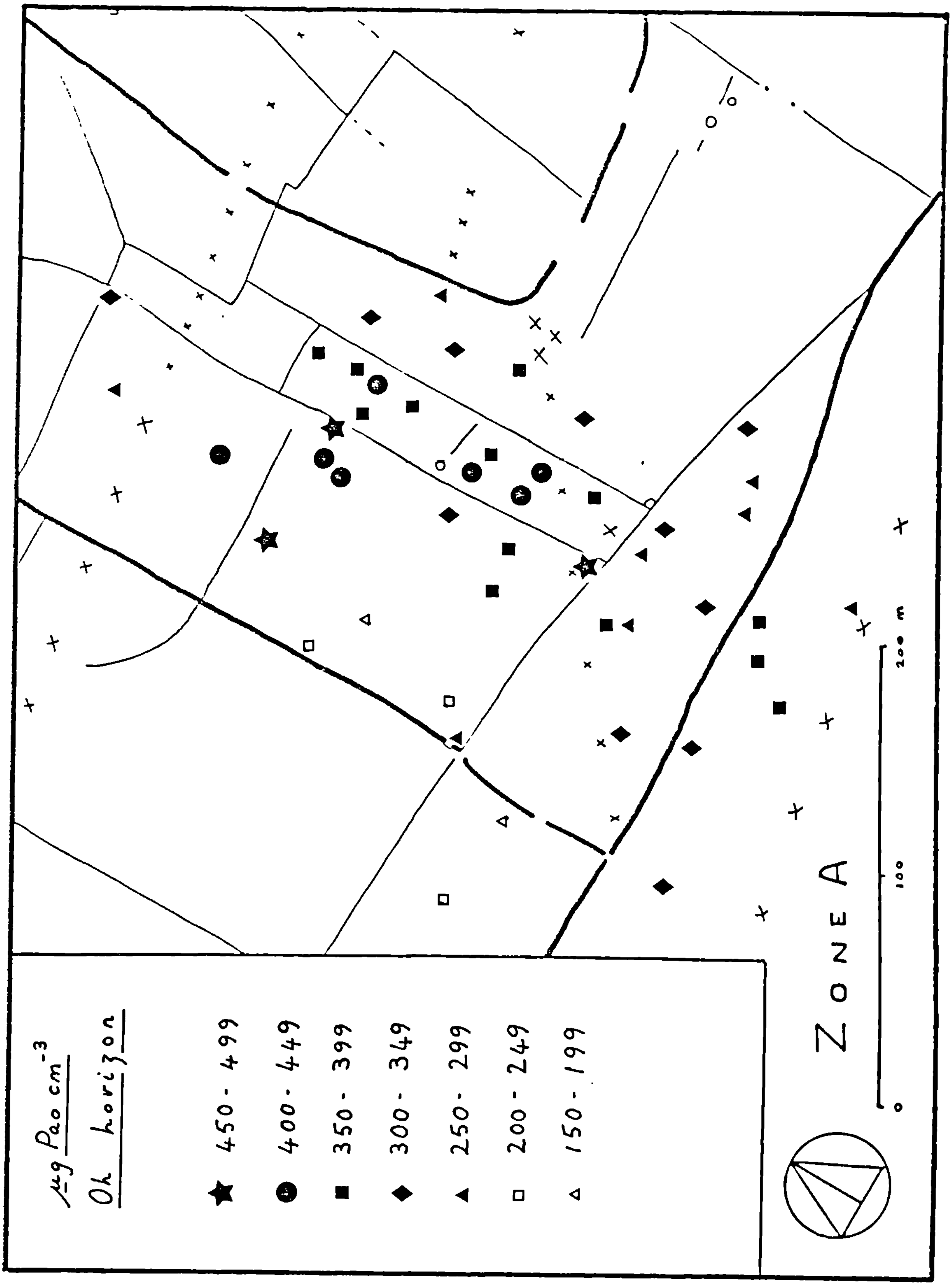


Fig. 5.160 Zone A - Distribution of vegetation



μg Pao cm-3
Oh horizon
450 - 499
400 - 449
350 - 399
300 - 349
250 - 299
200 - 249
150 - 199
ZONE A
0
100
200 m

Fig 5.161

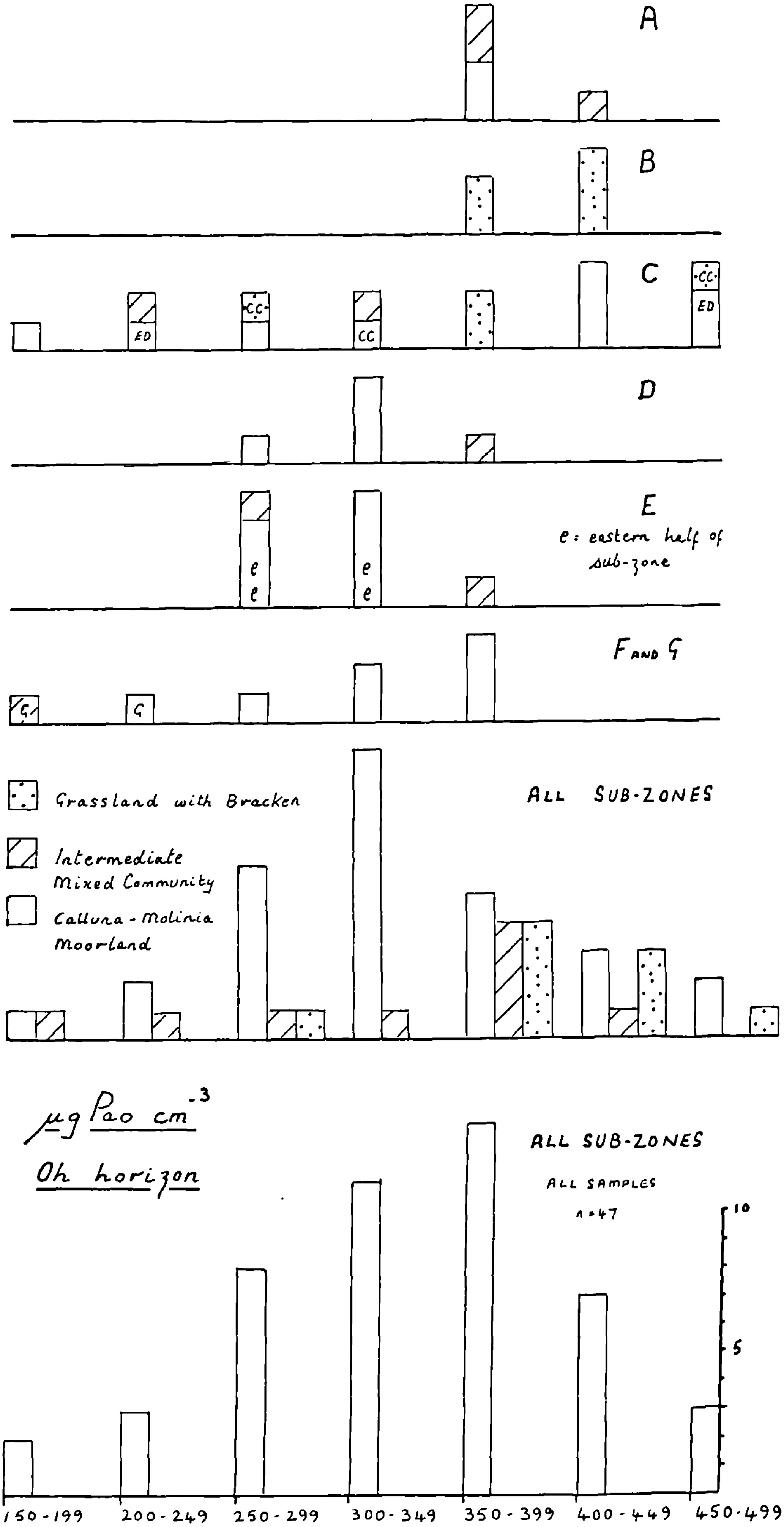


Fig. 5.162 Zone A - Histograms: $\mu gPao\ cm^{-3}$ in Oh horizon by sub-zones and vegetation groups

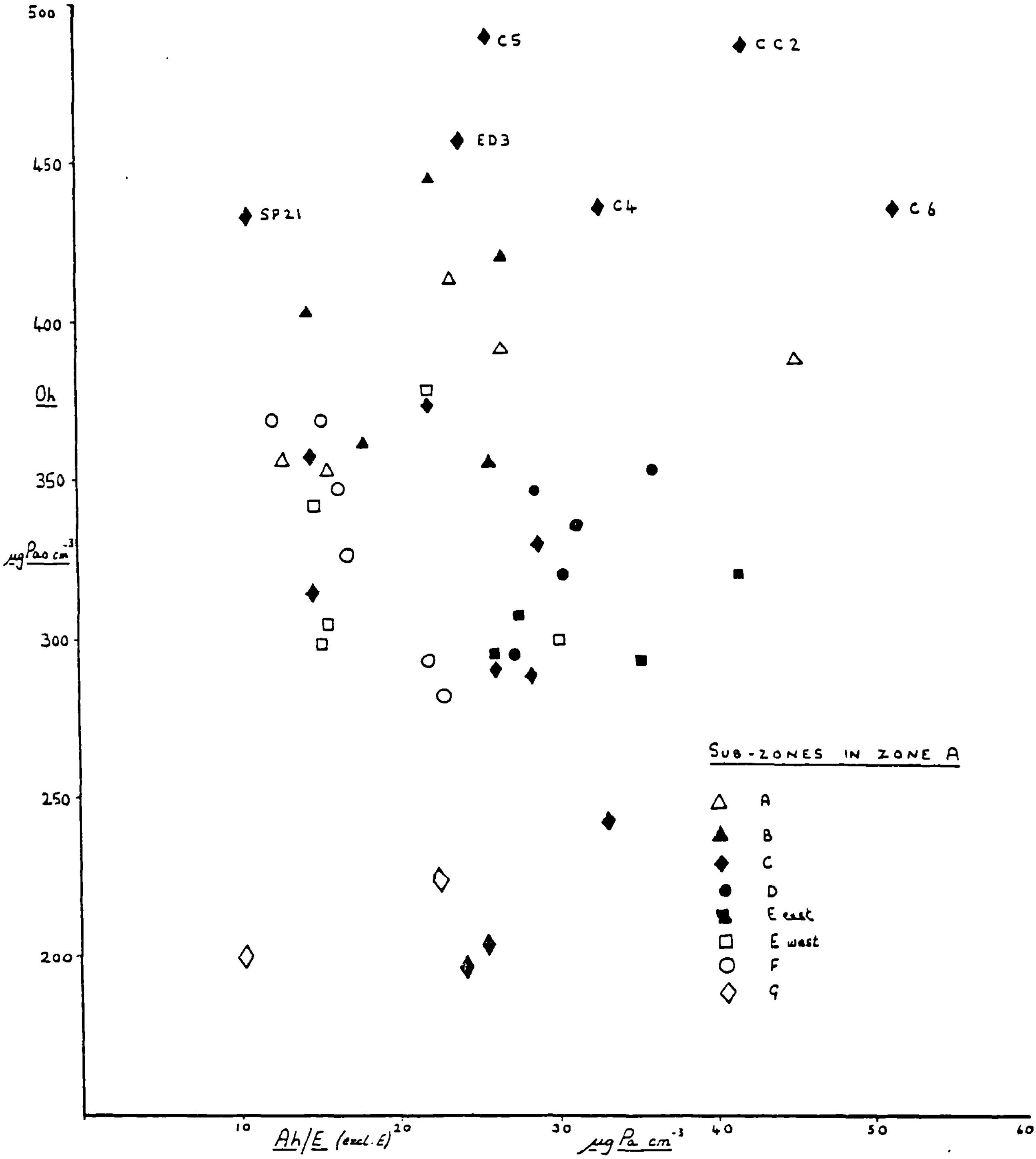


Fig. 5.163 Zone A - Scattergram: µgPa cm^{-3} in Ah/E horizon / µgPao cm^{-3} in Oh horizon

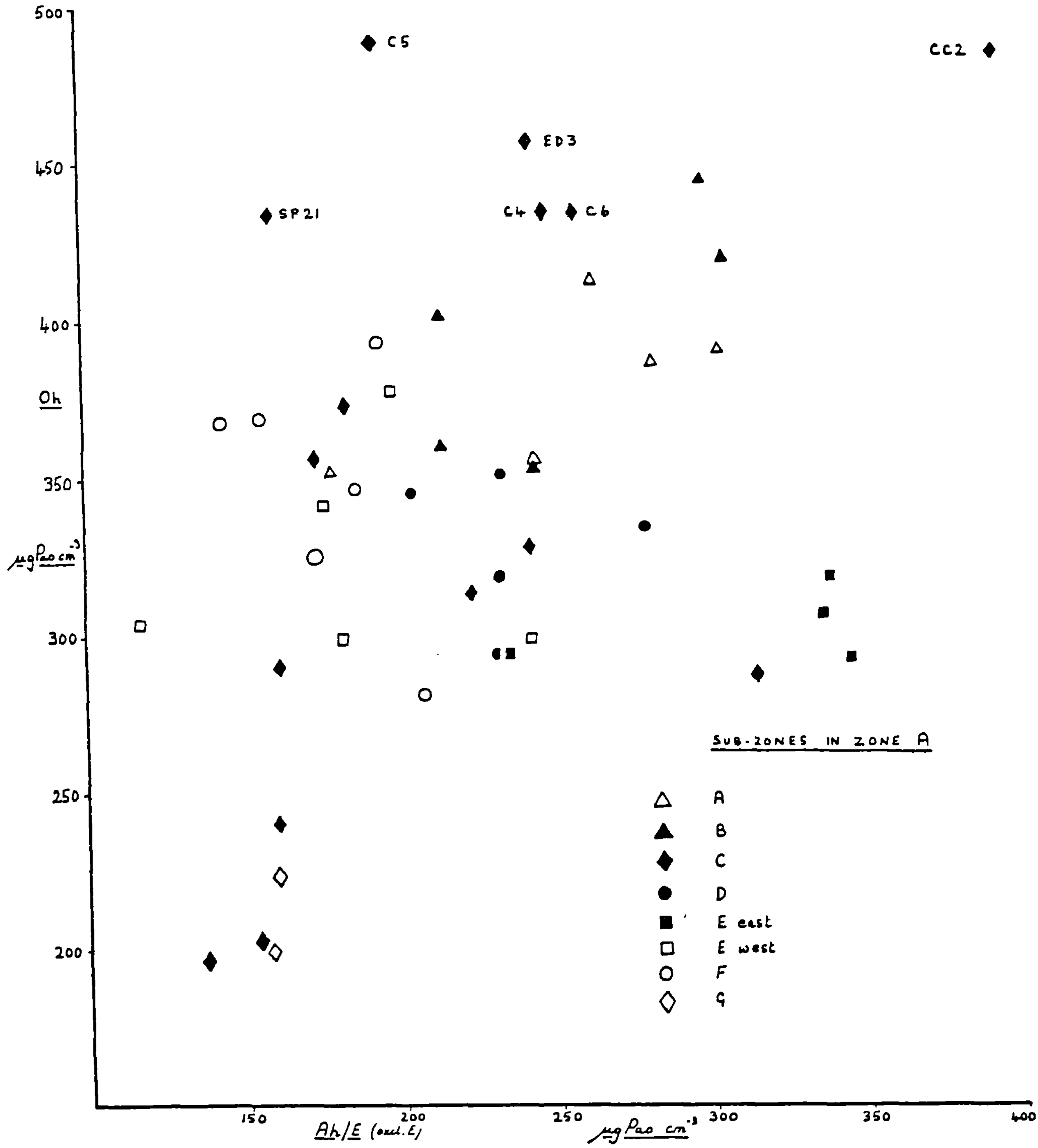


Fig. 5.164 Zone A - Scattergram: μgPao cm^{-3} in Ah/E horizon / μgPao cm^{-3} in Oh horizon

