TABLE OF CONTENTS

ABSTRACT (IN THAI)	iii
ABSTRACT (IN ENGLISH)	iv
ACKNOWLEGMENTS	
TABLE OF CONTENTS	
LIST OF TABLES	viii
LIST OF FIGURES	
CHAPTER 1 INTRODUCTION	
1.1 Theory of geophysical methods	5
1.2 Literature reviews	29
1.3 Objective	38
CHAPTER 2 RESEARCH METHODOLOGY	39
2.1 Equipment	39
2.2 Materials	42
2.3 Methodology	42
CHAPTER 3 RESULTS	54
3.1 Ground Penetrating Radar	54
3.2 Magnetic Mapping	82
3.3 Ground Resistivity Mapping	87
3.4 CVES	91
3.5 Comparison between geophysical results and previous	105
archaeological excavation	
4. CONCLUSION AND DISCUSSION	109
REFERENCES	
APPENDICES	
VITAE	

LIST OF TABLES

Table		Page
1.1	Typical dielectric constant, electrical conductivity, velocity and	9
	attenuation observed in common geological materials at 100 MHz	
1.2	Magnetic susceptibilities of rocks and materials	15
1.3	Resistivities of common geologic materials	29
2.1	Table for recording the magnetic field and corrected field	46
2.2	Table for recording data in the field for Wenner array	47
2.3	Table for recording data in the field for Dipole-Dipole array	48
3.1	Locations of discontinuity zones in the middle layer of sub-area A	57
3.2	Locations of hyperbolic anomalies in the middle layer of sub-area A	58
3.3	Locations of discontinuity zones in the middle layer of sub-area B	70
3.4	Locations of hyperbolic anomalies in the middle layer of sub-area B	71

LIST OF FIGURES

Figure		Page
1.1	The map of Lao PDR and location of study area	3
1.2	The Location of study area, an Lao Pako archaeological site	4
1.3	(a) Conceptual illustration of GPR used in the reflection profile	6
	mode on soil over bedrock and (b) Radar record obtained over the	
	idealized situation in (a)	
1.4	The two way time-distance curve of reflected EM wave	10
1.5	GPR configuration	11
1.6	Schematic diagram of the GPR system	12
1.7	The magnetic flux surrounding a bar magnet	13
1.8	Schematic representation of an element of material in which	15
	elementary dipoles align in the direction of an external field B to	
	produce an overall induced magnetization.	
1.9	(a) Geomagnetic elements (b) variation of the inclination of the	17
	total magnetic field with latitude based on simple dipole	
	approximation of geomagnetic field	
1.10	Total field anomalies for the dipole for geomagnetic inclinations	19
	(a) 90° , (b) 45° , and (c) 0°	
1.11	The horizontal (ΔH), vertical (ΔZ) and total field (ΔB) anomaly	21
	due to an isolated positive pole	
1.12	Principle of the proton magnetometer	22
1.13	Point source current at the surface of homogenous medium	24
1.14	Two current and two potential electrodes array for resistivity	25
	measurement	
1.15	Common electrode arrays used in resistivity survey (a) Wenner	27
	Array and (b) Dipole-Dipole Array	
1.16	CVES plotting with Dipole-Dipole array	28
1.17	Excavation in 2003 (a) a pit with vessels and potsherds, (b)	31
	potteries, and (c) potsherds with different shapes	

Figure		Page
1.18	Excavation in 2003 (a) ten spindle whorls, (b) clay seal, diameter	32
	30 mm, and (c) stamp roller	
1.19	Glass beads from the 2003 excavation	32
1.20	Objects relating to iron working (a) structure of fired clay, (b)	33
	tuyère, and (c) iron narrow head	
1.21	Objects relating to iron working (a) bronze bangle, (b) bronze helix	34
	Ring, and (c) bronze bells	
1.22	Stone objects (a) whetstones, (b) stone adzes	34
1.23	Schematic section of the archaeological stratigraphy in the study	35
	area	
2.1	Malå System RAMAC/GPR	40
2.2	Proton Magnetometer G-856	40
2.3	Geoelectrical equipment	41
2.4	GPR measurement at Lao Pako archaeological site	43
2.5	Magnetic measurement at Lao Pako archaeological site	43
2.6	Resistivity measurements at Lao Pako archaeological site	44
2.7	Map of study area showing sub-area A and sub-area B and line of	44
	measurement within the study area.	
2.8	Arrangement of model blocks and apparent resistivity data points	52
	for line A-26	
2.9	The measured apparent resistivity pseudosection (a), The measured	53
	resistivity pseudosection (b) and the inverse model resistivity section	
	(c) under the Line A-26 , calculated with 15 iterations (RMS error =	
	6.1%)	
3.1	Hyperbola fitting for Line A-11	54
3.2	Velocity distributions (a) in sub-area A and (b) in sub-area B	55
3.3	Radar section of Line A-00 to A-02	59
3.4	Radar section of Line A-03 to A-05	60
3.5	Radar section of Line A-06 to A-08	61

