CHAPTER 1

INTRODUCTION

One of the main objectives to process the seismic and ground-penetrating radar (GPR) data is to suppress noises and enhance signals in profile. Some seismic noises can be greatly reduced by filtering methods including deconvolution, f-k filtering and stacking. Most methods can be applied for both coherent and random noises. The GPR profiles can be contaminated with extraneous reflections such as air wave and multiple reflections. The GPR signals can be enhanced by filtering methods. They include dewow filtering, time-zero correction, frequency filtering, deconvolution, velocity analysis, gain function and migration.

Deconvolution and NMO stacking are the most effective for noise attenuation. Deconvolution can remove the multiples and coherent noises from the data. NMO stacking can reduce the coherent and random noises. Unfortunately, these techniques do not always provide sufficient noise suppression. The multichannel techniques such as f-k filtering were used to eliminate noise such as ground roll and air wave, when noise has properties to be illustrious from signal (Yilmaz, 2001).

In some case, noises of seismic or GPR data cannot be suppressed using the general filtering or basic processing in support of improvement signal to noise ratio. Special technique, the singular value decomposition (SVD) filtering can be suppressed the coherent and random noises and implemented in shot gather, CDP gather, NMO corrected CDP gather, and stacked sections (Ulrych et al., 1988). The SVD filtering can extract between signals and noises in multi-trace data.

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It can be applied to enhance the signal to noise ratio (S/N) in data sections containing laterally coherent events (Andrews and Patterson, 1976).

1.1 Research Objectives

1. To develop the SVD filter code using Mathematica® Software.
2. To suppress coherent and random noise in seismic and GPR data.
3. To compare the quality improvement of seismic data and GPR after filtering by SVD filter.
4. To compare efficiency of noise suppression between SVD filter, f-x prediction filter and 2-D median filter.
5. To correlate the seismic stack section with borehole logging data.

1.2 Study Scope

In this thesis, Mathematica® Software is used for creation and development the SVD filter code. The seismic and GPR data processing are done in VISTA® 2D/3D Seismic Processing Software version 5.5. the filters are applied on forms of seismic shot gather, shot gather, CDP gather, NMO corrected CDP supergather and final stack section and GPR common offset gather. The SVD filter results of seismic and GPR data are compared with f-x prediction filter and 2-D median filter results. Finally, the result of seismic section is correlated with borehole logging data in Mae Sot Basin.

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1.3 Seismic Data Set from Mae Sot

Mae Sot oil shale is the largest oil shale resource in Thailand. The basin is closed to the border between Thailand and Myanmar. Mae Sot Basin is located in Mae Sot district and Mae Ramat district, Tak province, Thailand. Oil shale is commonly exposed in several creeks of Mea Sot Basin. The most of oil shale was low quality and not economically competitive compared to other natural fuels. But the technology has opened a chance to develop oil shale. The chemical component produce of oil shale can be used in industry such as resin, plastic and petroleum product (Department of Mineral Resources, 1997). In the future, if the Mae Sot oil shale wanted be developed for alternative sources in the country, the seismic reflection data will be very useful to image geologic structure in the area.

In 2008, the seismic method was surveyed by Department of Mineral Fuels (DMF) and Electricity Generating Authority of Thailand (EGAT) at northern of Mae Sot district, Tak province. They needed to know the geological structure for estimate the volume of oil shale.

The seismic raw data from Mae Sot Basin presented rather poor quality of low reflection signals and weak first breaks. They contaminated with many noises. The seismic noises came from strong wind and soft raining. An example of a raw shot gather in the Figure 1-1 is contaminated with ground roll, air wave (A), constant low frequency signal, (B) and human activity events (C). These are the problems which need to be eliminated by data processing to enhance signal to noise ratio.

