

TABLE OF CONTENTS

Acknowledgments.....	iii
บทคัดย่อ.....	v
Abstract	viii
List of tables	xv
List of illustrations	xvi
Chapter 1 Introduction	1
1.1 Background and problems.....	1
1.2 Palynology.....	3
1.3 Objectives.....	4
Chapter 2 Basins and Stratigraphy	5
2.1 Physiographic features.....	5
2.1.1 Topography and climates.....	5
2.1.2 Vegetations.....	8
2.1.3 General geology.....	9
2.2 Li basin.....	11
2.2.1 Geographical setting.....	11
2.2.2 Geology.....	13
2.2.3 Paleontology and age determination.....	19
2.3 Chiang Muan basin.....	22

2.3.1 Geographical setting.....	22
2.3.2 Geology.....	22
2.3.3 Paleontology and age determination.....	27
2.4 Mae Moh basin.....	29
2.4.1 Geographical setting.....	29
2.4.2 Geology.....	31
2.4.3 Paleontology and age determination.....	38
2.5 Mae Lamao basin.....	39
2.5.1 Geographical setting.....	39
2.5.2 Geology	41
2.5.3 Paleontology and age determination.....	45
2.6 Na Hong basin.....	46
2.6.1 Geographical setting.....	46
2.6.2 Geology.....	47
2.6.3 Paleontology and age determination.....	51
Chapter 3 Samplings and sample preparations.....	52
3.1 Sample collection.....	52
3.1.1 Li basin.....	52
3.1.2 Chiang Muan basin.....	57
3.1.3 Mae Moh basin.....	57
3.1.4 Mae Lamao basin.....	63
3.1.5 Na Hong basin.....	63

3.2 Sample preparation.....	69
3.2.1 Sedimentary sample preparation.....	69
3.2.2 Modern spores and pollen preparation.....	73
3.2.3 Specimen preparation for microscopy.....	75
3.2.4 Application of the light microscope and the scanning electron microscope to the same pollen grain.....	76
3.3 Microscopy.....	77
Chapter 4 Descriptive Palynology.....	78
4.1 Microscopic algae.....	78
4.2 Fungi.....	88
4.3 Pteridophytic spores.....	93
4.4 Gymnospermic pollen.....	106
4.5 Angiospermic pollen.....	113
Chapter 5 Results.....	156
5.1 Li basin.....	156
5.1.1 Ban Pa Kha coalfield.....	156
5.1.2 Na Sai coalfield and Mae Long locality.....	165
5.2 Chiang Muan basin.....	168
5.3 Mae Moh basin.....	173
5.4 Mae Lamao basin.....	178
5.5 Na Hong basin.....	181

5.6 Stratigraphic correlation and basin development.....	185
Chapter 6 Discussion	190
6.1 Sample treatment.....	190
6.2 Recognition of two stratigraphic zones.....	190
6.3 Microfossils vs Macrofossils.....	191
6.4 Cause of climatic changes.....	195
6.5 Marine incursion.....	200
Chapter 7 Conclusions.....	204
References.....	208
Appendix A: Indeterminant sporomorphs.....	232
Appendix B: Index to scientific names.....	270
Curriculum vitae.....	278

LIST OF TABLES

Table

3-1	Description of samples collected from Ban Pa Kha coalfield.....	54
3-2	Description of samples collected from Na Sai coalfield.....	58
3-3	Description of samples collected from Chiang Muan coalfield.....	60
3-4	Description of samples collected from Mae Moh coalfield.....	64
3-5	Description of samples collected from Mae Lamao coalfield.....	67
3-6	Description of samples collected from Na Hong coalfield.....	70
5-1	Sporomorph taxa appearance in relative amounts of three degrees, rare, common, and abundant from the Ban Pa Kha Formation.....	157
5-2	Sporomorph taxa appearance in relative amounts of three degrees, rare, common, and abundant from the Na Sai coalfield.....	166
5-3	Sporomorph taxa appearance in relative amounts of three degrees, rare, common, and abundant from the Ban Pa Kha Formation.....	170
5-4	Sporomorph taxa appearance in relative amounts of three degrees, rare, common, and abundant from the Mae Moh Group.....	174
5-5	Sporomorph taxa appearance in relative amounts of three degrees, rare, common, and abundant from the Mae Lamao coalfield.....	179
5-6	Sporomorph taxa appearance in relative amounts of three degrees, rare, common, and abundant from the Na Hong coalfield.....	182