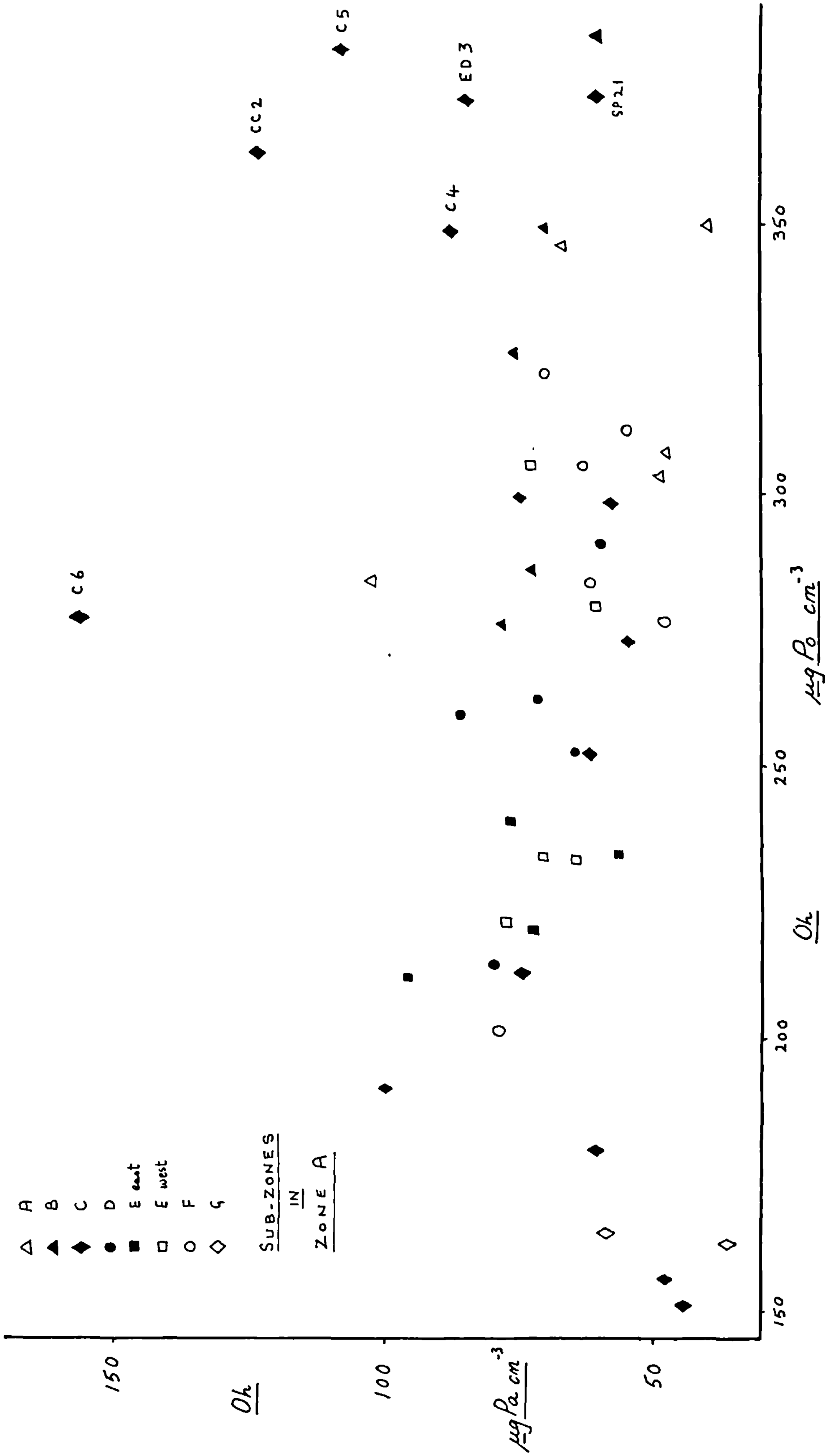


Fig. 5.165 Zone A - Scattergram: µgPo cm^{-3} in Oh horizon / µgPa cm^{-3} in Oh horizon

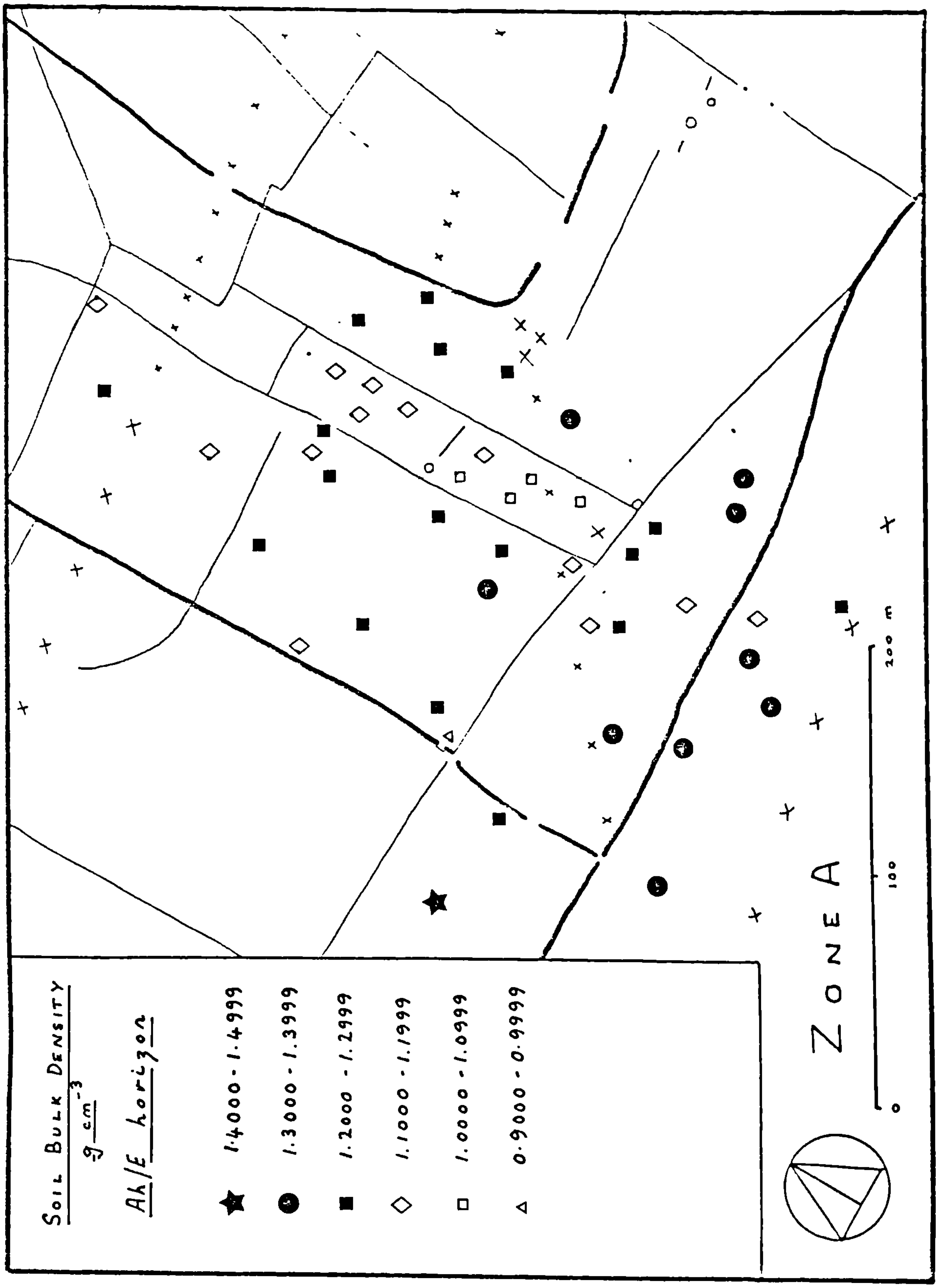

Soil Bulk Density
g cm-3
Ah/E horizon
1.4000 - 1.4999
1.3000 - 1.3999
1.2000 - 1.2999
1.1000 - 1.1999
1.0000 - 1.0999
0.9000 - 0.9999
Zone A
0
100
200 m

Fig. 5.166

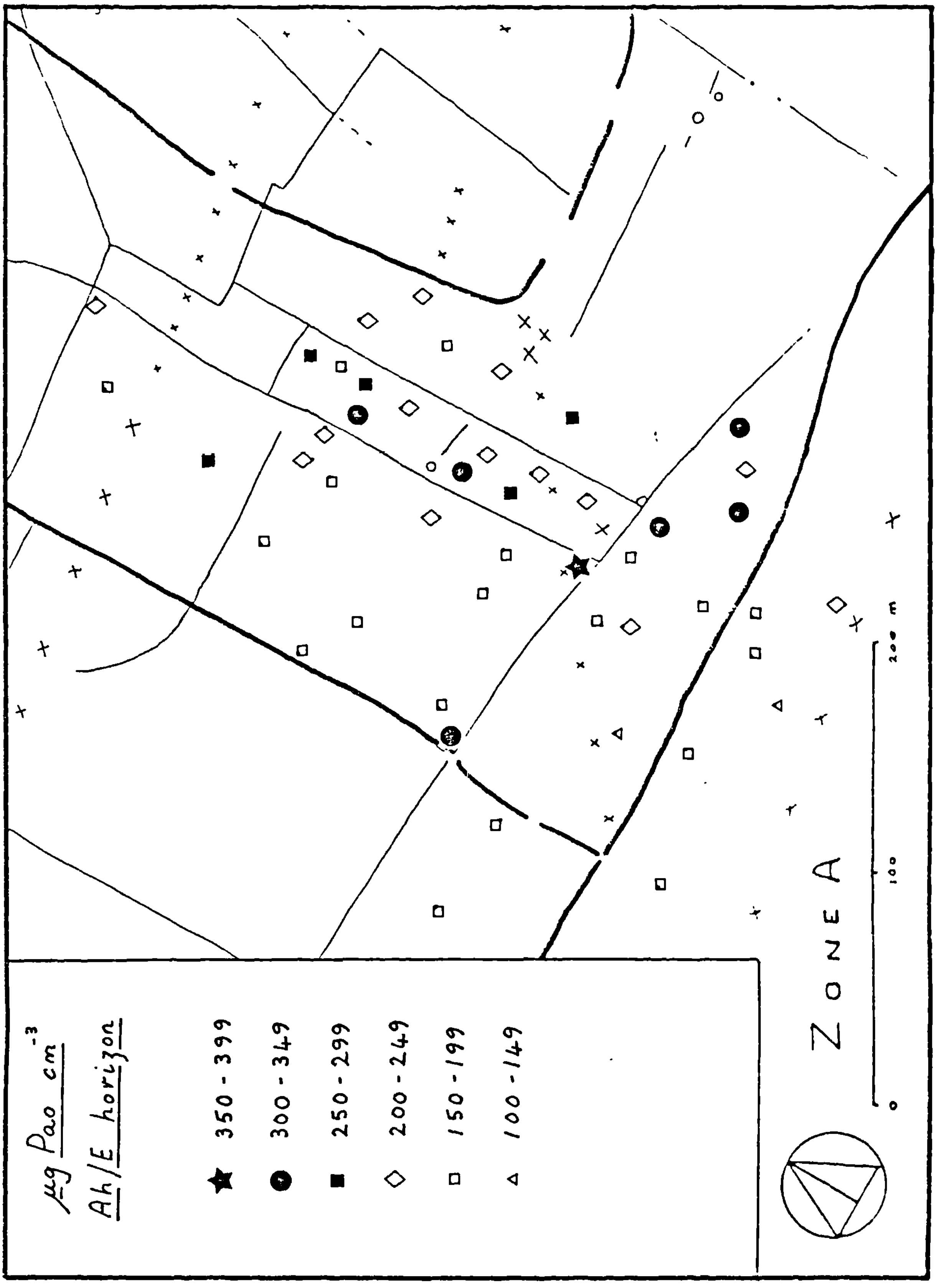

µg Pao cm-3
Ah/E horizon
350 - 399
300 - 349
250 - 299
200 - 249
150 - 199
100 - 149
ZONE A
0
100
200 m

Fig. 5.167

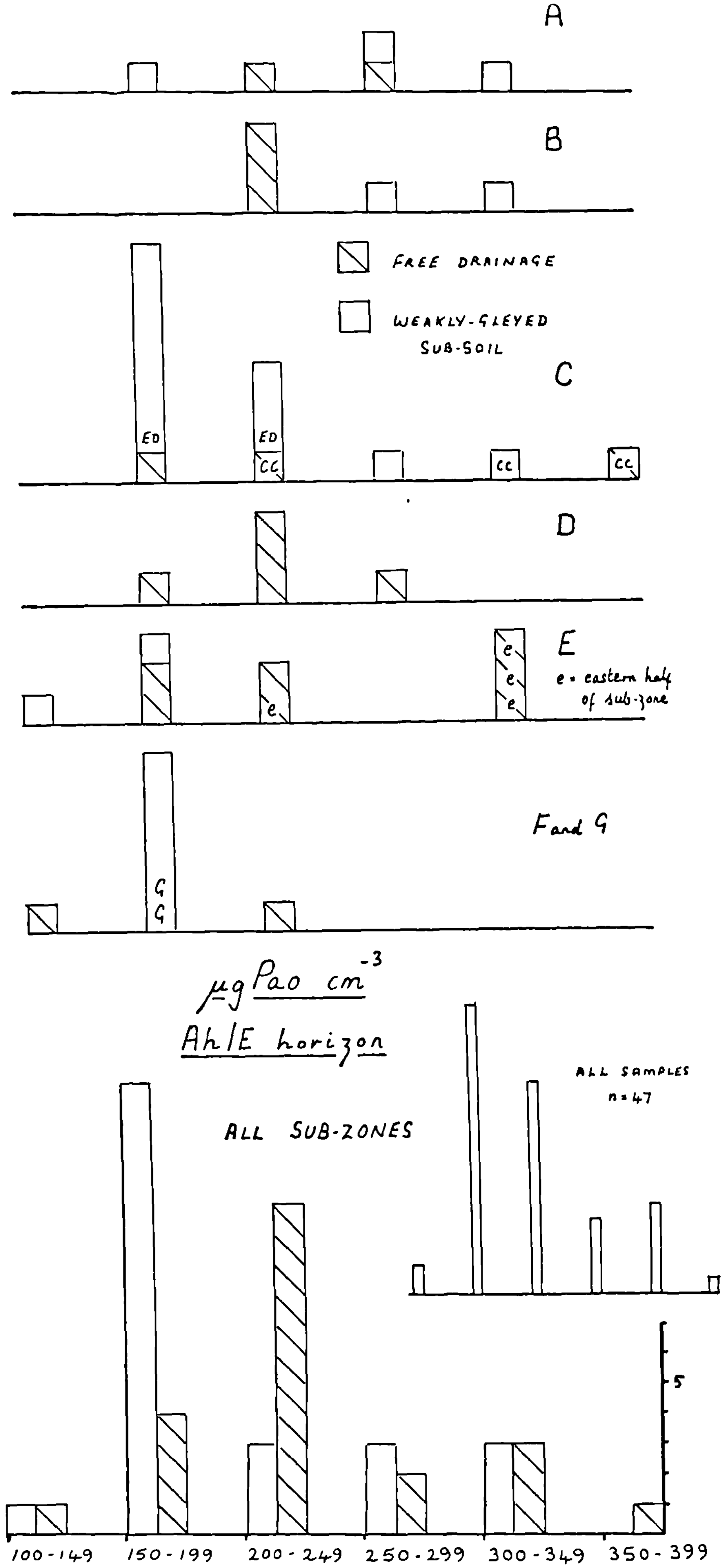


Fig. 5.168 Zone A - Histograms: μgPao cm^{-3} in Ah/E horizon by sub-zones and soil drainage groups

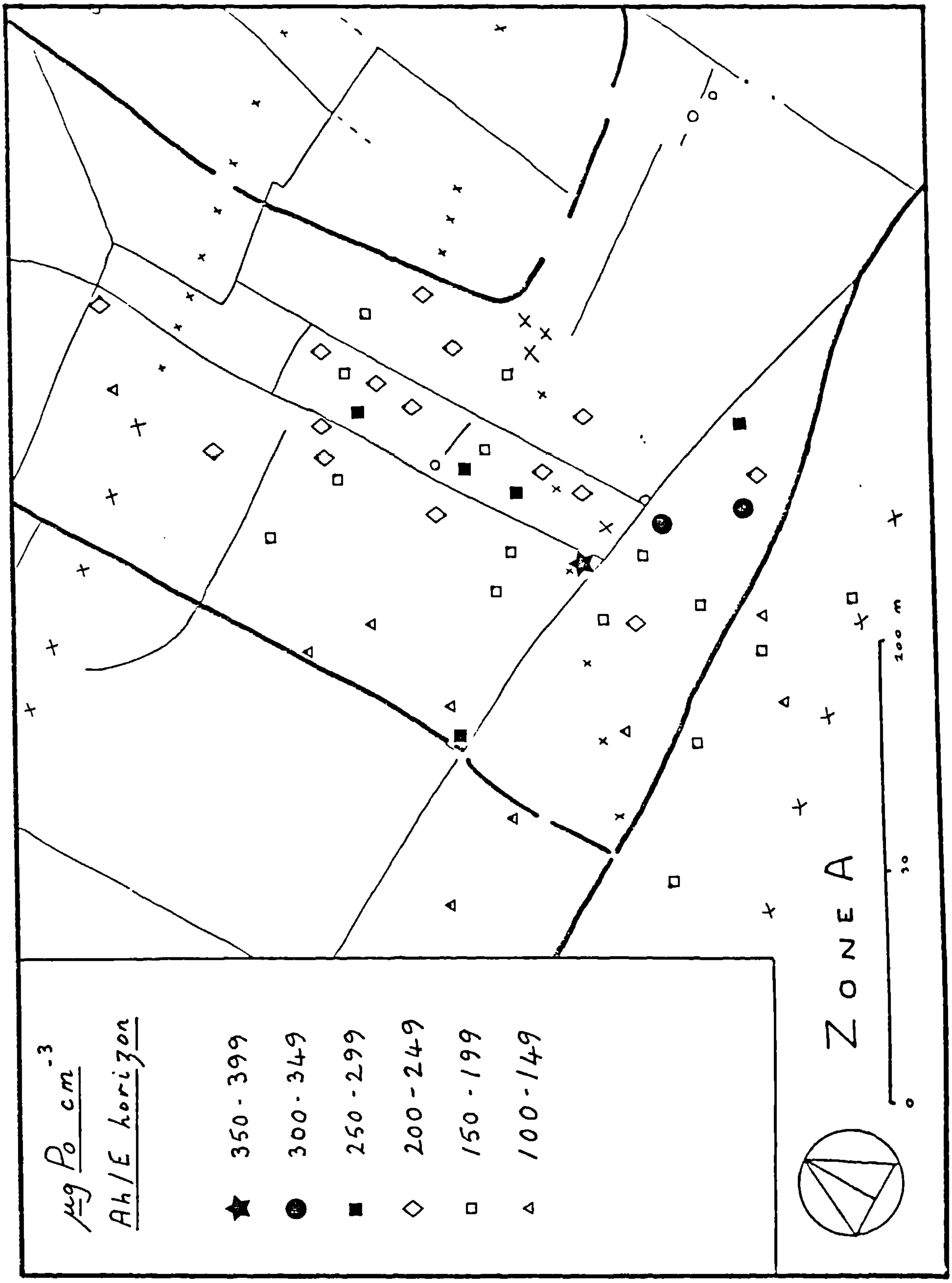

μg Po cm-3
Ah/E horizon
350 - 399
300 - 349
250 - 299
200 - 249
150 - 199
100 - 149
ZONE A

