

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

SOILS OF ELTHAM COUNTY  
AND THE  
TEPHROCHRONOLOGY  
OF  
CENTRAL TARANAKI

A thesis presented in partial fulfilment  
of the requirements for the degree of  
Doctor of Philosophy in Soil Science  
at Massey University

by

ALISON MARGARET FRANKS

1984





Frontispiece.

View across the south of Eltham County, to the north-west, with Mt. Egmont in the background, from Tirimoana Road, at N129/917395. The landscape shown here comprises an uplifted marine bench (Kaiatea Terrace) overlain by laharic breccia (Eltham Lahars) and thick volcanic ash. Soils are mapped as Stratford hill-Stratford association.

## ABSTRACT

The soils of Eltham County west of the Patea River, are described and their distribution shown on a map at a scale of 1:50,000. The soil-forming factors are discussed with particular emphasis on the soil parent materials, which range from volcanic ash in the west, to peat and sedimentary rock, mainly siltstone and sandstone, in the east. An account is given of the genesis and historical development of the Ngaere and Eltham Swamps and a classification made of the Eltham peat.

A detailed account is given of the stratigraphy of the late Quaternary tephras in central Taranaki. Eight new tephra units (p2, p1, E5, E4, E3, E2, E1 and Mahoe) are described, with type sections and reference localities designated. Isopach maps of their distribution are presented and an attempt is made to correlate these tephras with those further north. Details are given of the westernmost occurrences of Aokautere Ash and the implications of these for the Late Quaternary in Taranaki are examined.

Petrographic studies, X-ray fluorescence and chemical analysis of titanomagnetites by inductively-coupled argon plasma emission spectroscopy (I.C.P.) are also applied to effect positive identification and correlation of the tephras. The composition of the lithic Manganui tephra is established as basaltic.

The morphology and physical properties of the soils are described as are the soil mapping units employed in this survey. Characteristics of the component members of the mapping units are given in an extended legend. Fifteen soil taxonomic units have been recognised and named in the soil survey. Descriptions designed primarily for correlation and reference purposes are provided for each of the taxonomic units. The soils are also rated in terms of their limitations for pastoral cropping, horticultural, forestry and urban uses and in terms of their value for food production. The position of the boundary between Stratford and Egmont soils is established and a basis for distinguishing the two soils is proposed. By examining two steepland subcatchments in detail an insight is provided into the wide range of variability found in the steepland soils in the east of Eltham County. An indication of the presence of volcanic ash or its absence due to erosion is gained by applying the phosphate retention and allophane test. This also provides an understanding of the pattern of parental material variability.

Finally, selected laboratory analyses have been chosen to help characterise the chemical and physical properties of five yellow-brown loams, a gley, an intergrade between yellow-brown loams and recent soils and an organic soil from Eltham County. Detailed analytical data from ten New Zealand Soil Bureau reference sites in Taranaki are included for comparative purposes.

## ACKNOWLEDGEMENTS

I would like to thank my supervisors Dr. V.E. Neall and Dr. J.A. Pollok. Dr. Neall's patient guidance and Dr. Pollok's enthusiasm were much appreciated.

I am grateful to my colleagues Mr. R.C. Wallace, and Dr. R.B. Stewart, who provided helpful advice and constructive criticism. Thanks are also due to Mr. J. Hunt, Soil Bureau, D.S.I.R. Wellington, for assistance with the X-ray fluorescence, to Dr. J. Lee, Applied Biochemistry Division, D.S.I.R. Palmerston North for ICP analyses of the titanomagnetites and to New Zealand Soil Bureau for the reference site analyses.

Acknowledgement is given to New Zealand Soil Bureau, Department of Scientific and Industrial Research, for funding the project "Soil and Ashbeds in Taranaki". In particular special recognition is given to Mr. R.H. Wilde and Mr. J.D. Cowie of New Zealand Soil Bureau for field correlation and encouragement.

I must also thank Mrs. D. Syers for her efficient typing and Mr. M.R. Lewis for data analysis.

Finally, I offer grateful thanks to Ms. S.L. Marx and other friends, in both Taranaki and Palmerston North, and my family, who have been supportive throughout.