LIST OF ILLUSTRATIONS

Figures

2-1	Map of northern Thailand showing distribution of Cenozoic basins and the five study localities.....	6
2-2	Map of northern Thailand showing ranges of topographic elevations with some peaks of high mountains and the four major rivers.....	7
2-3	Geological Map of the Tertiary Li basin.....	12
2-4	Geological cross section across the Na Sai and Ban Pa Kha Coalfields along line A-B on figure 2-3.....	15
2-5	Schematic stratigraphic succession of the Ban Pa Kha Formation.....	18
2-6	A partial schematic stratigraphic succession of the Na Sai coalfield.....	20
2-7	Geological map of the Tertiary Chiang Muan basin.....	24
2-8	Schematic stratigraphic succession of the Chiang Muan Formation.....	26
2-9	Schematic stratigraphic section of Chiang Muan coalfield with magnetic Polarity timescale.....	30
2-10	Geological map of the Tertiary Mae Moh basin.....	32
2-11	Schematic stratigraphic succession of the Mae Moh Group.....	34
2-12	Schematic stratigraphic section of Mae Moh Group with magnetic Polarity timescale.....	40
2-13	Geological map of the Tertiary Mae Lamao basin.....	42
2-14	A partial schematic stratigraphic succession from the Mae Lamao coalfield.....	44

2-15	Geological map of the Tertiary Na Hong basin.....	48
3-1	Schematic stratigraphic succession of the Ban Pa Kha Formation showing stratigraphic levels of the sample collecting.....	50
3-2	A partial schematic stratigraphic succession of the Na Sai coalfield showing stratigraphic levels of the sample collecting.....	56
3-3	Schematic stratigraphic succession of the Chiang Muan Formation showing stratigraphic levels of the sample collecting.....	59
3-4	Schematic stratigraphic succession of the Mae Moh Group showing stratigraphic levels of the sample collecting.....	66
3-5	A partial schematic stratigraphic succession of the Mae Lamao coalfield showing stratigraphic levels of the sample collecting.....	68
3-6	A partial schematic stratigraphic succession of the Na Hong coalfield showing stratigraphic levels of the sample collecting.....	71
3-7	Flow chart showing general standard technique of paleopalynological processing procedure.....	72
5-1	Pollen diagram showing plots of pollen occurrence in percentage against lithostratigraphic units and palynological zones of Ban Pa Kha coalfield.....	162
5-2	Pollen diagram showing plots of pollen occurrence in percentage against lithostratigraphic units and palynological zones of Na Sai coalfield	167
5-3	Pollen diagram showing plots of pollen occurrence in percentage against lithostratigraphic units and palynological zones of Chiang Muan	

	coalfield	172
5-4	Pollen diagram showing plots of pollen occurrence in percentage against lithostratigraphic units and palynological zones of Mae Moh coalfield	176
5-5	Pollen diagram showing plots of pollen occurrence in percentage against lithostratigraphic units and palynological zones of Mae Lamao coalfield.....	180
5-6	Pollen diagram showing plots of pollen occurrence in percentage against lithostratigraphic units and palynological zones of Na Hong coalfield	183
5-7	Warm temperate and tropical stratigraphic zones of the selected Tertiary basins in northern Thailand.....	188
6-1	Fossil macrofloras vs palynofloras from the Ban Pa Kha coalfield.....	193
6-2	Fossil macrofloras vs palynofloras from the Ban Pa Kha coalfield.....	194
6-3	Schematic map of Cenozoic extrusion tectonics and large faults in Eastern Asia.....	197
6-4	Minimum estimate of extrude area.....	199
6-5	Classification of Miocene environments of Phrae basin reconstructed from palynological analyses showing affect of marine incursion during deposition.....	201