Fig. 5.169

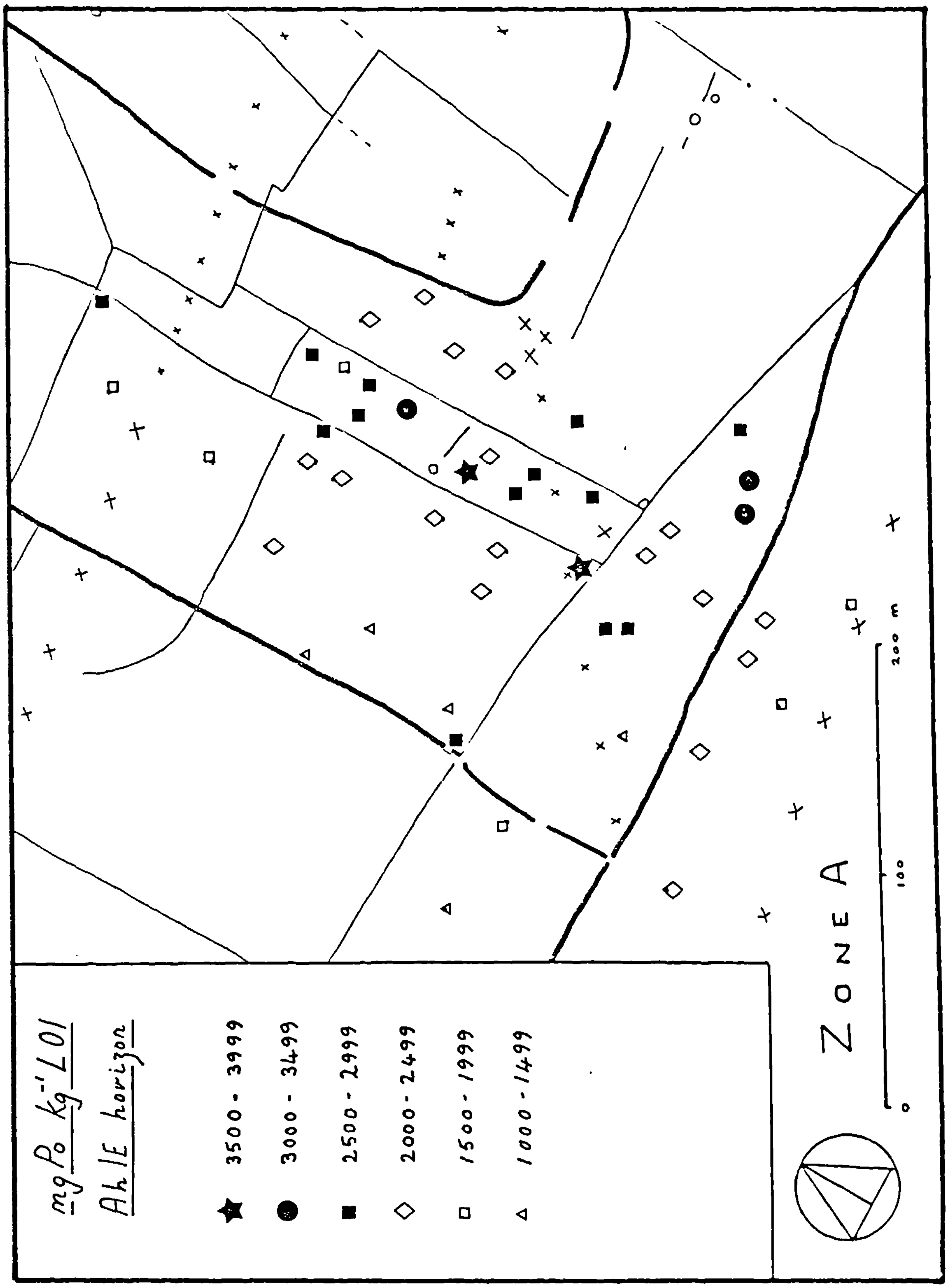

mg Po kg-1 LOI
Ah/E horizon
3500 - 3999
3000 - 3499
2500 - 2999
2000 - 2499
1500 - 1999
1000 - 1499
ZONE A
0
100
200 m

Fig. 5.170

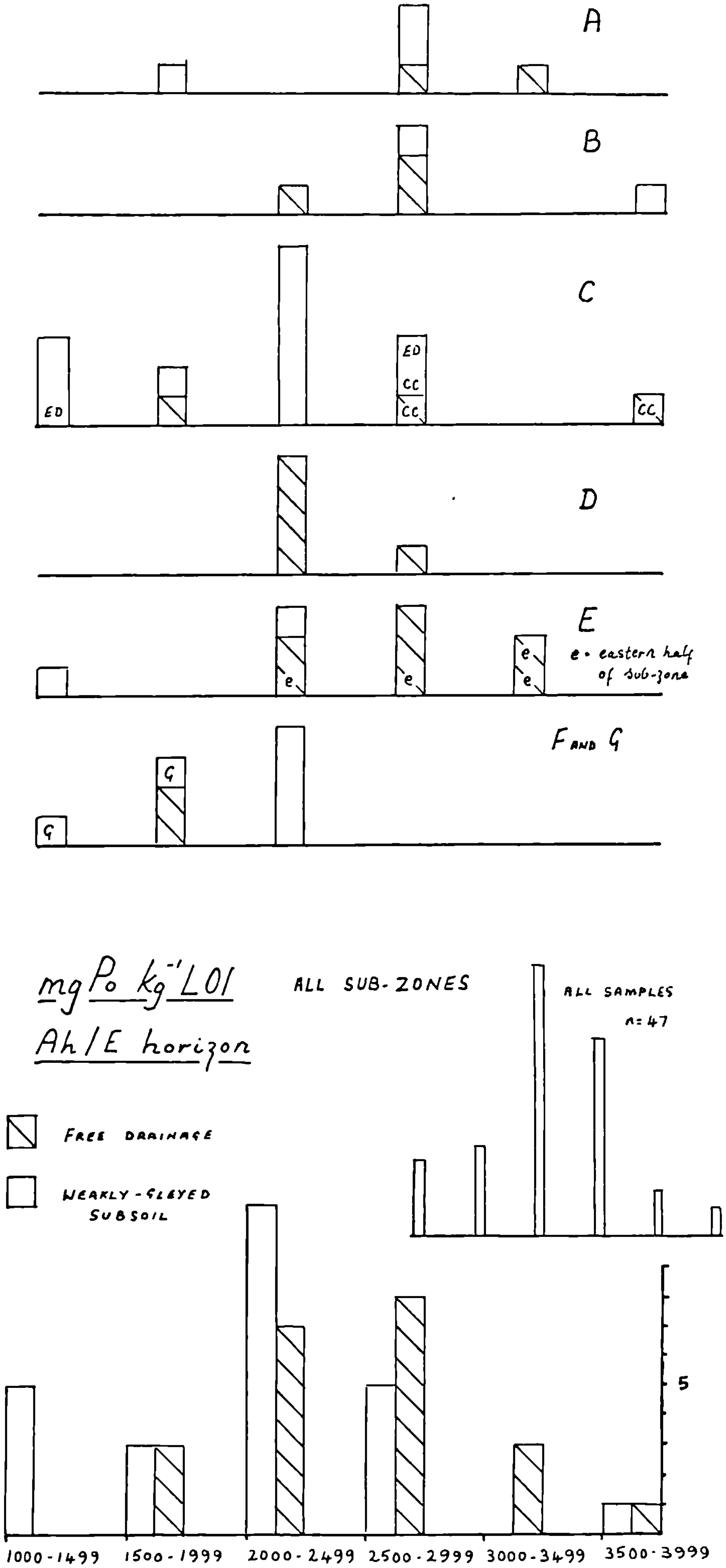
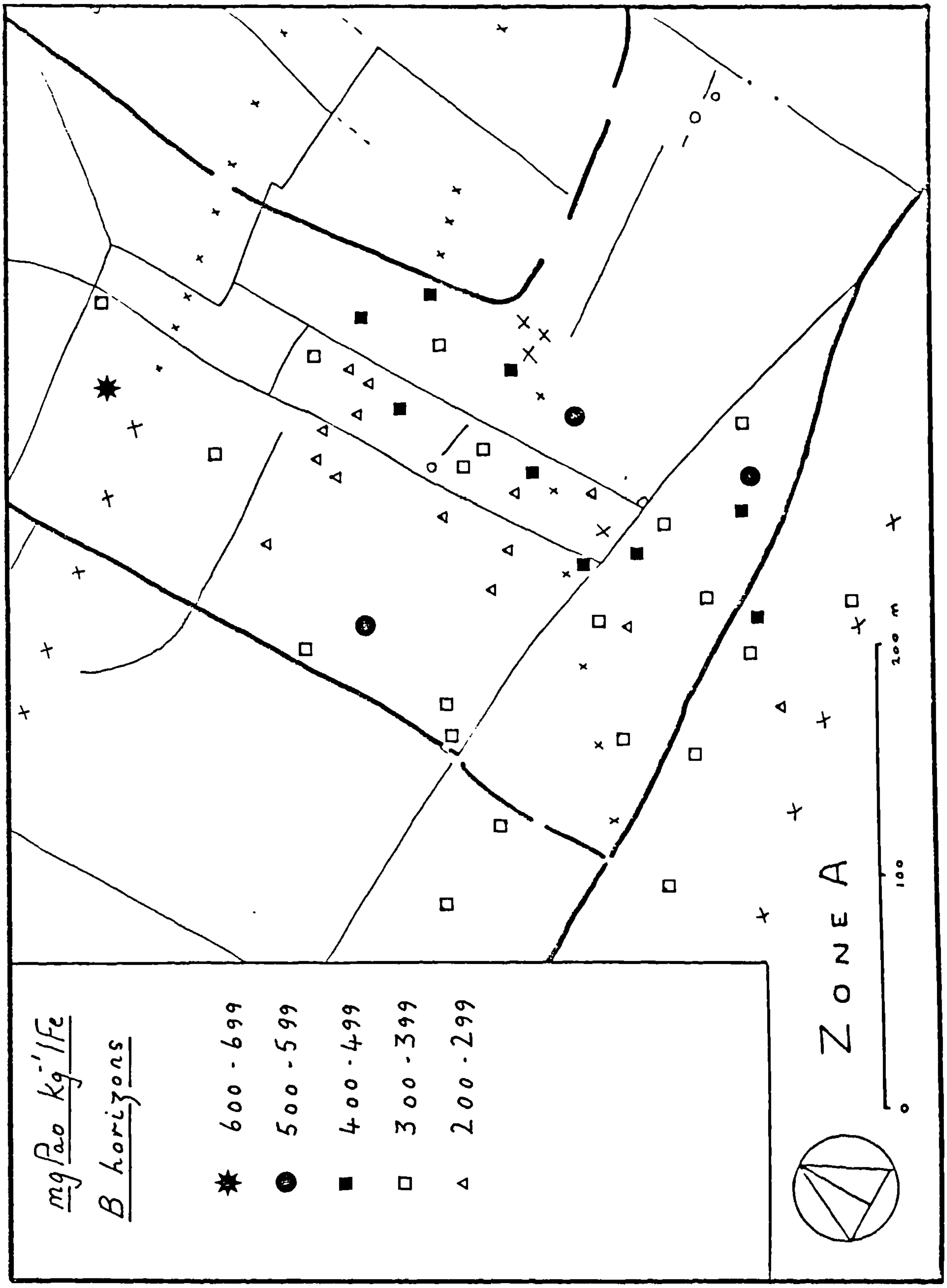


Fig. 5.171 Zone A - Histograms: mgPo kg^{-1} LOI in Ah/E horizon by sub-zones and soil drainage groups



mg Pao kg⁻¹ Fe
B horizons
600 - 699
500 - 599
400 - 499
300 - 399
200 - 299
ZONE A
0
100
200 m

Fig. 5.172

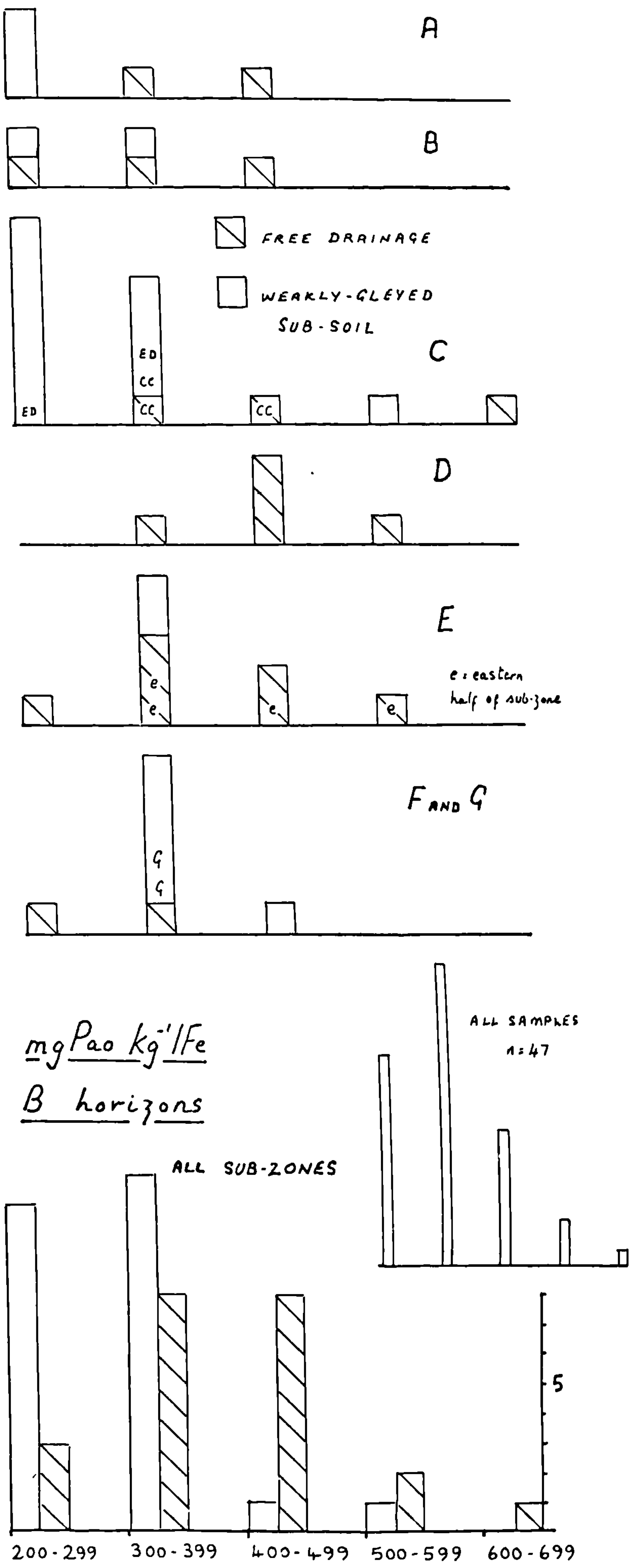


Fig. 5.173 Zone A - Histograms: mgPao kg^{-1}IFe in B horizons by sub-zones and soil drainage groups

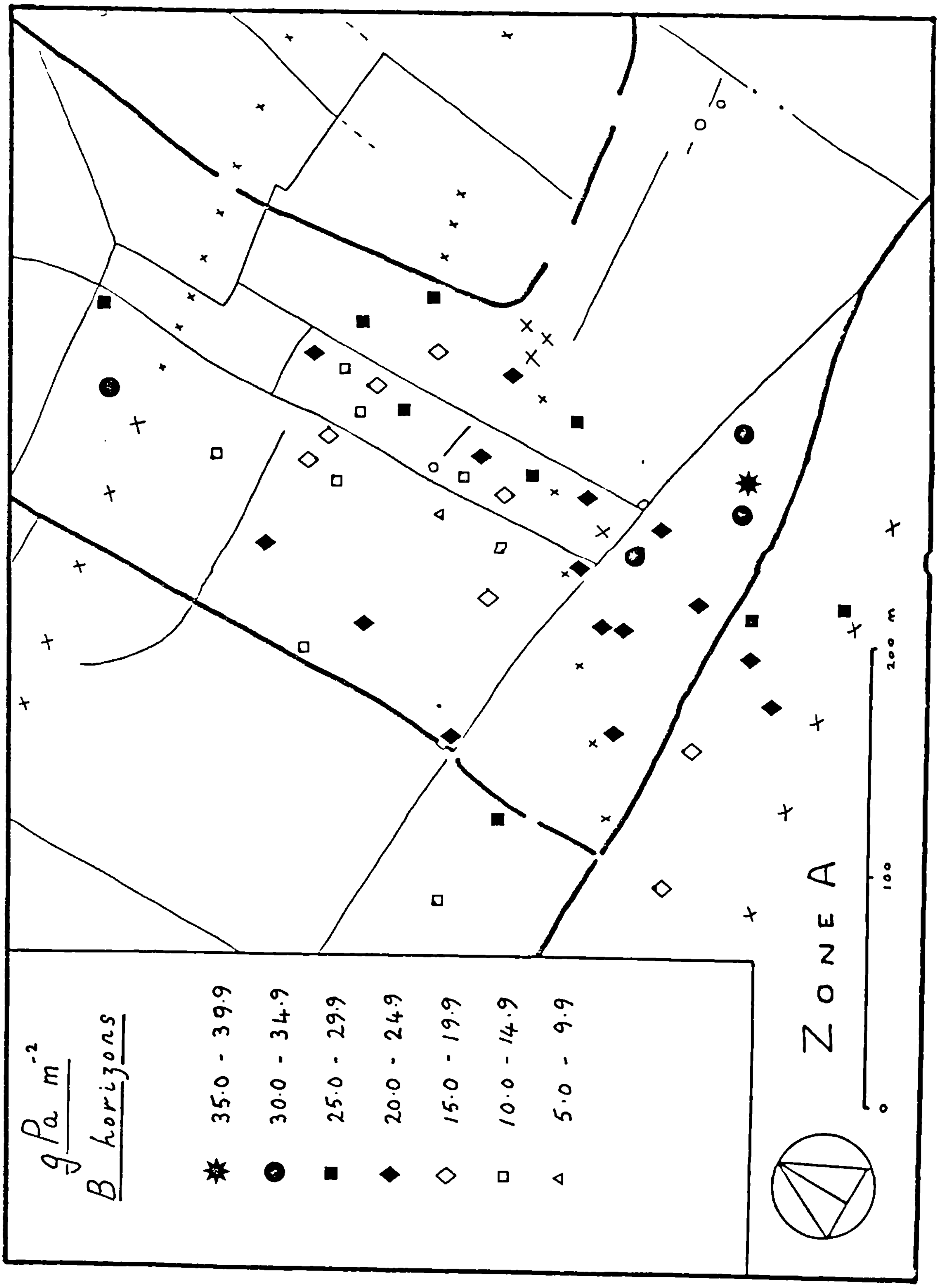

g Pa m-2
B horizons
35·0 - 39·9
30·0 - 34·9
25·0 - 29·9
20·0 - 24·9
15·0 - 19·9
10·0 - 14·9
5·0 - 9·9
ZONE A
0
100
200 m