TABLE OF CONTENTS

	Page
FRONTISPIECE . . . . .	i
ABSTRACT . . . . .	ii
ACKNOWLEDGEMENTS . . . . .	iv
TABLE OF CONTENTS . . . . .	v
LIST OF FIGURES . . . . .	viii
LIST OF TABLES . . . . .	xi
LIST OF PLATES . . . . .	xiv
CHAPTER 1. Introduction	
1. Previous Work . . . . .	1
2. General Description of Area . . . . .	6
CHAPTER 2. Soil forming environment of Eltham County	
1. Physiography . . . . .	10
2. Vegetation . . . . .	11
3. Climate . . . . .	15
4. Soil Parent Materials	
i. Regional Quaternary History . . . . .	23
ii. Quaternary History of Eltham County . . . . .	24
5. Drainage and Iron Movement . . . . .	34
6. Genesis and Historical Development of the Ngaere and Eltham Swamps . . . . .	37
CHAPTER 3. Tephrochronology of Central Taranaki	
1. Introduction . . . . .	51
2. Definitions and Terminology . . . . .	53
3. Historical Background and Previous Work . . . . .	55
4. Method of Study . . . . .	58
5. Stratigraphic Units . . . . .	61

## CHAPTER 3.

- |   |    |
|---|----|
| 6. Systematics  |    |
| i. Late Quaternary Tephtras of Central Taranaki . . . . .   | 62 |
| ii. The Westernmost Occurrences of Aokautere Ash<br>and Implications for the Late Quaternary<br>in Taranaki . . . . . | 85 |

## CHAPTER 4. Mineralogical Identification of Central Taranaki Tephtras

- |  |     |
|--|-----|
| 1. Previous work . . . . .   | 91  |
| 2. X-Ray Fluorescence Spectrometry . . . . .                                 | 92  |
| 3. Chemical Analyses of Titanomagnetites<br>from Taranaki Tephtras . . . . . | 97  |
| 4. Mineralogy of the Tephtra Sequence . . . . .                              | 103 |

## CHAPTER 5. Soils of Eltham County

- |  |     |
|--|-----|
| 1. Soil Mapping and Taxonomic Units . . . . .                          | 115 |
| 2. Soil Groups in Survey Area . . . . .                                | 123 |
| 3. Soil Taxonomic Units . . . . .                                      | 125 |
| 4. Soil Mapping Units . . . . .  | 146 |
| 5. Distinguishing Stratford Soils from Egmont Soils . . . . .          | 155 |
| 6. An Insight into the Variability of<br>the Steepland Soils . . . . . | 184 |

## CHAPTER 6. Laboratory Analyses

- |   |     |
|---|-----|
| 1. Soils and Sampling Sites . . . . .                             | 219 |
| 2. Results . . . . .  | 224 |
| 3. pH Measurements . . . . .                                      | 232 |
| 4. Organic Matter . . . . .                                       | 234 |
| 5. Phosphorus . . . . .   | 236 |
| 6. Cation Exchange Properties . . . . .                           | 241 |
| 7. Reserve Potassium and Magnesium . . . . .                      | 249 |
| 8. Sulphur . . . . .  | 249 |
| 9. Acid-Oxalate Extractable Iron, Aluminium and Silicon . . . . . | 255 |
| 10. Bulk Density . . . . .  | 261 |
| 11. Moisture Retention . . . . .                                  | 264 |
| 12. Allophane and Total Clay . . . . .                            | 267 |
| 13. Conclusion . . . . .  | 267 |

CHAPTER 7. Conclusions . . . . .	273
REFERENCES . . . . .	276
APPENDICES	
I. List of Stratigraphic Sections Mentioned in Text . . . . .	287
II. Aokautere Ash Localities . . . . .	289
III. Detailed Descriptions of Two Reference Localities . . . . .	291
IV. Extended Legend . . . . .	305
V. Soil Limitations for Use . . . . .	319
VI. Soil Taxonomic Unit Sheets . . . . .	332
VII. Small Scale Maps . . . . .	411

Soil Map inside back cover.

