

CONTENT

	Page
Acknowledgement	c
Abstract in Thai	d
Abstract in English	f
List of Tables	j
List of Figures	k
Chapter 1 Introduction	1
1.1. Problem and Methodology	2
1.2. Research Scope and Objectives	6
1.3. Study area and Geological setting	6
1.4. Previous geophysical and related works	7
1.5. Thesis summary	10
Chapter 2 Seismic Method	12
2.1. Seismic wave propagation	13
2.1.1. Seismic waves travel times	14
2.1.2. Reflection and transmission coefficients	16
2.2. Essential concepts for reflection data processing	17
2.2.1. Amplitude attenuation and gain recovery	17
2.2.2. Static correction	19
2.2.3. Frequency filter	20
2.2.4. F-K filter	21
2.2.5. Surface Consistent Deconvolution	22
2.2.6. Normal move out correction	24
2.2.7. Velocity analysis	26
2.3. Seismic Acquisition	27
2.4. Seismic Reflection Processing	32
2.4.1. Geometry setting	32

2.4.2. Trace editing, amplitude recovery and static correction	34
2.4.3. Frequency filter analysis	37
2.4.4. Deconvolution parameter testing	38
2.4.5. Velocity analysis and NMO correction	42
2.4.6. Processing summary parameters and final seismic sections	44
2.5. Seismic data interpretation	51
 Chapter 3 Potential Field Method	56
3.1. Potential filed data source	56
3.2. Wavenumber domain analysis of potential field data	59
3.2.1. Concept of wavenumber domain of analysis	59
3.2.2. Depth estimation of potential filed data	62
3.3. 2D Forward modeling of gravity data	64
3.3.1. Concept of 2D forward modeling	64
3.3.2. 2D gravity model	64
 Chapter 4 Conclusion and Discussion	69
4.1. Results and discussion	69
4.2. Conclusion	71
4.3. Problem and suggestion	72
 Reference	73
Appendix A Lithological Log	80
Appendix B Reflection Seismic	81
Appendix C Resistivity and MASW Methods	90
Curriculum Vitae	92

LIST OF TABLES

	Page
Table 2.1 exhibits elastic wave velocities and densities in typical formation (Bourbié, Coussy, and Zinszner, 1987)	14
Table 2.2 shows acquisition parameters of survey Line MO-1, MO-2, MO-3 and MO-4	30
Table 2.3 reviews the processing steps and parameters applied for Line MO-1.	45
Table 2.4 reviews the processing steps and parameters applied for Line MO-2.	45
Table 2.5 reviews the processing steps and parameters applied for Line MO-3.	46
Table 2.6 reviews the processing steps and parameters applied for Line MO-4.	46
Table 2.7 shows the interpretation detail on three reflectors with approximate two-way travel time, average stacking velocity or approximate V_{rms} , and depth.	52
Table 2.1 exhibits elastic wave velocities and densities in typical formation (Bourbié, Coussy, and Zinszner, 1987)	14
Table 3.1 lists densities for various kind of	66
Table 3.2 shows the summation of density values in the final pseudo-geological model.	67
Table 4.1 summarizes physical properties from the pseudo geological model resulted from gravity modeling in the study area.	72
Table A.1 shows the lithological log modified from Department of Mineral Resources report in 2003.	80

LIST OF FIGURES

	Page	
Figure 1.1	shows (a) Satellite map of Mae On District, Chiang Mai Province in UTM coordinates is in 47Q zone (Google Earth Pro, 2017) black lines indicate seismic reflection surveys and black star marks well location, and (b) the basaltic tuff outcrop in black square zone. The pictures are facing west direction.	3
Figure 1.2	shows (a) The geological map of northern Thailand and that of (b) Mea On District, Chiang Mai Province (Department of Mineral Resources, 2007), black lines indicate seismic reflection surveys and black star marks well location.	4
Figure 1.3	indicates the gravity anomaly map from the ground survey of Mae On area (Department of Mineral Resources, 2015) overlapped with boundary of geological units, black lines are geophysical survey lines and black star presents well log location.	5
Figure 1.4	indicates reduction to the pole of residual aeromagnetic map from Mae On area (Department of Mineral Resources, 1989) overlapped with boundary of geological units , black lines are geophysical survey lines and black star presents well log location.	5
Figure 2.1	represents scheme of seismic method	13
Figure 2.2	exhibits seismic wave ray-paths in the simplest model, a single horizontal layer overlay the half-space medium. The directed, refracted, and reflected waves are represented with red, blue, and green lines, respectively.	15
Figure 2.3	illustrates the travel time curves of directed, refracted, and reflected waves in red, green and blue lines, respectively.	15
Figure 2.4	shows the normal incident P-wave generates reflected and transmitted P-waves.	17