Fig. 5.174

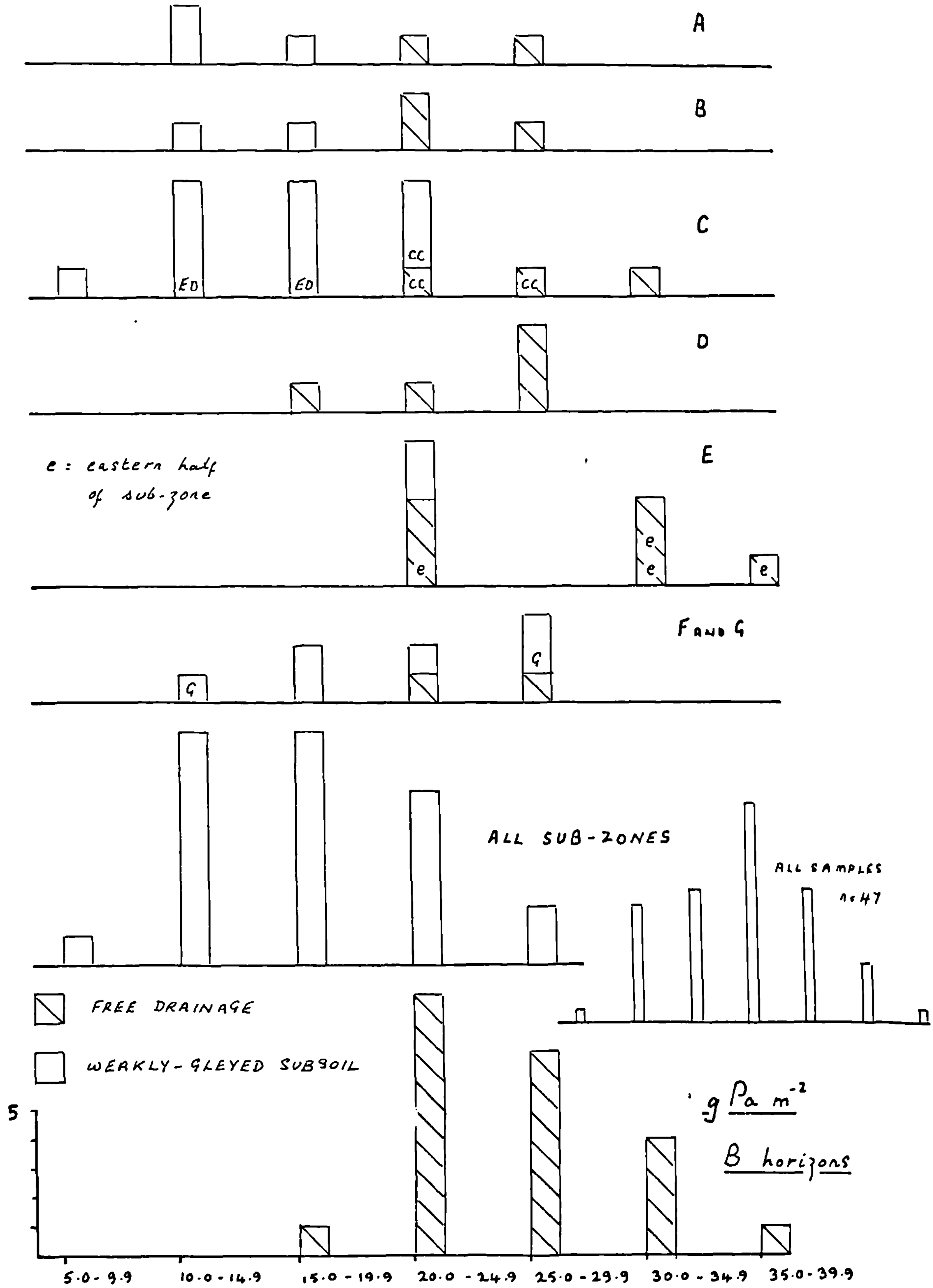


Fig.5.175 Zone A - Histograms: gPa m^{-2} in B horizons by sub-zones and soil drainage groups

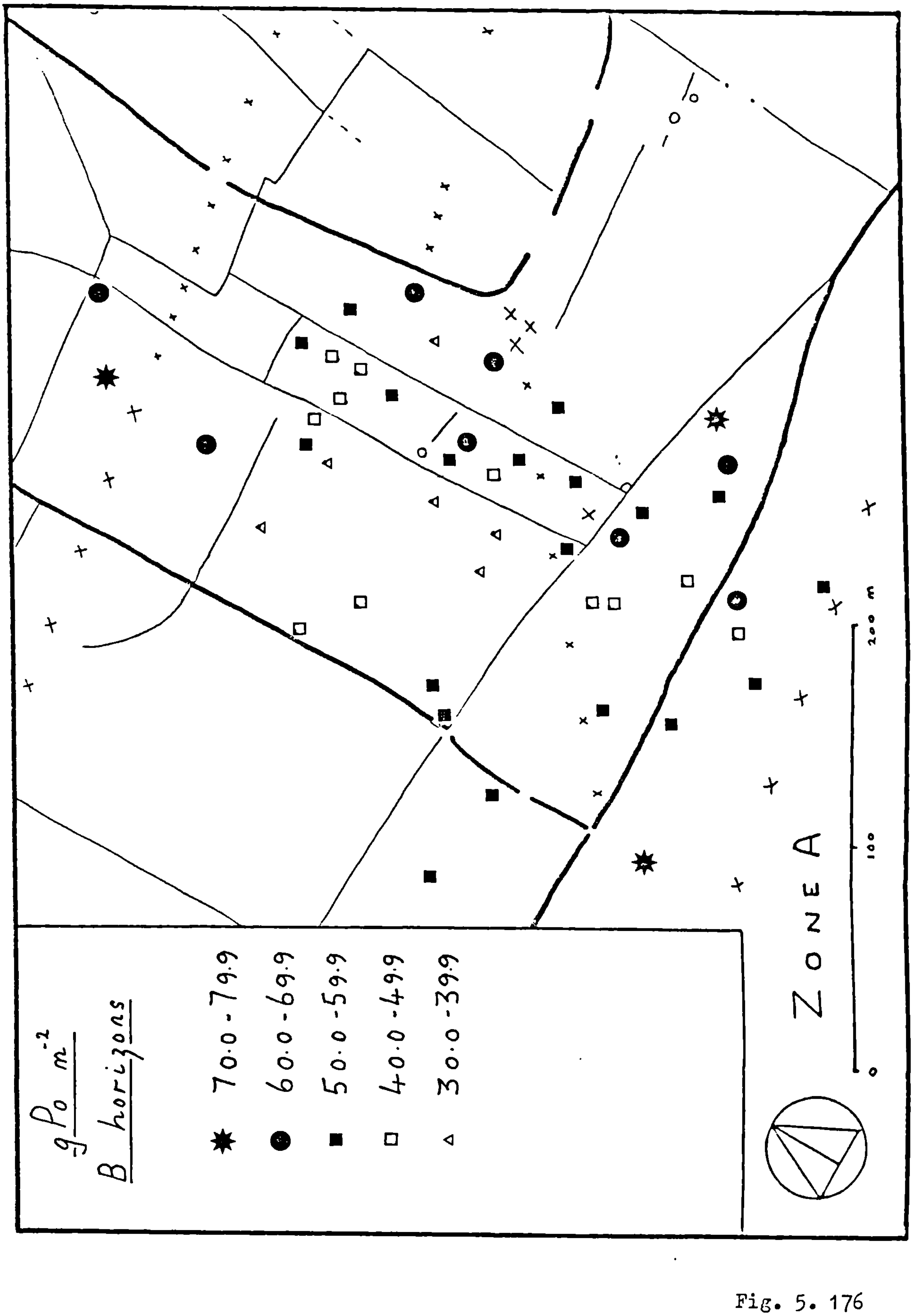

gPo m-2
B horizons
70.0-79.9
60.0-69.9
50.0-59.9
40.0-49.9
30.0-39.9
ZONE A
0
100
200 m

Fig. 5. 176

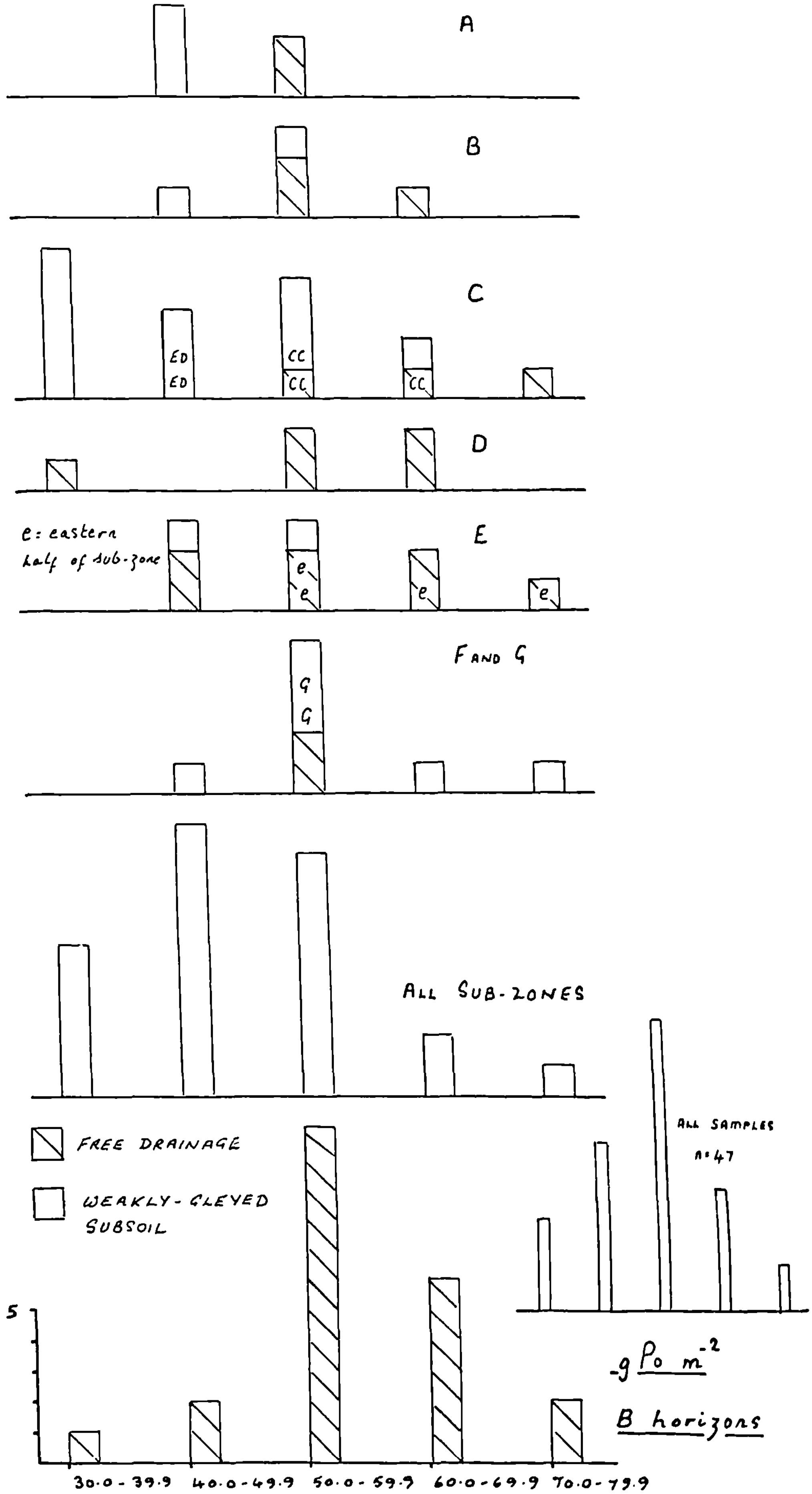


Fig. 5.177 Zone A - Histograms: gPo m^{-2} in B horizons by sub-zones and soil drainage groups

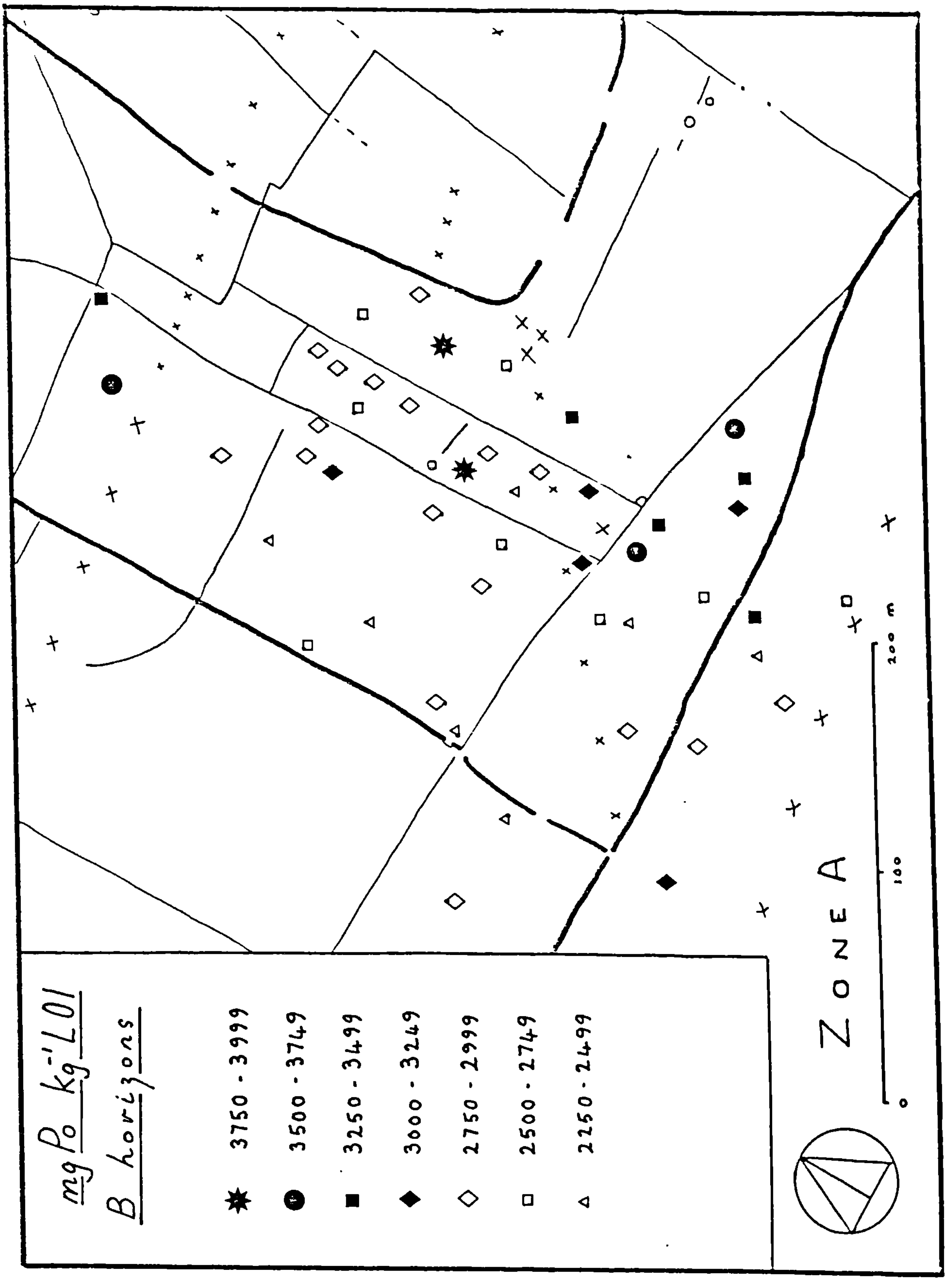

mg Po kg-1 LOI
B horizons
3750 - 3999
3500 - 3749
3250 - 3499
3000 - 3249
2750 - 2999
2500 - 2749
2250 - 2499
ZONE A
0
100
200 m