## LIST OF FIGURES

Figure		Page
1.1	Location of Eltham County . . . . .	7
1.2	Principal streams and rivers in Eltham County . . . . .	8
2.1	Mean annual rainfall isohyets, Taranaki region (Official New Zealand, Meteorological Office data 1941-1970) . . . . .	17
2.2	Quaternary geological map of Eltham County . . . . .	26
2.3	Location of the Ngaere and Eltham Swamps . . . . .	38
2.4	Ngaere section survey map (1895) . . . . .	40
2.5	Contour map of Ngaere and Eltham Swamps at 100' intervals . . . . .	42
2.6	Profile of Eltham peat near Rawhitiroa Road . . . . .	48
3.1	Distribution of well drained soils of central and southern Taranaki as governed by the distribution of tephra . . . . .	59
3.2	Locality map of Taranaki showing study area . . . . .	60
3.3	Stratigraphic sections referred to in text (for locality details see Appendix I) . . . . .	60
3.4	Isopach map of unit p2 . . . . .	65
3.5	Appearance of unit E5 . . . . .	67
3.6	Isopach maps of unit E5 . . . . .	69
3.7	Appearance of unit E4 . . . . .	71
3.8	Isopach maps of unit E4 . . . . .	73
3.9	Correlation columns 1-8 from near Inglewood to Type Section, Mangatoki Stream . . . . .	74
3.10	Appearance of unit E3 . . . . .	76
3.11	Isopach map of unit E3 . . . . .	77
3.12	Appearance of unit E2 . . . . .	80
3.13	Appearance of unit E1 . . . . .	82
3.14	Appearance of the Mahoe tephra . . . . .	84

Figure	Page
3.15	Thickness (in mm) and isopachs for Aokautere Ash in central and southern Taranaki . . . . . 88
3.16	Isopachs (at 1m intervals) of tephric materials post-20,000 years B.P. in Taranaki . . . . . 90
4.1	Classification of rocks "typically associated with andesites in orogenic areas" (after Taylor, S.R., 1969, p 45) . . . . . 95
4.2	Parker's Index versus % $K_2O$ for the tephra sequence . . . . . 96
4.3	Graph of manganese values versus zinc values for the Taranaki tephtras . . . . . 102
4.4	Profile of Eltham peat from Eltham Swamp . . . . . 106
4.5	Section exposed in upper part of drainage ditch, Durham Road . . . . . 107
4.6	Diagram to show range of augite values in the tephra sequence, Kaupokonui-p1 . . . . . 111
4.7	Diagram to show range of augite values in pre-p1 tephtras . . . . . 112
5.1	Hypothetical cross-section of Eltham County showing soil series in relation to leaching, drainage and parent materials . . . . . 122
5.2	Grange and Taylor's reconnaissance soil map of western Taranaki modified to show distribution of Egmont and Stratford soil series in vicinity of study area . . . . . 156
5.3	Modified soil map of part of Taranaki in vicinity of study area by N.Z. Soil Bureau, 1954 . . . . . 157
5.4	Map to show present known distribution of Stratford and Egmont soils in vicinity of study area . . . . . 162
5.5	Sampling sites of a Patua soil, Burrell soil, four Stratford soils, a Stratford fine topsoil variant and three Egmont soils . . . . . 171
5.6	Elevation versus $pH_{H_2O}$ at $\frac{1}{2}$ m and 1m depth . . . . . 174
5.7	Flow diagram to aid field identification of Stratford series, Stratford series fine topsoil variant and Egmont series. . . . . 183
5.8	Location of steepland areas in central Eltham County . . . . . 185

Figure	Page
5.9	Location of steepland study areas . . . . . 185
6.1	Location of soil site information referred to in soil analyses section . . . . . 223
6.2	Values for $pH_{H_2O}$ and $pH_{NaF}$ in the soil toposequence of this study . . . . . 233
6.3	Values for $pH_{H_2O}$ and $pH_{NaF}$ in the soil climosequence of this study . . . . . 233
6.4	0.5M $H_2SO_4$ extractable phosphorus values in the soil climosequence of this study . . . . . 240
6.5	Phosphate retention values in the soil climosequence of this study for six selected Taranaki soils . . . . . 242
6.6	Base saturation ( $\frac{\Sigma \text{ Bases}}{CEC \text{ pH7 } NH_4OAc}$ ) in the soil climosequence . . . . . 245
6.7	Reserve potassium values for nine Taranaki soils . . . . . 250
6.8	Reserve magnesium values for nine Taranaki soils . . . . . 250
6.9	Phosphate-extractable sulphate versus phosphate retention for seventeen selected Taranaki soils . . . . . 252
6.10	Phosphate-extractable sulphate values in a soil toposequence of this study . . . . . 254
6.11	Phosphate-extractable sulphate values in the soil climosequence of this study . . . . . 254
6.12	Acid-oxalate extractable aluminium values in a soil toposequence of this study . . . . . 256
6.13	Acid-oxalate extractable iron in the soil climosequence and toposequence of this study . . . . . 257
6.14	Acid-oxalate extractable iron versus phosphate retention for seventeen selected Taranaki soils . . . . . 260
6.15	Bulk density and total porosity of six selected Taranaki soils . . . . . 262
6.16	Histograms to show relative amounts of Total Clay and Allophane in fifteen Taranaki soils . . . . . 268