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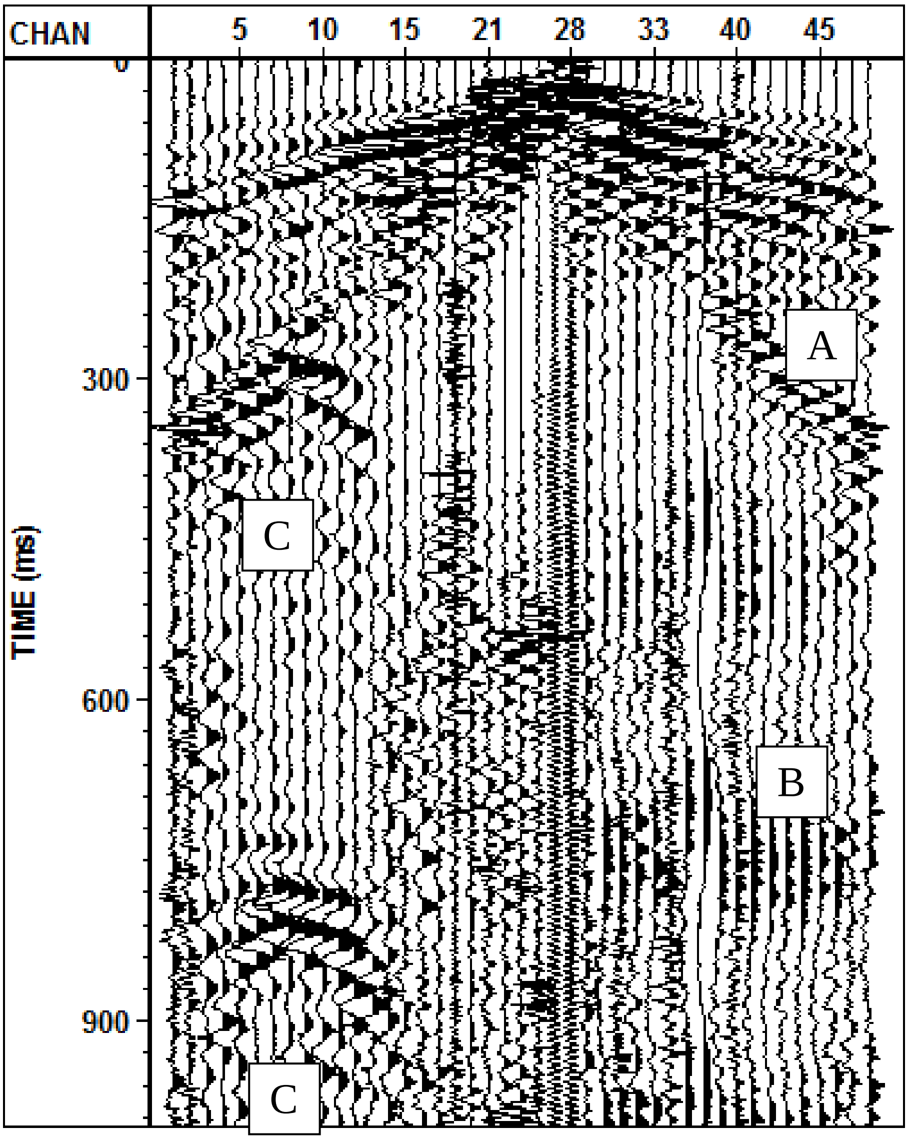

Figure 1-1. An example of a raw shot gather.

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Table 1-1 Parameters of seismic data acquisition.

Options	Parameters used
Geophone spacing	5 meters
Shot spacing	5 meters
Maximum far offset	240 meters
Record length	4000 millisecond
Sampling interval	1 millisecond
Number of shot	1260
Number of trace / shot	48
Configuration	split-spread
Source type	air-gun
Data format	SEG-2

1.3.1 Study Area

The MSO-0450 seismic line in total 6 kilometers length was selected for this study. Seismic survey was conducted at Bann Huai Kalok, Mae Sot district, Tak province as shown in Figure 1-2.