Fig. 5.178

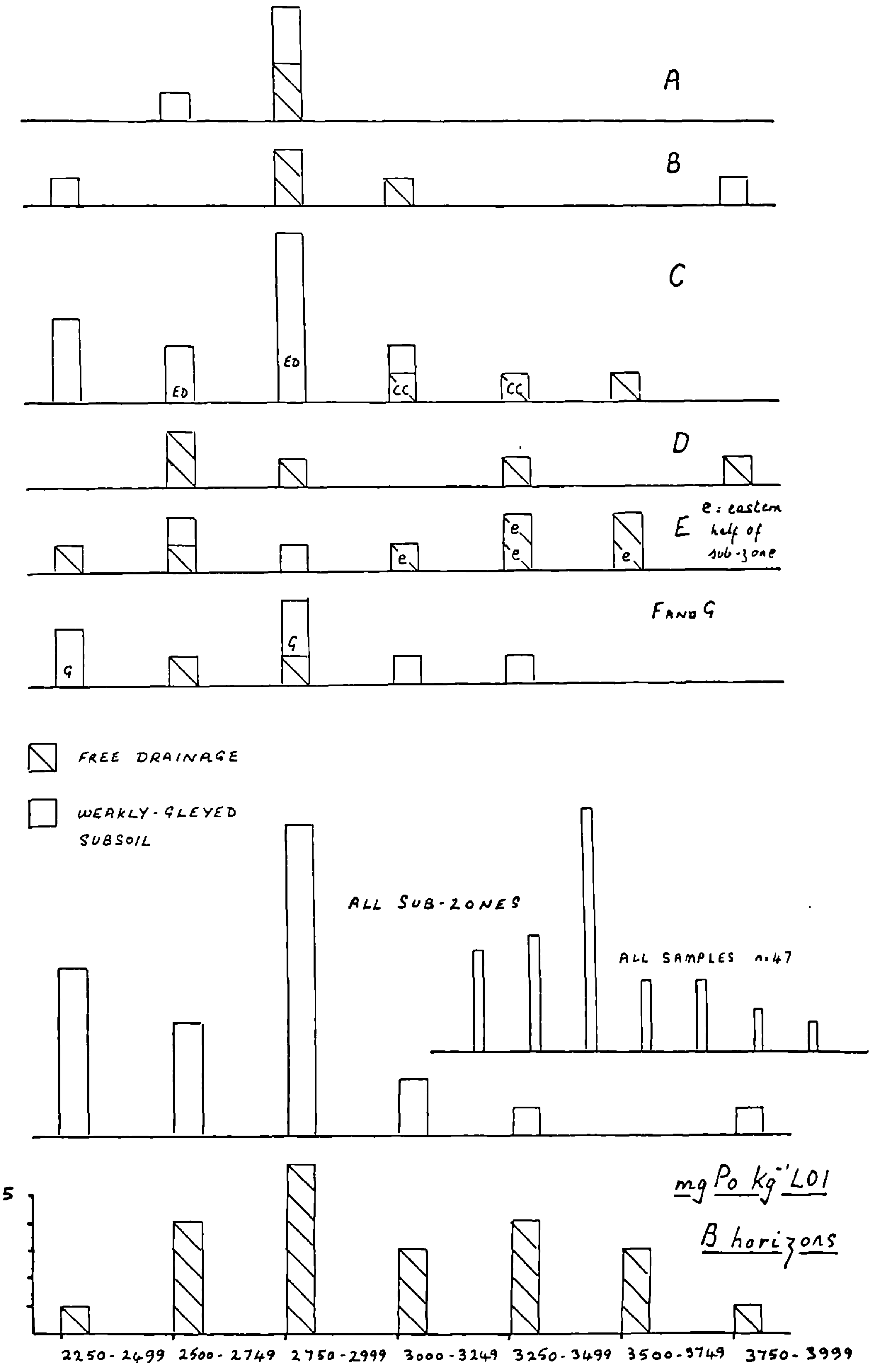


Fig. 5.179 Zone A - Histograms: mgPo kg^{-1} LOI in B horizons by sub-zones and soil drainage groups

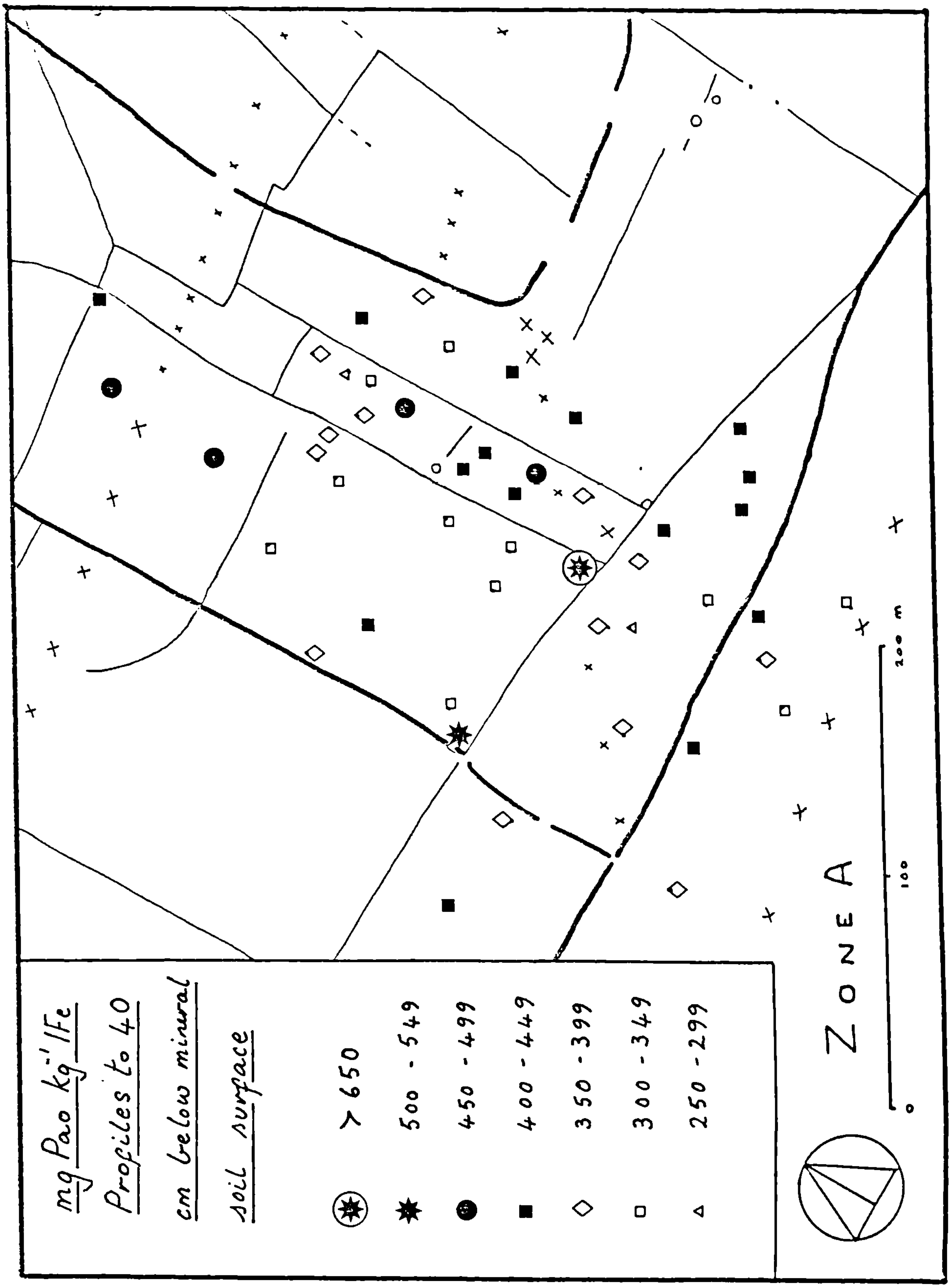
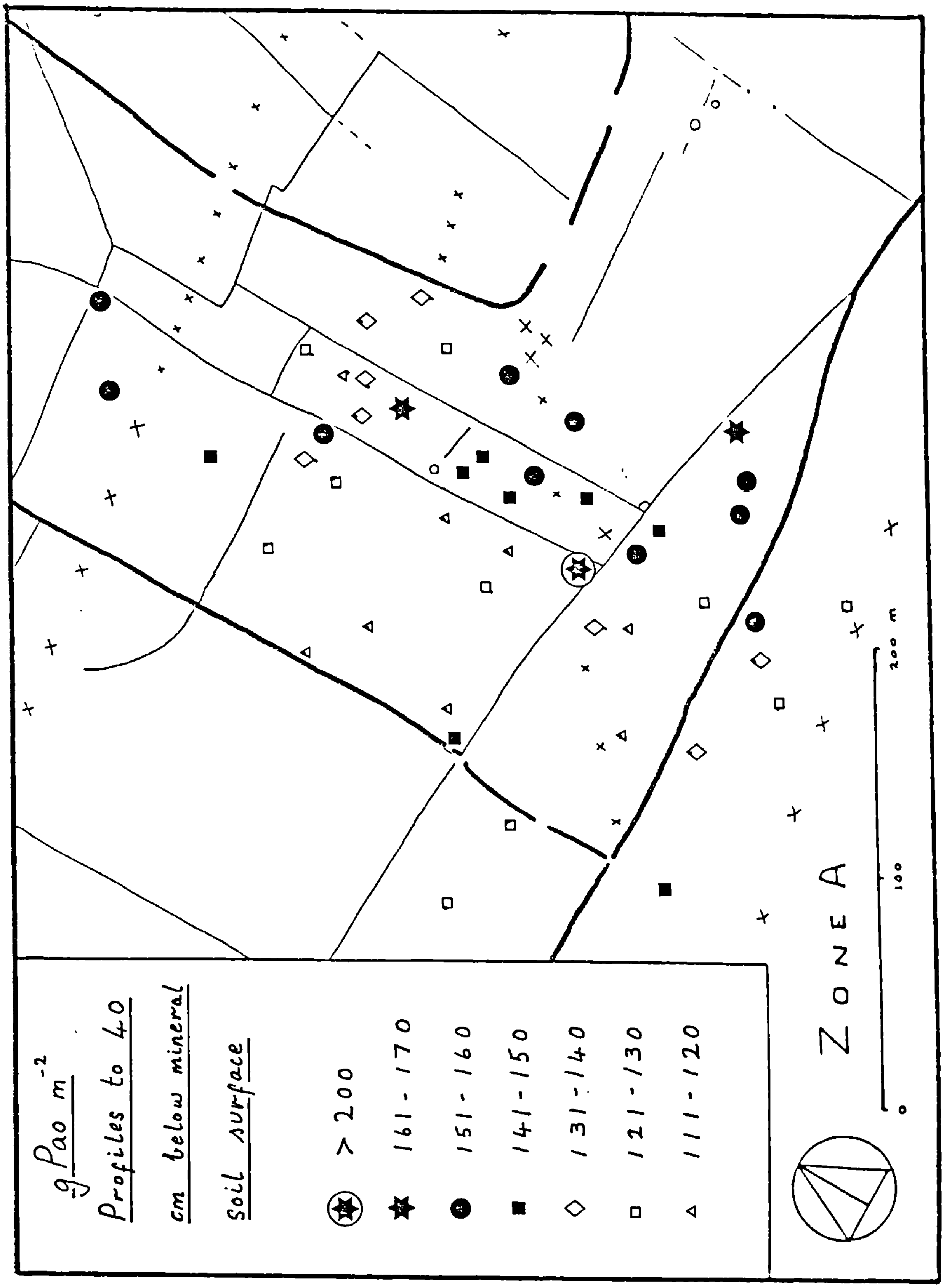

mg Pao kg-1 IFe
Profiles to 40
cm below mineral
soil surface
> 650
500 - 549
450 - 499
400 - 449
350 - 399
300 - 349
250 - 299
ZONE A
0
100
200 m

Fig. 5.180



gPao m-2
Profiles to 40 cm below mineral soil surface
> 200
161 - 170
151 - 160
141 - 150
131 - 140
121 - 130
111 - 120
ZONE A
0
100
200 m

Fig. 5.181

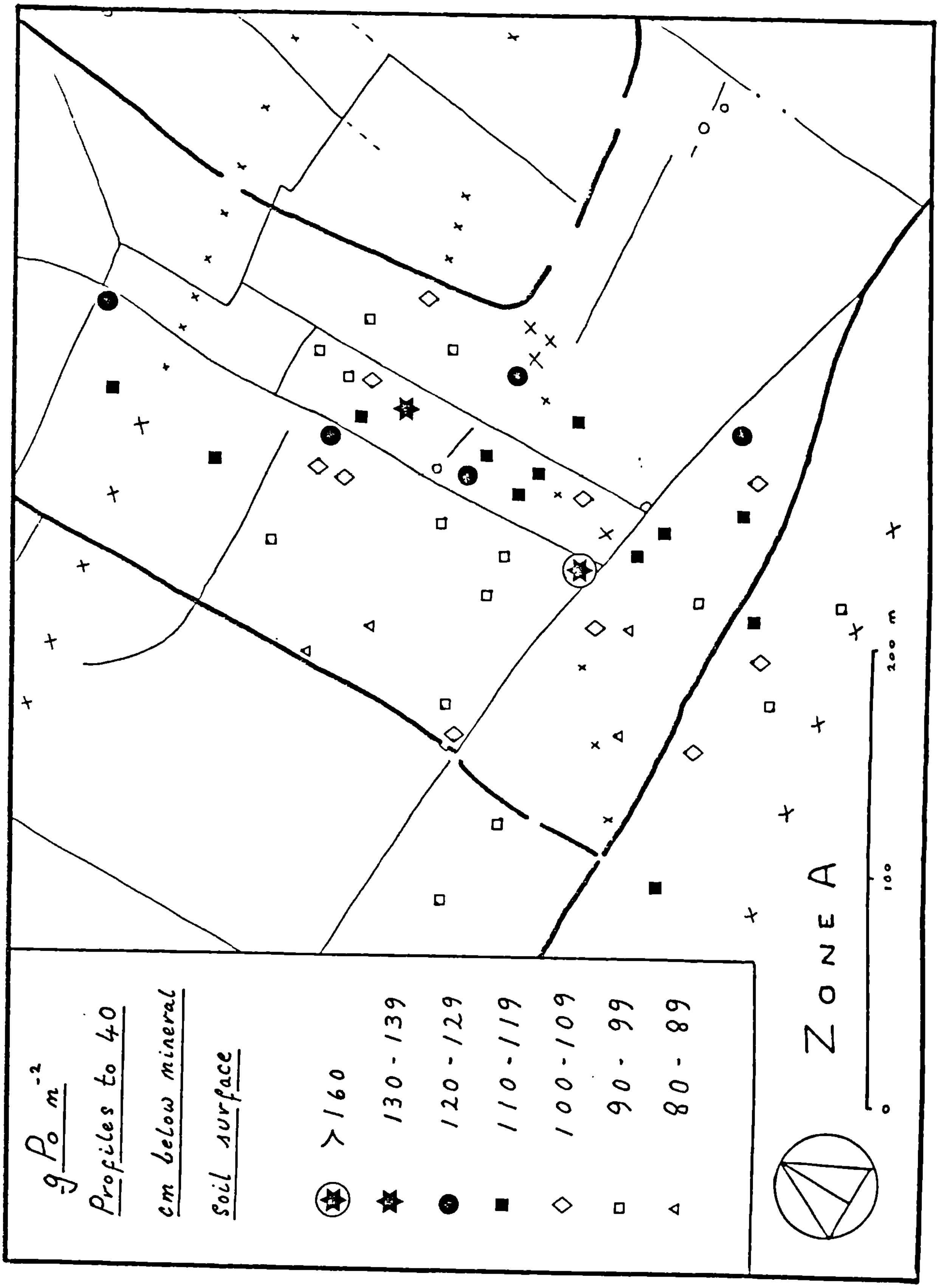

g Po m-2
Profiles to 40
cm below mineral
soil surface
>160
130 - 139
120 - 129
110 - 119
100 - 109
90 - 99
80 - 89
ZONE A
0
100
200 m

Fig. 5.182

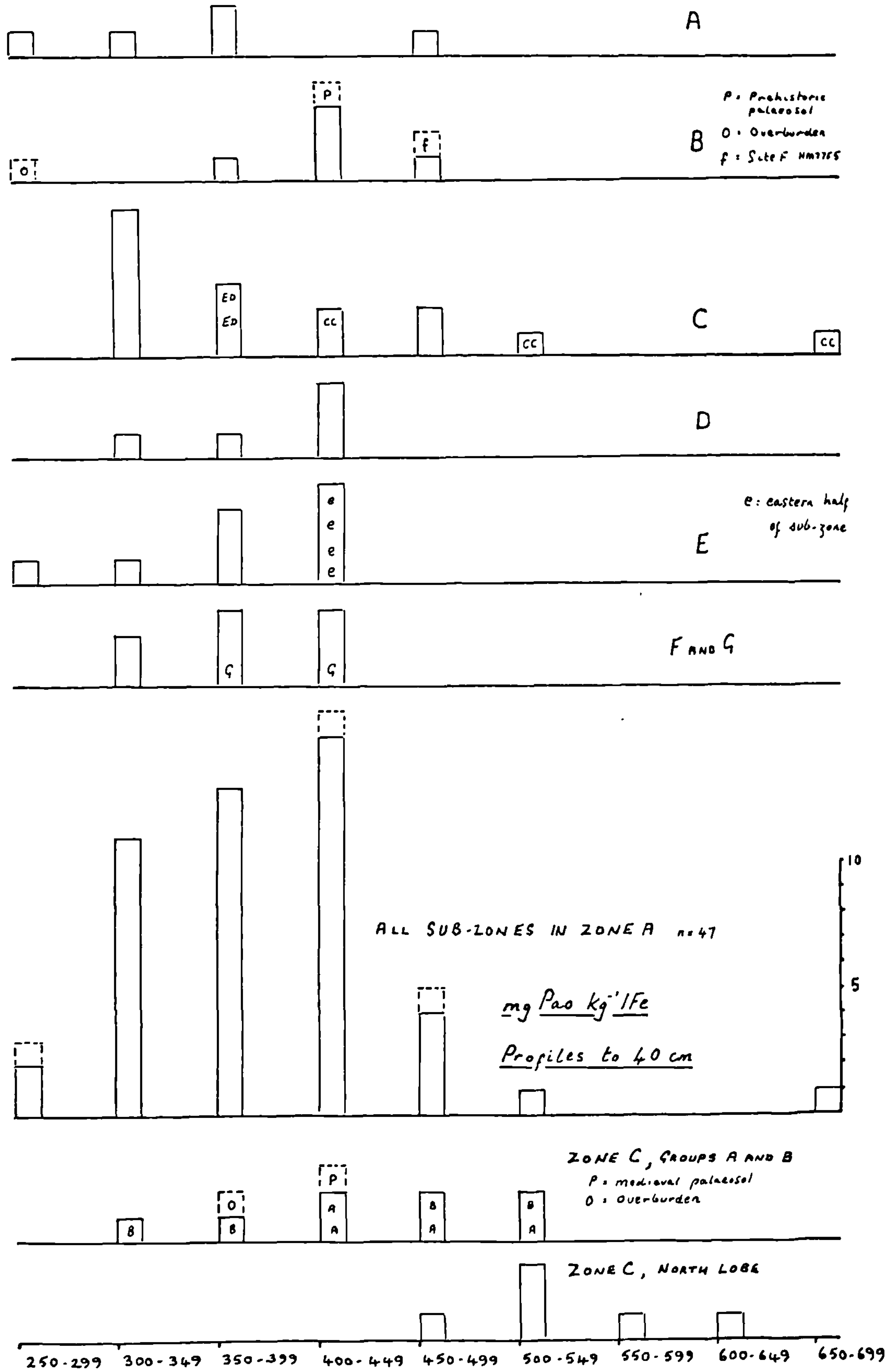


Fig. 5.183 Zone A and Zone C - Histograms: mgPao kg^{-1}IFe in profiles to a depth of 40 cm by sub-zones and groups