	Page	
Figure 2.5	shows that (a) the reflectors are not lying in hyperbola cause by the effect of surface topography and weathered layer velocity variation and (b) the reflector is lying in hyperbola after applied static correction.	19
Figure 2.6	demonstrates (a) sharp boundaries in frequency domain cause (b) ringing artifact in time domain and (c) window of band-pass filter, f_2-f_3 , and f_1 and f_4 as ramps functions to remove ringing effect in time domain (d) resulted from optimum operator filter.	20
Figure 2.7	illustrates (a) common sketch of shot gather in time and offset domain and (b) its frequency-wavenumber spectrum plot, the reflection events (wanted signals) and different types of noise (linear events) will be separated and easy to identify.	21
Figure 2.8	displays reflection seismogram viewed as convolution between reflectivity function and source.	22
Figure 2.9	shows (a) seismic raypaths associated with a single CMP gather and (b) corresponding hyperbola travel time curve for a horizontal reflector.	24
Figure 2.10	reveals the principle of NMO correction, reflections showed as (a) hyperbolas traveltimes curves are moved up with correct velocities (b) aligned horizontally and then (c) stacked to improve the signal to noise ratio.	25
Figure 2.11	displays velocity analysis with (a) input CMP offset gather, (b) velocity spectrum and (c) constant velocity stack.	27

	Page
Figure 2.12 indicates the location of seismic reflection survey Lines, MO-1, MO-2, MO-3, and MO-4 shown in red, pink, purple, and blue lines, respectively, modify from (Google Earth Pro, 2013), the data from Line MO-2 are used for processing display.	28
Figure 2.13 illustrates seismic equipment (a) elastic wave generator (EWG), (b) hammer 20lb, (c) single geophone and seismic cable (red cable) and (d) Geode TM the acquisition system.	29
Figure 2.14 shows stacking chart of survey Line MO-1 (red and blue dots are shot and receiver locations) with split-spread configuration (yellow zone) and end-on configuration (light-red zone).	30
Figure 2.15 shows stacking chart of survey Line MO-2 (blue star and black dot are shot and receiver locations) with split-spread configuration (yellow zone) and end-on configuration (light-red zone).	31
Figure 2.16 shows stacking chart of survey Line MO-3 (red and blue dots are shot and receiver locations) with split-spread configuration (yellow zone) and end-on configuration (light-red zone).	31
Figure 2.17 shows stacking chart of survey Line MO-4 (red and blue dots are shot and receiver locations) with split-spread configuration (yellow zone) and end-on configuration (light-red zone).	32
Figure 2.18 displays geometry setting of Line MO-2. The receiver and shot locations represent by blue plus and red square. The surface line is in red-circle line constructed base on the straight-line. The black dots are common midpoints. The bins are shown in rectangular area with $1.96 \times 20 \text{ m}^2$ and color bar represents the fold coverage.	33
Figure 2.19 exhibits the total fold coverage of each CMP from Line MO-2	34

	Page
Figure 2.20	shows example shot gather number 6046, (a) raw shot record with its average amplitude spectrum (b) and (c) shot gather after geometry setting, static correction, amplitude scaling and recovery with exponential constant 0.5 to compensate for attenuation loss and bandpass filter 10-20-200-250 Hz with its average amplitude spectrum in (d). 36
Figure 2.21	displays example seismic shot record number 6046 from Line MO-2 with amplitude balancing. The directed wave, reflected wave, air wave, and ground roll are indicated with velocity information in red, yellow, green, and blue lines, respectively. 36
Figure 2.22	displays velocity model of Line MO-2 determined from first arrival time. The velocity values are shown in m/s unit 37
Figure 2.23	demonstrates bandpass frequency analysis of shot number 6046 38
Figure 2.24	is the autocorrelation of shot number 6046 showing the second zero crossing time at about 21 ms. 39
Figure 2.25	demonstrates deconvolution operator length testing with the same predictive lag of 21 ms. 40
Figure 2.26	demonstrates deconvolution predictive lag testing with the same 80 ms operator length. 41
Figure 2.27	displays the signal entrancing of (left) example shot after frequency filter 10-20-200-250 and then (right) after surface consistent deconvolution with operator length 80 ms and predictive lag 21 ms follow by 10-20-90-120 bandpass filter and mean scaling. 42
Figure 2.28	demonstrates velocity analysis of CMP number 90 from Line MO-2, (a) semblance, (b) NMO corrected gather applied by picking velocity function, and (c) constant velocity stack panel, CVS. 43