LIST OF TABLES

Table	Page	
1.1	Correlation of soil series in this survey with soil sets of "General survey of the soils of North Island, New Zealand" (N.Z. Soil Bureau, 1954) and units of other soil surveys in Taranaki . . . . .	5
2.1	Monthly and annual rainfall figures for Riverlea between 1913-1980 (in mm). Supplied by N.Z. Meteorological Service . . . . .	18
2.2	N.Z. Meteorological Service rainfall normals for Eltham and Omoana 1941-1970 (in mm) from N.Z. Meteorological Service Misc. Pub. 145 . . . . .	19
2.3	N.Z. Meteorological Service summaries of climatological observations to 1980 for Stratford Demonstration Farm . . . . .	21
2.4	N.Z. Meteorological Service summaries of climatological observations to 1980 for Stratford Mountain House . . . . .	22
2.5	Relationships between South Taranaki marine terraces and volcanic activity in western Taranaki as adopted in this survey (Adapted from Pillans, 1981) . . . . .	25
2.6	Bulk density values for the Eltham peat . . . . .	49
3.1	Chronology and distribution of principal Quaternary volcanic deposits in central and eastern Taranaki . . . . .	52
3.2	Granulometric classification of pyroclasts and of unimodal well sorted pyroclastic deposits . . . . .	54
4.1	Major element analyses by X-ray fluorescence of a tephra sequence in Taranaki . . . . .	93
4.2	Chemical analyses of titanomagnetites from Taranaki tephras . . . . .	98
4.3	Percentage augite, hornblende and hypersthene in the tephra sequence . . . . .	104
4.4	Ratios of ferromagnesian minerals in the tephra sequence . . . . .	109
4.5	Ratios of ferromagnesian minerals in tephra samples from Eltham Swamp and Durham Road . . . . .	110

Table	Page
5.1	Soil mapping units arranged physiographically . . . . . 116
5.2	Soil taxonomic units arranged pedologically . . . . . 118
5.3	Soil members within associations and their relation to topographical sites . . . . . 121
5.4	Tephros currently recognised in Eltham county . . . . . 160
5.5	Range of elevation and rainfall, landform and mean annual air temperature under which Stratford, Stratford fine topsoil variant and Egmont soils are found . . . . . 164
5.6	Range of general morphological profile features . . . . . 168
5.7	pH <sub>KCl</sub> and pH <sub>H<sub>2</sub>O</sub> results . . . . . 173
5.8	pH <sub>NaF</sub> results . . . . . 175
5.9	Phosphate retention results . . . . . 176
5.10	% Decrease of 15-bar water results . . . . . 178
5.11	Weighted average 15-bar moisture retention - field moist and air dry . . . . . 179
5.12	KCl-extractable aluminium results . . . . . 181
5.13	N.Z. Meteorological Service summaries of climatological observations to 1980 for Te Wera Forest . . . . . 194
5.14	Allophane test and phosphate retention values for Area 1 and Area 2 . . . . . 216
6.1	Details of the eighteen soil sites in Taranaki . . . . . 220
6.2	Results of chemical and physical analyses of selected Taranaki soils . . . . . 225
6.3	Ratings for chemical properties . . . . . 229
6.4	Diagnostic properties of "Amorphous material dominant in the exchange complex" . . . . . 231
6.5	Organic matter (% Organic C x 1.7) in seventeen Taranaki soils . . . . . 235
6.6	Inorganic phosphorus fraction soluble in 0.5H <sub>2</sub> SO <sub>4</sub> as a percentage of inorganic phosphorus in seventeen Taranaki soils . . . . . 239
6.7	Effective base saturation of eighteen soils from Taranaki . . . . . 244

Table		Page
6.8	Exchangeable aluminium as a percentage of ECEC of seventeen soils from Taranaki . . . . .	248
6.9	Correlation matrix between all variables . . . . .	253
6.10	Ratio between sodium pyrophosphate extractable aluminium and iron and citrate-dithionite aluminium and iron . . . . .	259
6.11	15-bar water content for seventeen soils in Taranaki . . . . .	266
6.12	Classification of soils from Taranaki according to Soil Taxonomy and the 1978 Andisol Proposal . . . . .	272