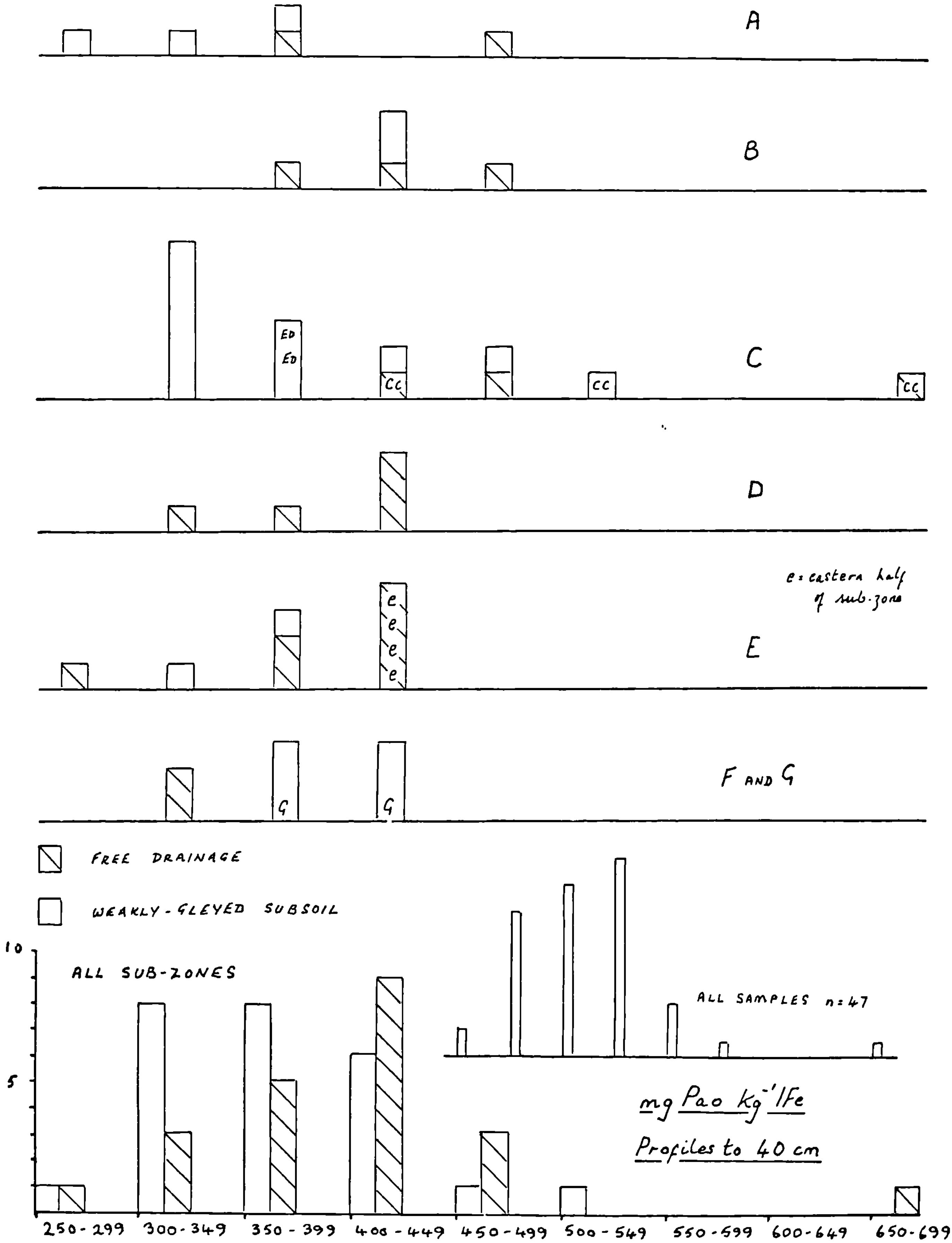


Fig. 5.184 Zone A - Histograms: mgPao kg^{-1} IFe in profiles to a depth of 40 cm by sub-zones and soil drainage groups

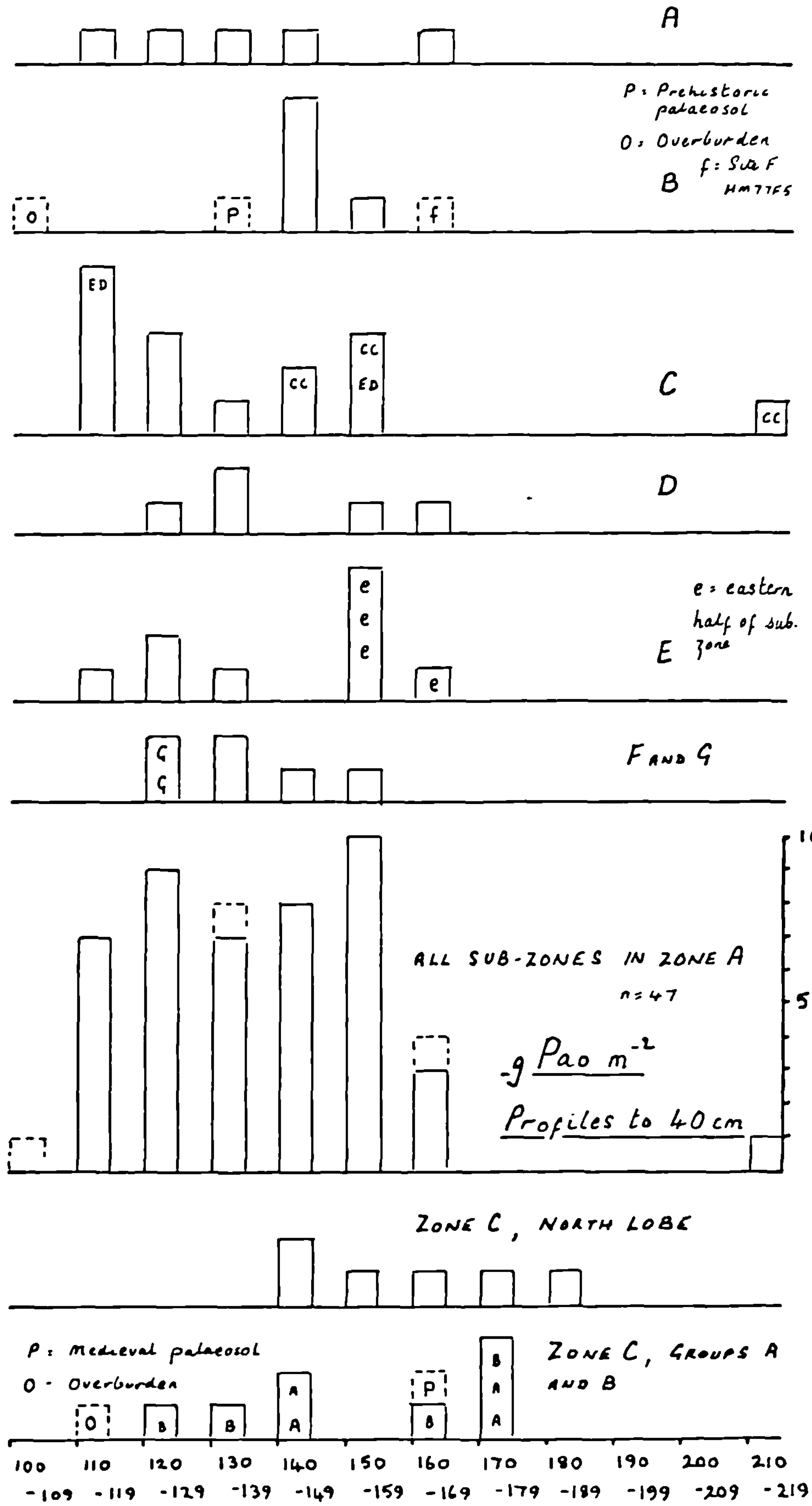


Fig. 5.1 5 Zone A and Zone C - Histograms: gPao m^{-2} in profiles to a depth of 40 cm by sub-zones and groups

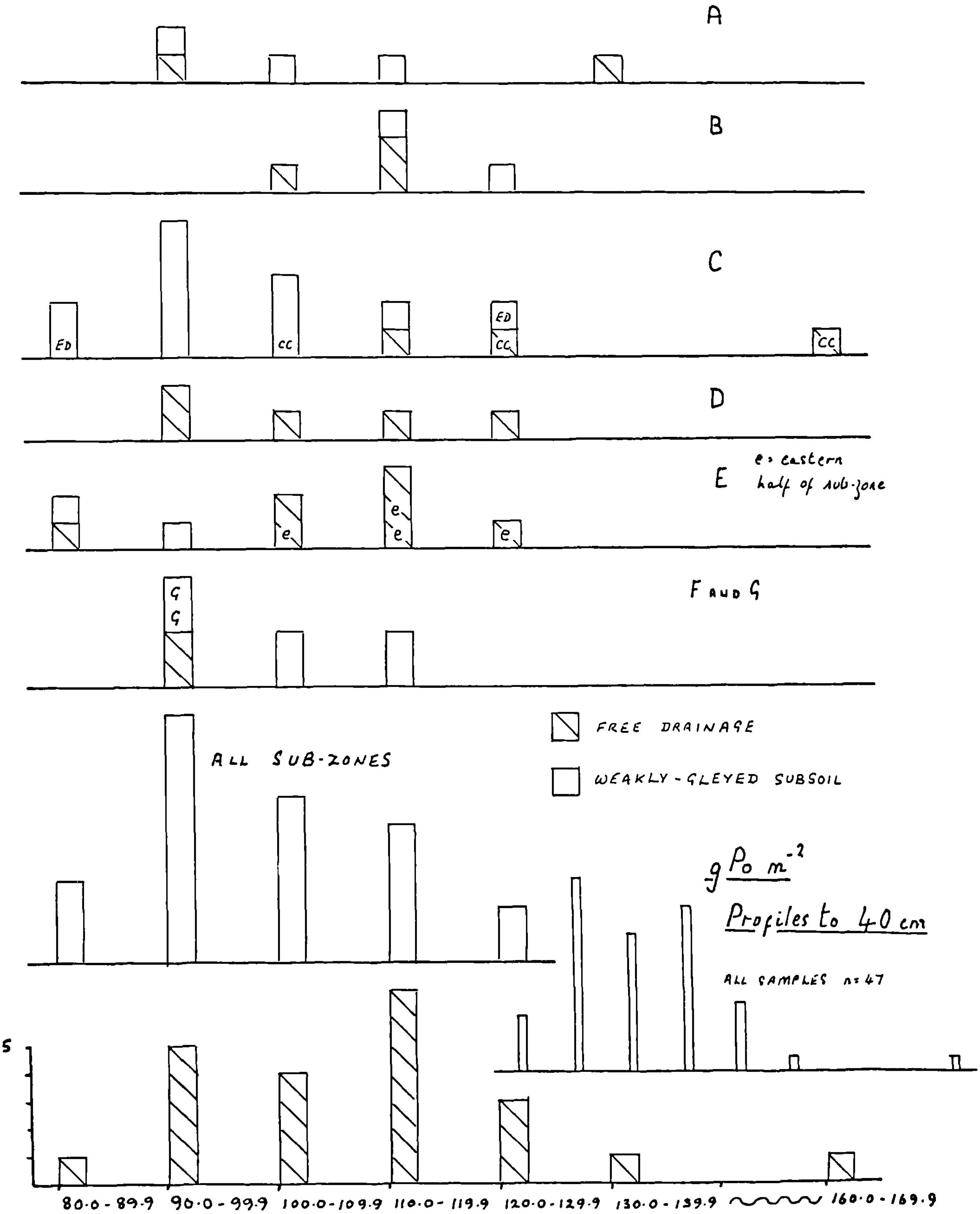


Fig. 5.186 Zone A - Histograms: gPo m^{-2} in profiles to a depth of 40 cm by sub-zones and soil drainage groups

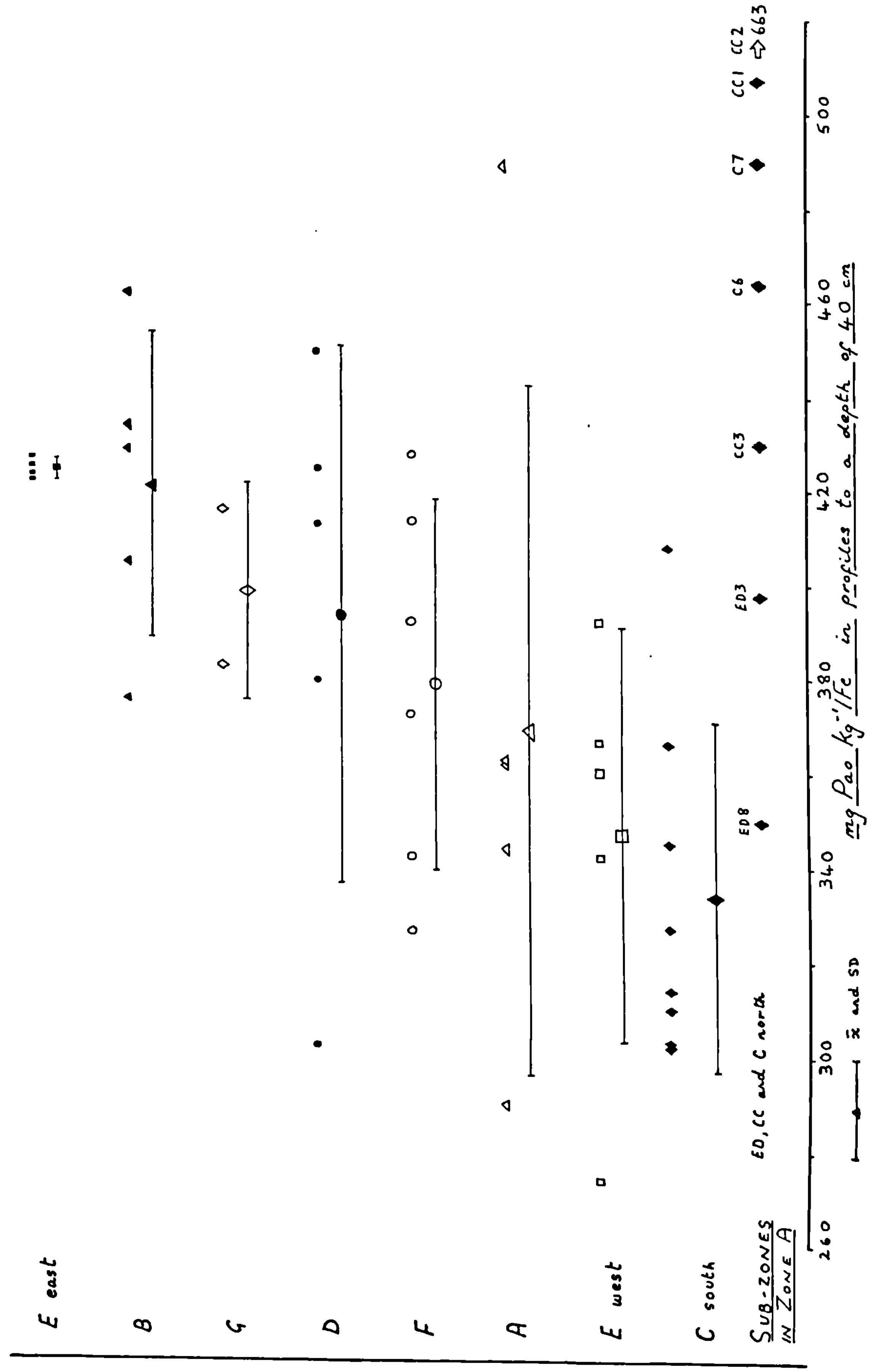


Fig. 5.187 Zone A - Diagram showing sub-zone $\bar{x}$ and SD: mg Pao kg^{-1}IFe in profiles to a depth of 40 cm