	Page
Figure 2.29 shows the stacking velocity models from velocity analysis of Line MO-2.	43
Figure 2.30 shows (a) fold coverage in each CMP, (b) final stacked section and (c) stacking velocity models from velocity analysis of Line MO-1	47
Figure 2.31 shows (a) fold coverage in each CMP, (b) final stacked section and (c) stacking velocity models from velocity analysis of Line MO-2	48
Figure 2.32 shows (a) fold coverage in each CMP, (b) final stacked section and (c) stacking velocity models from velocity analysis of Line MO-3	49
Figure 2.33 shows (a) fold coverage in each CMP, (b) final stacked section and (c) stacking velocity models from velocity analysis of Line MO-4	50
Figure 2.34 shows final stacked section of line survey MO-1 (a), MO-3 (b), and MO-4 (c) with interpretation, blue, green, and yellow line are upper (USR), middle (MSR), and lower (LSR) reflectors, respectively.	54
Figure 2.35 displays (a) interpreted seismic reflection section, (b) true electrical resistivity model and (c) S-wave velocity model from Line MO-2.	55
Figure 3.1 expresses high, intermediate, and low anomaly zones indicated by A, B, and C, respectively, on the RTP of residual magnetic map overlapped with boundary of geological units (Department of Mineral Resources, 1989).	58
Figure 3.2 expresses high, intermediate, and low anomaly zones indicated by A, B, and C, respectively, on the ground gravity anomaly map overlapped with boundary of geological units (Department of Mineral Resources, 2015). Two-dimension forward modeling profile line AA' is crossed overlap two seismic reflection lines from west to east direction.	59

	Page	
Figure 3.3	presents the radially averaged power spectrum of sample gravity map and geological source depth approximation, noise and Nyquist wavenumber.	61
Figure 3.4	shows the radially average power spectrum of the magnetic map in	63
Figure 3.5	shows the radially average power spectrum of the complete Bouguer map.	63
Figure 3.6	displays a flowchart diagram for forward modeling. Amea is measured anomaly while Acal is calculated anomaly.	65
Figure 3.7	shows forward modeling form profile AA' (a) the observed and calculated gravity anomalies with density in g/cm^3 (D), (b) the final pseudo-geologic model constrained by (c) seismic cross-sections from line MO-1 (left) and MO-4 (right).	68
Figure B.1	displays the geometry setting of Line MO-1. The surface line shows in red circle. The bins show in rectangular area with $2 \times 20 \text{ m}^2$ and color bar represents the fold coverage.	81
Figure B.2	exhibits the total fold coverage of each CMP from Line MO-1.	81
Figure B.3	displays velocity model determined from first arrival time.	82
Figure B.4	shows example shot gather number 2590 from Line MO-1, (a) raw shot record with its average amplitude spectrum (b) and (c) shot gather after geometry setting, static correction, amplitude scaling and recovery with exponential constant 1 to compensate for attenuation loss and bandpass filter 10-20-200-250 Hz with its average amplitude spectrum in (d).	82

	Page	
Figure B.5	displays the shot gather number 2590 from Line MO-1 (left) after frequency filter 10-20-200-250 and (right) after surface consistent deconvolution with operator length 80 ms and predictive lag 12 ms follow by 10-20-90-120 bandpass filter and mean scaling.	83
Figure B.6	displays the geometry setting of Line MO-3. The surface line shows in red circle. The bins show in rectangular area with 1×20 m^2 and color bar represents the fold coverage.	84
Figure B.7	exhibits the total fold coverage of each CMP from Line MO-3	84
Figure B.8	displays velocity model determined from first arrival time of Line MO-3.	84
Figure B.9	shows example shot gather number 823 from Line MO-3, (a) raw shot record with its average amplitude spectrum (b) and (c) shot gather after geometry setting, static correction, amplitude scaling and recovery with exponential constant 1 to compensate for attenuation loss and bandpass filter 10-20-200-250 Hz with its average amplitude spectrum in (d).	85
Figure B.10	displays the shot gather number 823 from Line MO-3 (left) after frequency filter 10-20-200-250 and then (right) after surface consistent deconvolution with operator length 80 ms and predictive lag 12 ms follow by 10-20-90-120 bandpass filter, mean scaling and bottom mute.	86
Figure B.11	displays the geometry setting of Line MO-4. The surface line shows in red circle. The bins show in rectangular area with $2.43 \times 20 \text{ m}^2$ and color bar represents the fold coverage.	87
Figure B.12	exhibits the total fold coverage of each CMP from Line MO-4	87

Figure B.13 displays velocity model determined from first arrival time of Line MO-4. 87

Figure B.14 shows example shot gather number 317 from Line MO-4, (a) raw shot record with its average amplitude spectrum (b) and (c) shot gather after geometry setting, static correction, amplitude scaling and recovery with exponential constant 0.25 to compensate for attenuation loss, FK filter and bandpass filter 10-20-200-250 Hz with its average amplitude spectrum in (d). 88

Figure B.15 displays the shot gather number 317 from survey Line MO-4 (left) after FK filter and (right) after predictive deconvolution with operator length 80 ms and predictive lag 20 ms and, (right) after frequency filter 10-20-90-120 follow by mean scaling and bottom mute. 89

Figure C.1 shows (a) true electrical resistivity model and (b) S-wave velocity model from Line MO-2. 91