Х

Figure		Page
3.6	Radar section of Line A-09 to A-11	62
3.7	Radar section of Line A-12 to A-14	63
3.8	Radar section of Line A-15 to A-17	64
3.9	Radar section of Line A-18 to A-20	65
3.10	Radar section of Line A-21 to A-23	66
3.11	Radar section of Line A-24 to A-26	67
3.12	Radar section of Line A-27 to A-29	68
3.13	Radar section of Line A-30 to A-32	69
3.14	Radar section of Line B-00 to B-02	72
3.15	Radar section of Line B-03 to B-05	73
3.16	Radar section of Line B-06 to B-08	74
3.17	Radar section of Line B-09 to B-11	75
3.18	Radar section of Line B-12 to B-14	76
3.19	Radar section of Line B-15 to B-17	77
3.20	Radar section of Line B-18 to B-20	78
3.21	Radar section of Line B-21 to B-23	79
3.22	Radar section of Line B-24 to B-26	80
3.23	Radar section of Line B-27 to B-29	81
3.24	Contour of total magnetic field in sub-area A; (a) and (b) contour	83
	map of total magnetic field at height of 1.25 m and 1.85 m above	
	the ground; and (c) contour map of residual magnetic field.	
3.25	Contour of total magnetic field in sub-area B; (a) and (b) contour	85
	map of total magnetic field at height of 1.25 m and 1.85 m above	
	the ground; and (c) contour map of residual magnetic field.	
3.26	Magnetic model along the profile AA' in sub-area B.	86
3.27	Contour map of apparent resistivity in sub-area A by using Wenner	88
	array with electrode spacing $a = 1$ m	
3.28	Locations of previous archeological excavation pits and anomalous	89
	zones obtained from Wenner mapping and GPR measurement in	

Figure		Page
	sub-area A.	
3.29	Contour map of apparent resistivity in sub-area B by using Wenner	90
	array with electrode spacing $a = 1$ m	
3.30	Locations of previous archeological excavation pits and anomalous	91
	zones obtained from Wenner mapping and GPR measurement in	
	sub-area B.	
3.31	LineA-06 (a) resistivity profile using Wenner array with $a = 1.0$ m	95
	(at depth of 0.5 m), (b) measured apparent resistivity pseudosection,	
	(c) inverse model resistivity section, and (d) radar section	
3.32	LineA-17 (a) resistivity profile using Wenner array with $a = 1.0$ m	96
	(at depth of 0.5 m), (b) measured apparent resistivity pseudosection,	
	(c) inverse model resistivity section, and (d) radar section	
3.33	LineA-26 (a) resistivity profile using Wenner array with $a = 1.0$ m	97
	(at depth of 0.5 m), (b) measured apparent resistivity pseudosection,	
	(c) inverse model resistivity section, and (d) radar section	
3.34	LineA-27 (a) resistivity profile using Wenner array with $a = 1.0$ m	98
	(at depth of 0.5 m), (b) measured apparent resistivity pseudosection,	
	(c) inverse model resistivity section, and (d) radar section	
3.35	LineA-28 (a) resistivity profile using Wenner array with $a = 1.0$ m	99
	(at depth of 0.5 m), (b) measured apparent resistivity pseudosection,	
	(c) inverse model resistivity section, and (d) radar section	
3.36	LineB-04 (a) resistivity profile using Wenner array with $a = 1.0$ m	102
	(at depth of 0.5 m), (b) measured apparent resistivity pseudosection,	
	(c) inverse model resistivity section, and (d) radar section	
3.37	LineB-07 (a) resistivity profile using Wenner array with $a = 1.0$ m	103
	(at depth of 0.5 m), (b) measured apparent resistivity pseudosection,	
	(c) inverse model resistivity section, and (d) radar section	
3.38	LineB-08 (a) resistivity profile using Wenner array with $a = 1.0$ m	104

Figure		Page
	(at depth of 0.5 m), (b) measured apparent resistivity pseudosection,	
	(c) inverse model resistivity section, and (d) radar section	
3.39	Locations of geophysical anomalies and previous archaeological	105
	pits in sub-area A	
3.40	Locations of geophysical anomalies and previous archaeological	106
	pits in sub-area A	
3.41	Plan views of archaeological pits in sub-area A	107
3.42	Plan views of archaeological pits in sub-area B	108