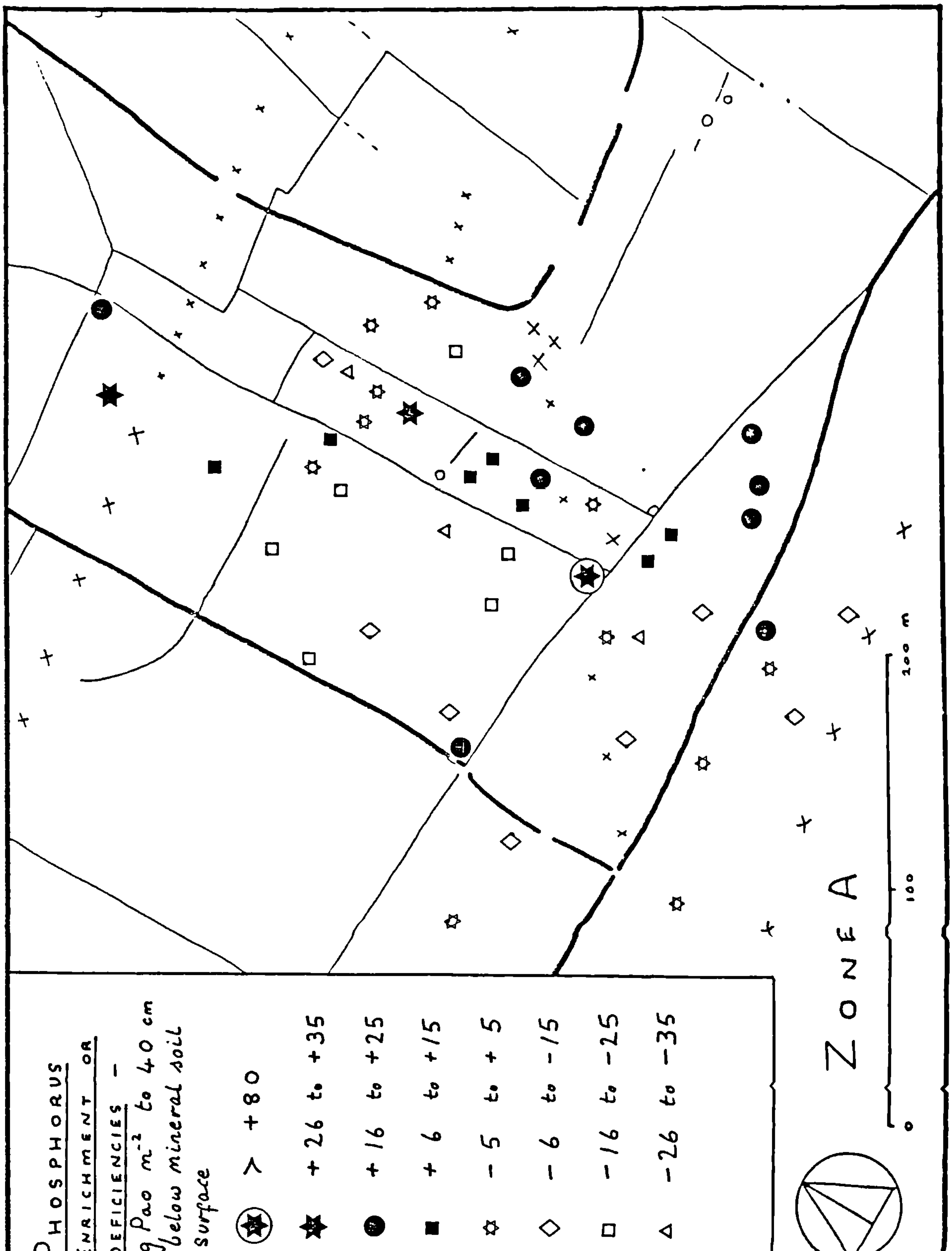

PHOSPHORUS
ENRICHMENT OR
DEFICIENCIES –
g Pa0 m-2 to 40 cm
below mineral soil
surface
> +80
+26 to +35
+16 to +25
+6 to +15
–5 to +5
–6 to –15
–16 to –25
–26 to –35
ZONE A
0
100
200 m

Fig. 5.188

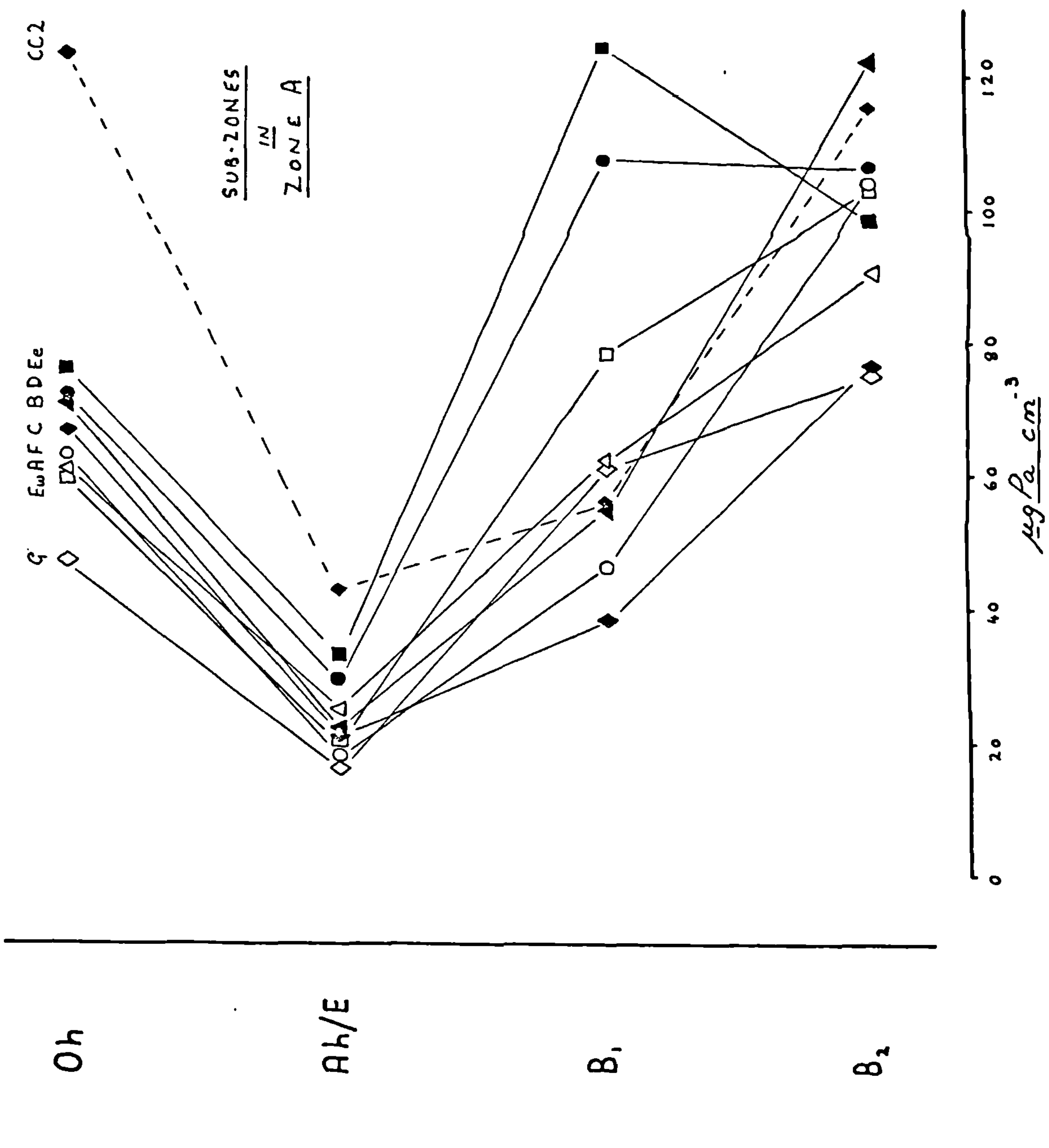


Fig. 5.189 Zone A - Vertical distribution, sub-zone $\bar{x}$: μgPa cm^{-3}

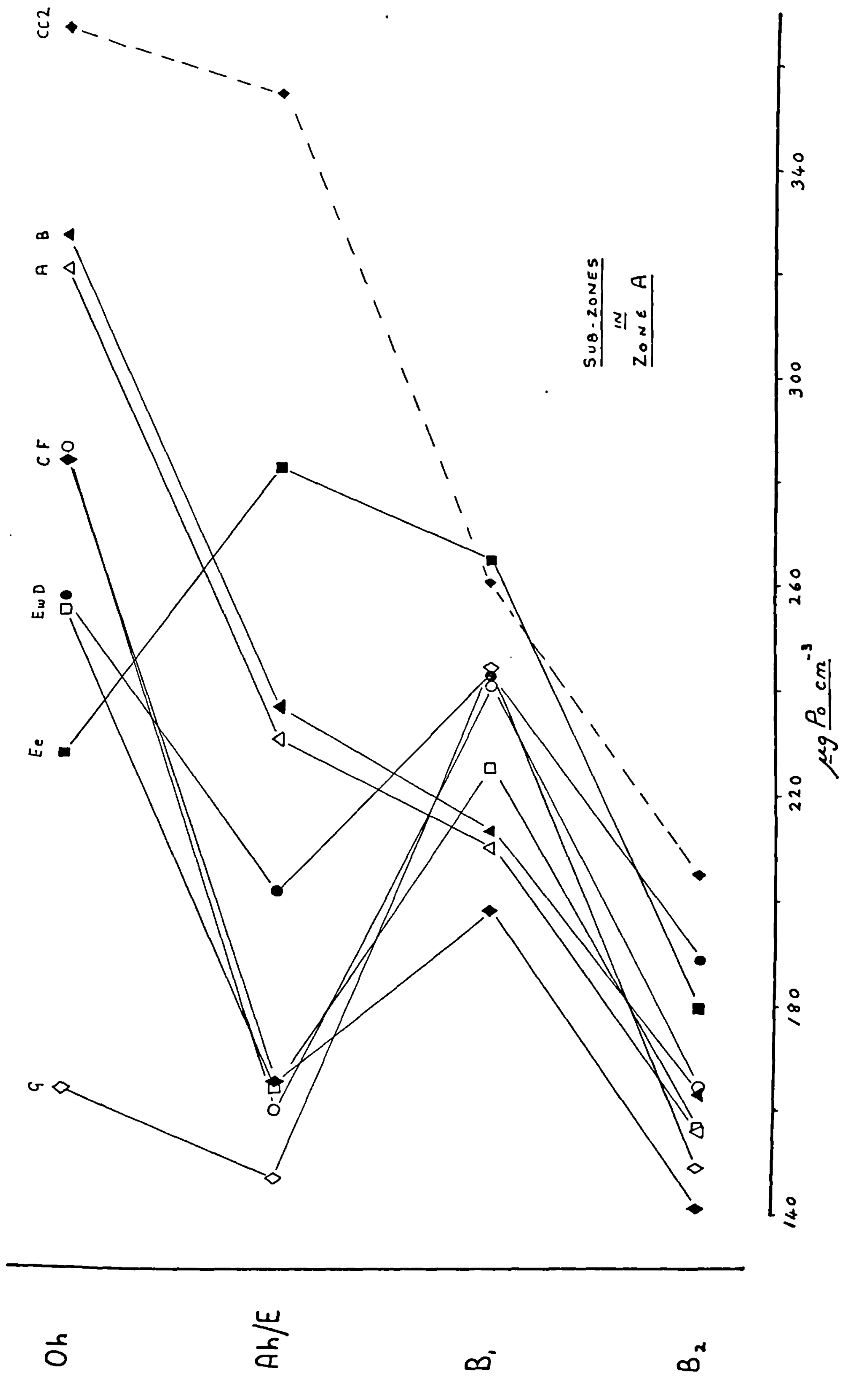


Fig. 5.190 Zone A - Vertical distribution, sub-zone $\bar{x}$: μgPo cm^{-3}

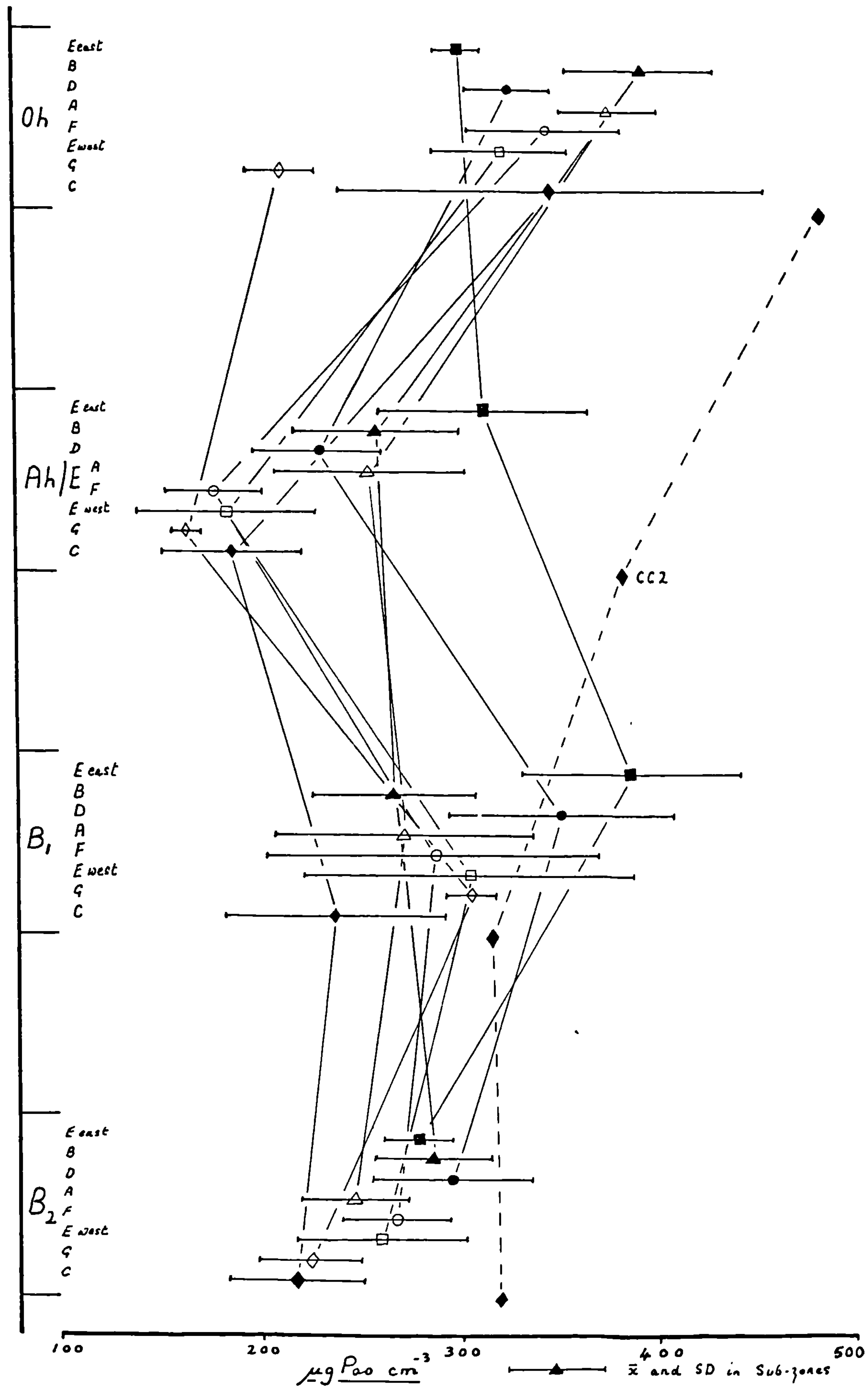


Fig. 5.191 Zone A - Vertical distribution, sub-zone $\bar{x}$ and SD: μgPao cm^{-3}