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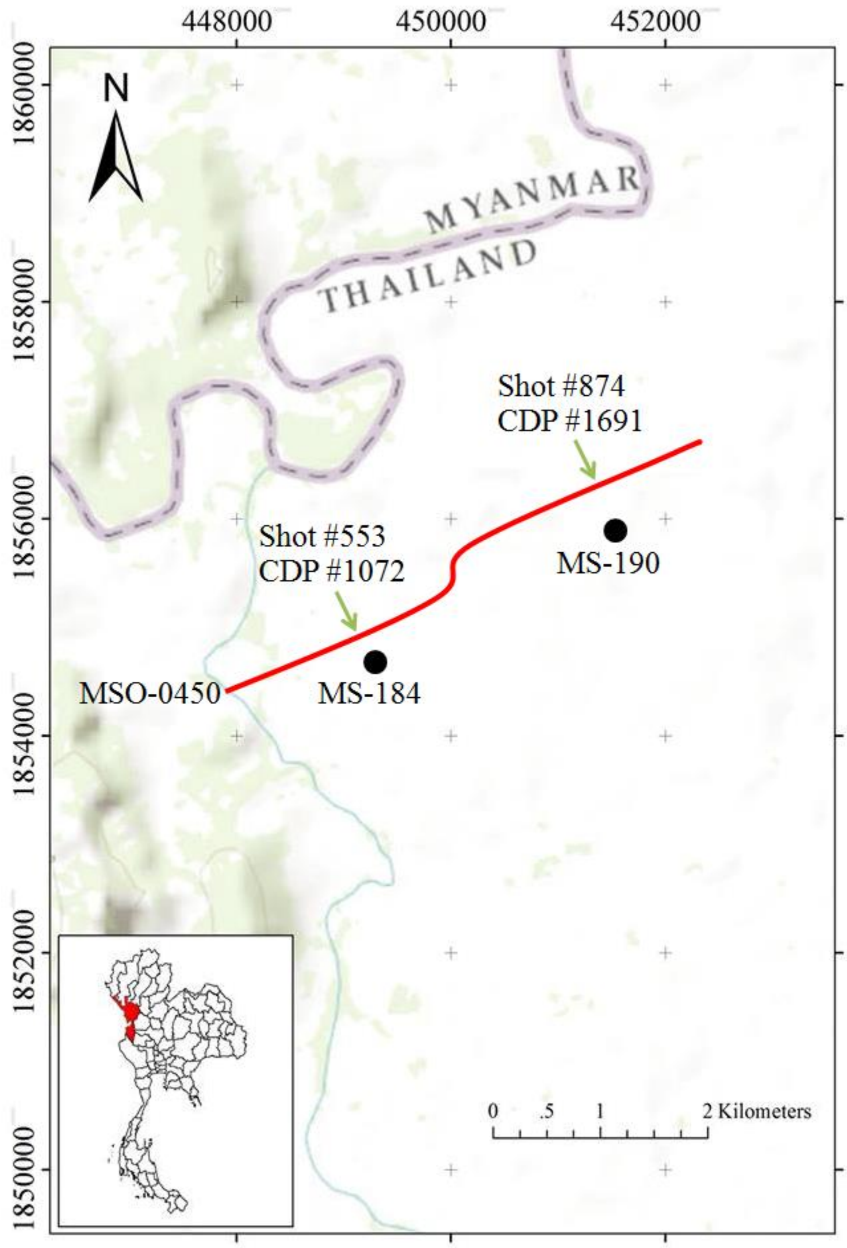

Figure 1-2. The seismic surveys map in Mae Sot district. The red line is MSO-0450 seismic line, the black dots are location of wells MS-184 and MS-190.

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1.3.2 Morphology and Geology of Mae Sot Basin

The gravity anomaly map on Mae Sot Basin at Bann Huai Kalok consists of 2 sub-basins, the northern sub-basin and the southern sub-basin (Figure 1-3). The orientation of oil shale bedding dips about 5-25° west. The oil shale layer in the northern sub-basin is shallower than the oil shale layer in southern sub-basin. The thickness and conformity of oil shale layer in the northern sub-basin is thicker and more continuous than the southern sub-basin. The distribution of oil shale area in the northern sub-basin is broader than in the southern sub-basin (Suwannathong and Khummongkol, 2007). The sedimentary rocks in the Tertiary basin consist of shale, marlstone, sandstone and conglomerate sandstone. The depositional environments can be classified into 2 types: fluvistile and lacustrine (Thanomsap and Sitahirun, 1992). The stratigraphy of Mae Sot Basin consists of three formations.

1. Mae Ramat Formation, the lowest formation, comprises sedimentary rocks deposited along the alluvial plain and in alluvial fans. The rocks consist of conglomerate, sandstone, limestone, siltstone and mudstone, unconformable overlying pre-Tertiary rocks.
2. Mae Pa Formation is the middle formation between Mae Ramat Formation and Mae Sot Formation. The rocks comprise two units of sedimentary rocks that were deposited in lacustrine and fluvio-lacustrine environments. They consist of pisolitic limestone, peloidal rocks, fosiliferous limestone of the estuary, channel and shore. They are found at the boundary of the southern basin.