LIST OF PLATES

Plate		Page
Frontispiece	View across the south of Eltham County, to the north-west, with Mt. Egmont in the background, from Tirimoana Road. . . . .	i
2.1	View of Mangamingi district, looking north-west, above Mangamingi Stream . . . . .	12
2.2	View of Mangamingi district. Stratford Formation in the foreground . . . . .	12
2.3	Looking north-west between Mountain Road and Boylan Road. Eltham Lahars in the foreground. . . . .	29
2.4	View of Mangamingi district, looking west. Patea River in the foreground with Opunake terrace and Stratford terrace above . . . . .	29
2.5	Pungarehu Formation, near Lower Stuart Road . . . . .	31
2.6	Mt. Egmont. Lahar mounds of the Warea Formation. . . . .	32
2.7	Warea Lahar exposed on Upper Auroa Road . . . . .	32
2.8	Opua Lahar exposed on Eltham Road . . . . .	33
2.9	Mangawhero soil, near Riverlea . . . . .	35
2.10	View north of the Ngaere Swamp from Rawhitiroa Road . . . . .	39
2.11	Exposed roots of a <u>Dacrycarpus dacrydioides</u> (Kahikatea) . . . . .	39
2.12	Section exposed in ditch showing Burrell lapilli, Kaupokonui tephra, Maketawa tephra, and Manganui tephra . . . . .	47
3.1	Section exposed on Opunake Road, 0.6km from Mahoe. Type section for p2B, p2A and p1 . . . . .	64
3.2	Detail of tephras p2A and p1 (Korito tephra) Section exposed near Tariki . . . . .	64
3.3	Detail of section exposed at Mahoe, on Opunake Road . . . . .	67
3.4	View of section exposed on Opunake Road, adjacent to Mangatoki Stream. Type section for E4 tephra . . . . .	70

Plate		Page
3.5	Detail of E4 tephra at Waingongoro Road . . . . .	71
3.6	Detail of E3 tephra on Pembroke Road, 1.5km south from Barclay Road . . . . .	76
3.7	View of section exposed on Pembroke Road, 1.5km south from Barclay Road. Reference locality for E2 . . . . .	79
3.8	Detail of E2 at the type section, on Opunake Road, above the Waingongoro Stream . . .	80
3.9	Reference locality for the Mahoe tephra, on Opunake Road, 0.6km from Cardiff . . . . .	84
3.10	Section exposed on Tirimoana Road showing the Omahina Tephra interbedded in andesitic ashes .	86
3.11	Section adjacent to Opunake Road, near Ronald Road showing the Aokautere Ash . . . . .	89
5.1	Rowan soil, Upper Mangawhero Road . . . . .	127
5.2	Rowan soil near Upper Mangawhero Road . . . . .	127
5.3	Riverlea soil, near Eltham Road . . . . .	129
5.4	Makaka soil at the type section, near Upper Mangawhero Road . . . . .	129
5.5	Lowgarth soil, at the type section, near Lower Hastings Road . . . . .	132
5.6	Kahui soil core, near Riverlea . . . . .	132
5.7	Tipoka soil, near Auroa Road . . . . .	135
5.8	Hangatahua soil, near Manaia Road . . . . .	135
5.9	Stratford soil, near Lower Hastings Road . . . . .	169
5.10	Stratford fine topsoil variant on Hicks Road . . .	169
5.11	Egmont soil, 1km west of Mokoia, along main Wanganui-Hawera highway . . . . .	169
5.12	Steepland study Area 1. . . . .	188
5.13	Steepland study Area 2. . . . .	189
5.14	Exposure of moderately consolidated silty sandstone belonging to the Matemateonga Formation at Mangamingi Saddle . . . . .	191
5.15	View from study Area 1 looking south-east . . . . .	191

Plate		Page
5.16	Ridge profile Area 1 . . . . .	200
5.17	Intermediate steep slope profile, Area 1 . . . . .	202
5.18	Intermediate steep slope profile, Area 2 . . . . .	202
5.19	Eroded slope site, Area 1 . . . . .	204
5.20	Profile from zone of local accumulation at foot of eroded site . . . . .	204
5.21	Accumulation slope profile, Area 1 . . . . .	206
5.22	Eroded slope site, now stabilised . . . . .	210
5.23	Eroded slope profile . . . . .	210
5.24	View north of accumulation slope site, Area 2 . . . . .	212
5.25	Accumulation slope profile . . . . .	212