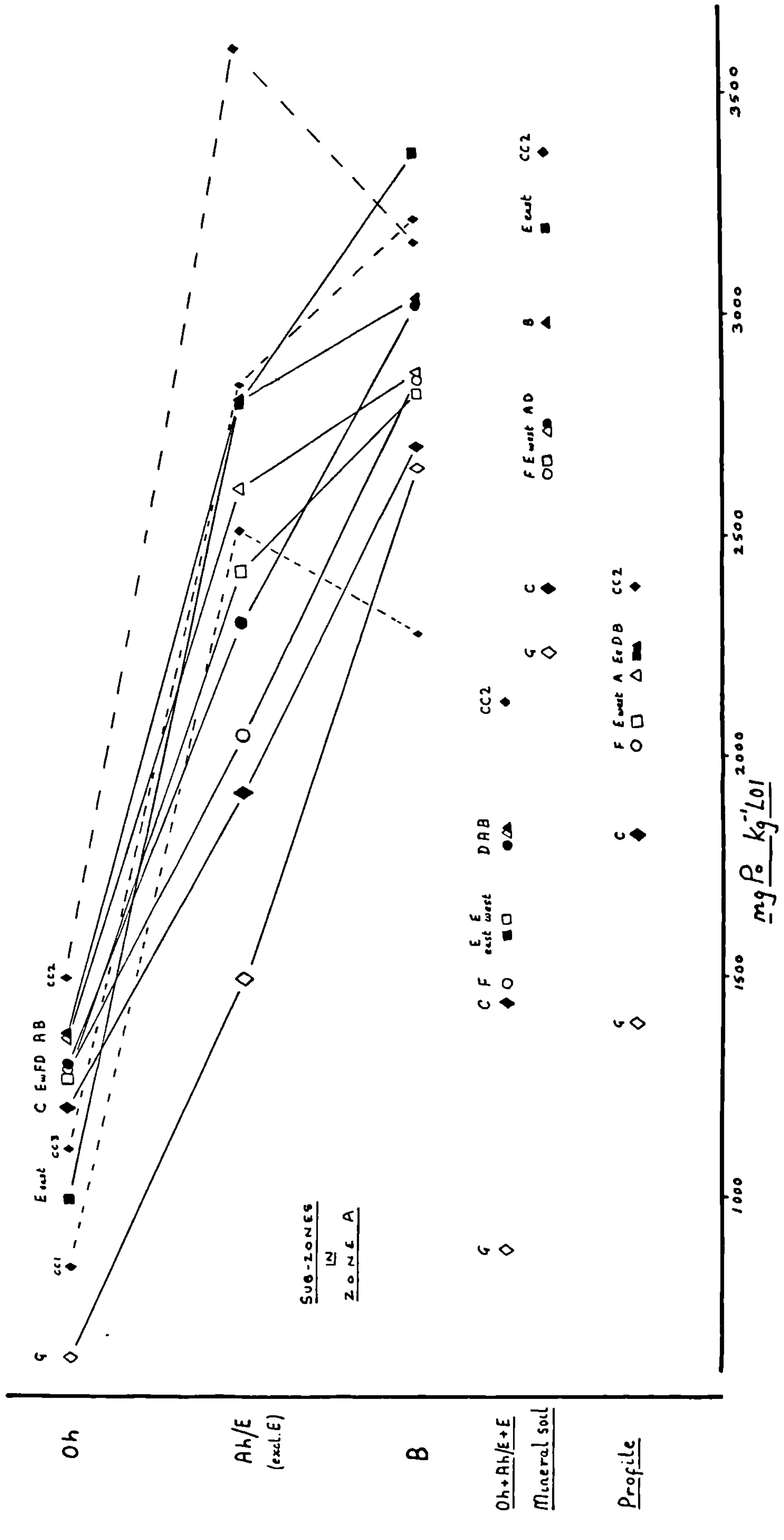


Fig. 5.192 Zone A - Vertical distribution, sub-zone $\bar{x}$: mgPo kg^{-1}LOI

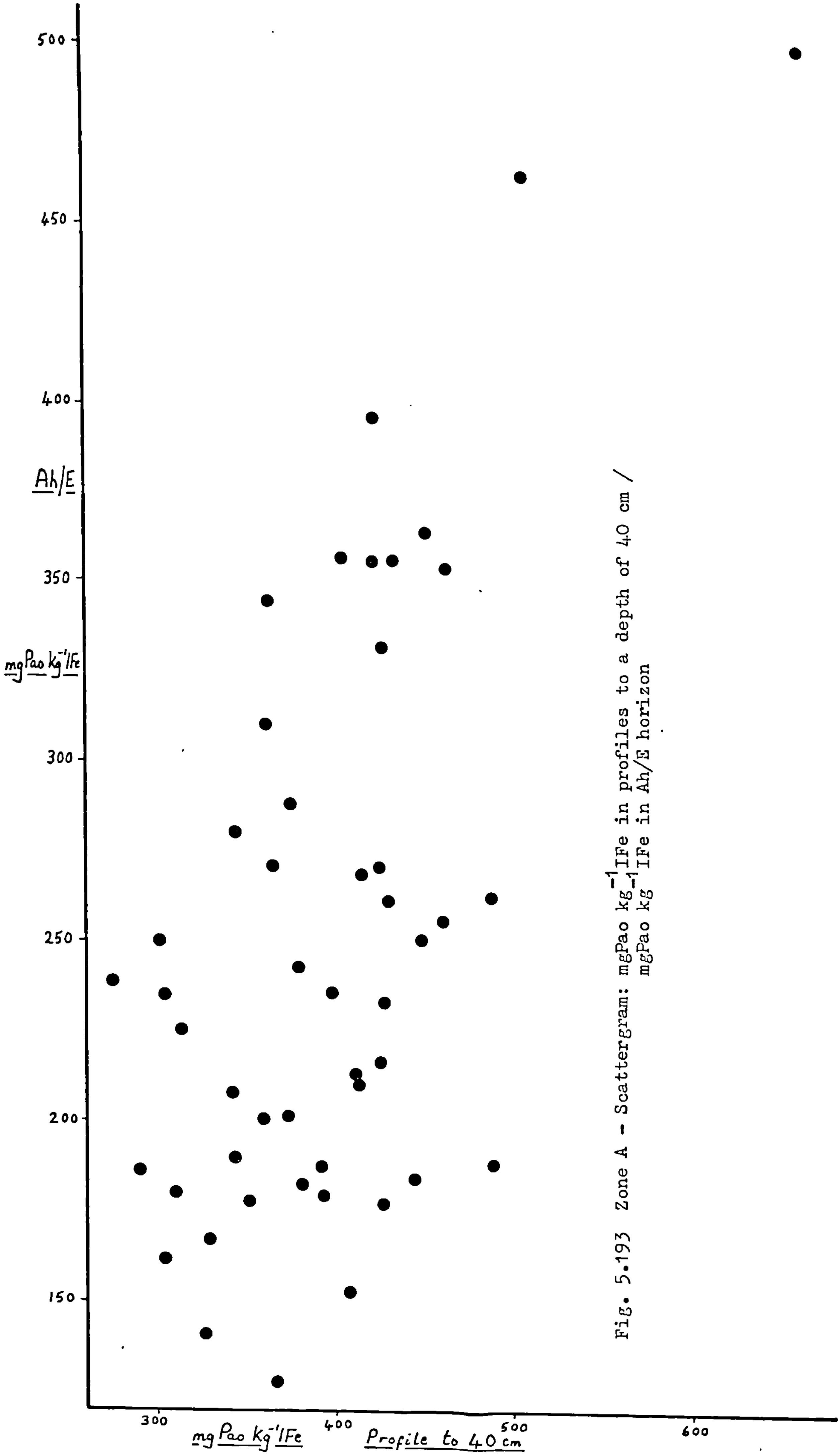
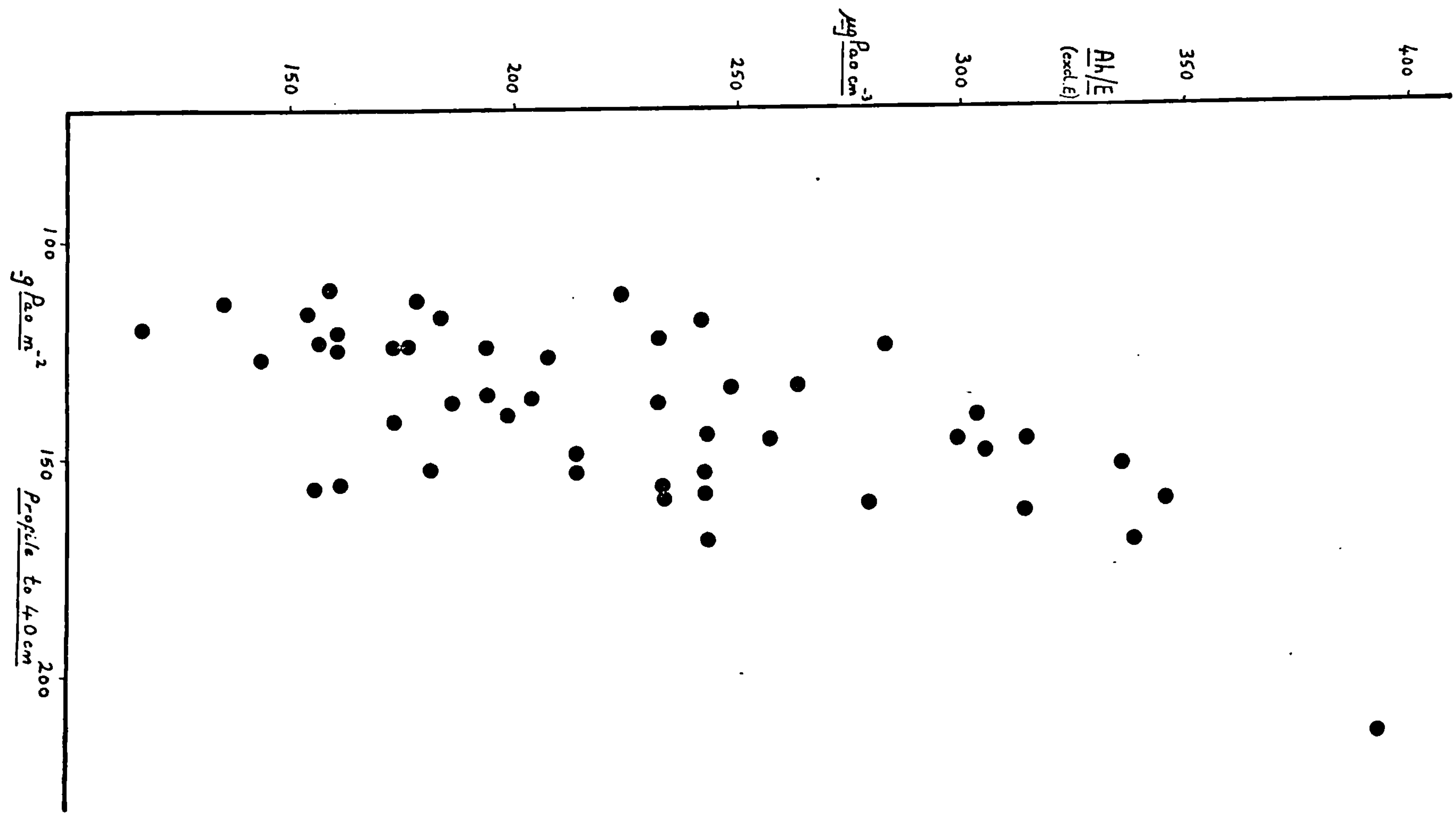


Fig. 5.193 Zone A - Scattergram: mgPao kg^{-1}IFe in profiles to a depth of 40 cm / mgPao kg^{-1}IFe in Ah/E horizon

Fig 5.194 Zone A - Scattergram: gPao m^{-2} in profiles to a depth of 40 cm / ugPao cm^{-3} in Ah/E horizon



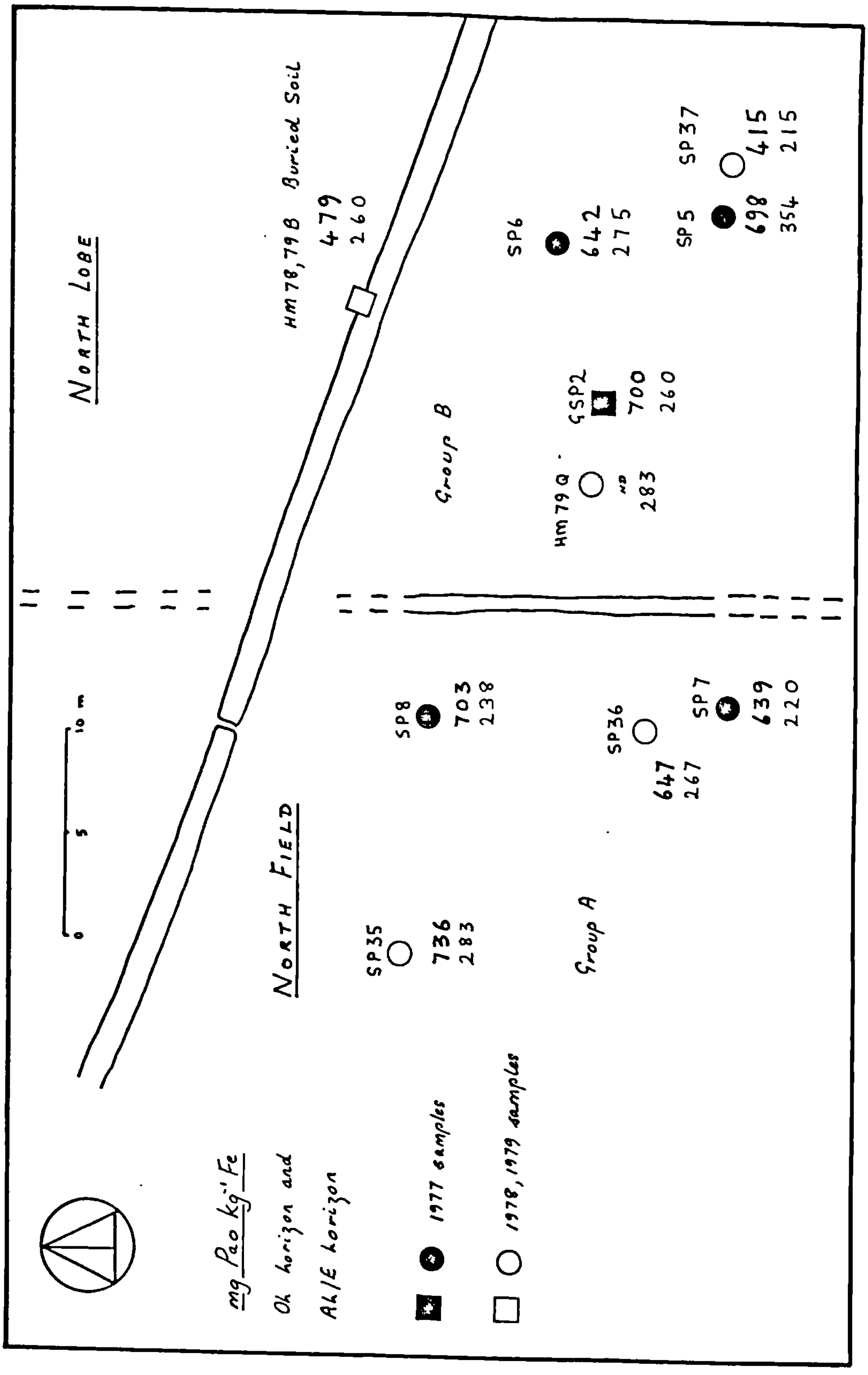


Fig. A 5.1 Zone C, Groups A and B - Lateral distribution: mgPao kg^{-1} Fe in Oh and Ah/E horizons

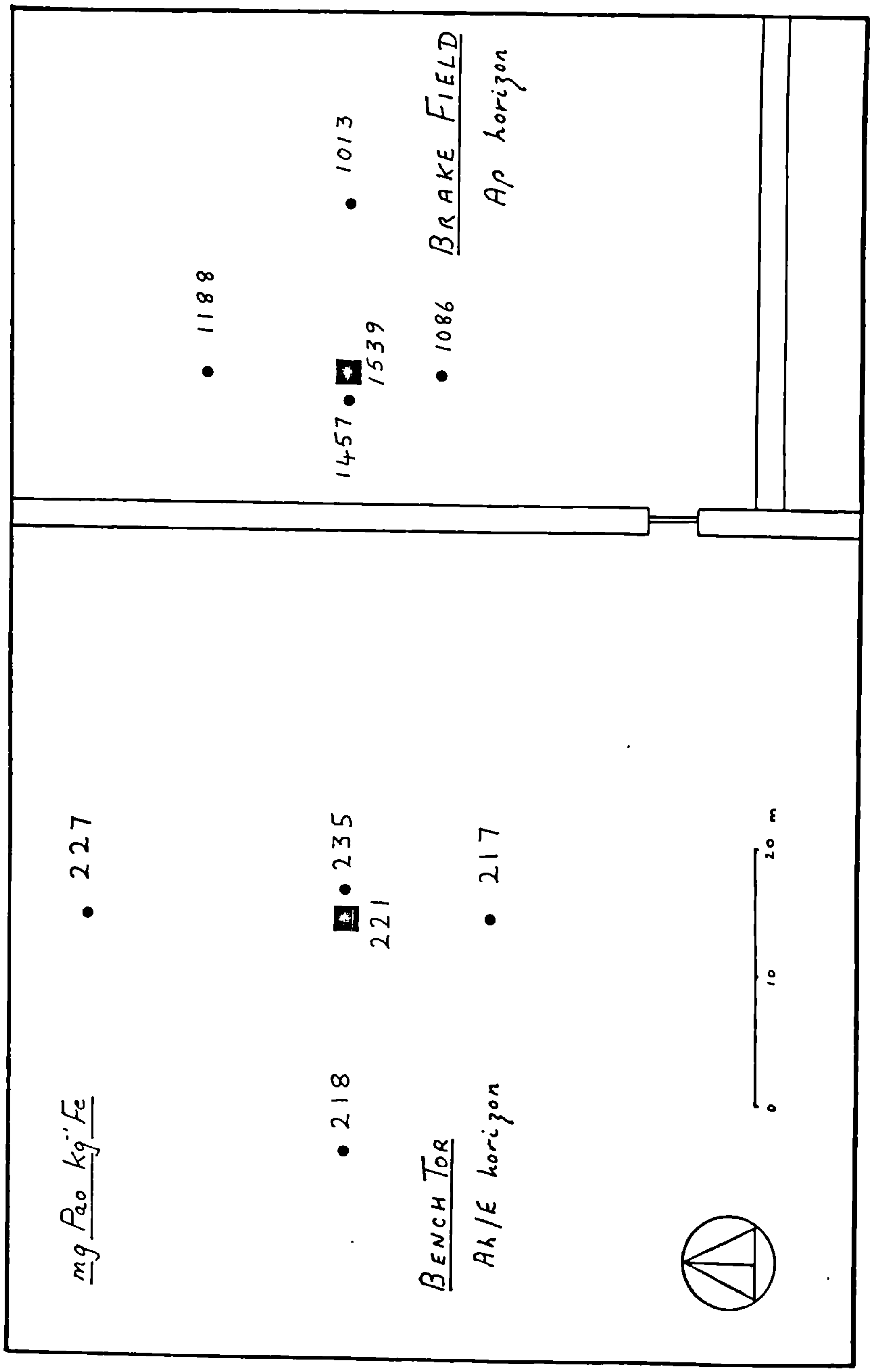


Fig. A 5.2 West Stoke Farm and Bench Tor - Lateral distribution: mgPao kg^{-1} Fe in Ap and Ah/E horizons