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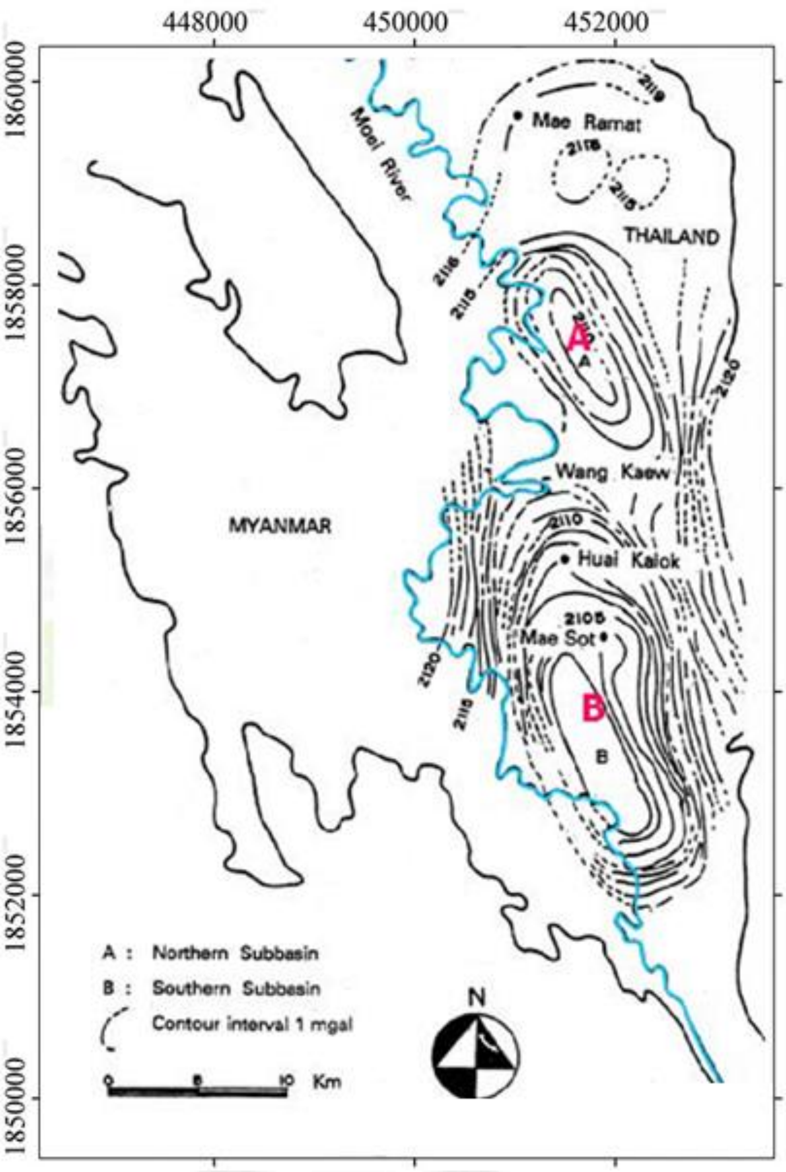

Figure 1-3. The gravity anomaly of Mae Sot Basin at Bann Huai Kalok, (A) northern sub-basin, (B) southern sub-basin (Suwannathong and Khummongkol, 2007).

3. Mae Sot Formation can be divided into two units:

   1.) Sandy shale, sandy marlstone, silt-clay stone and oil shale. These rocks deposited in the fluvio-lacustrine environment. They are found in the western and northern part of the basin covering Bann Mae Pa, Bann Huai Kalok and north of Bann Mae Pa Thai.

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2.) Grey to greenish grey shale and oil shale. The rocks deposited in a lacustrine environment. They are found in the middle part of the basin from Bann Huai Kalok to Bann Mae Ku Luang. The quality of oil shale varies from low to high grade with thickness over 30m in some areas (Suwannathong and Khummongkol, 2007).

1.4 GPR Data Set from Wat Pan Sao

Wat Pan Sao was constructed in the age of Mangrai kingdom between a reign of King Phaya Yoo (1336-1355 A.D.) and King Phaya Kue Na (1355-1385 A.D.). Wat Pan Sao is a mixed art of Lanna, Sukothai and Lanchang cultures. Wat Pan Sao was destroyed during the wars and was used as a field for feeding elephants. Some of the temple area was intruded and portioned out to private owners. Year 2007 A.D., Malaria Curing Center occupied the area and latterly gave the area back to the office of the Buddhism of Chiang Mai (Khwanmuang, 2012). The excavations of archaeologists were performed north of Malaria Curing Center indicative the old wall of temple in the smell area at a depth of about 150 centimeters. The sample excavation at the site shown the old wall overlain by two floodplain sediment in layers 3 and 4 (Figure 1-4). The sequent of landfill layer from Malaria Curing Center is overlain these sediment layers. An area in front of northern of Malaria Curing Center is the suspected location of the line of the old wall. This case may extend from the excavation point to the south and would be used clearly GPR sections.

GPR data from Wat Pan Sao was contaminated strong low frequency noise, high frequency noise and ringing noise. The GPR noises appeared nearly horizontal. These noises were needed to eliminate for data quality improvement.

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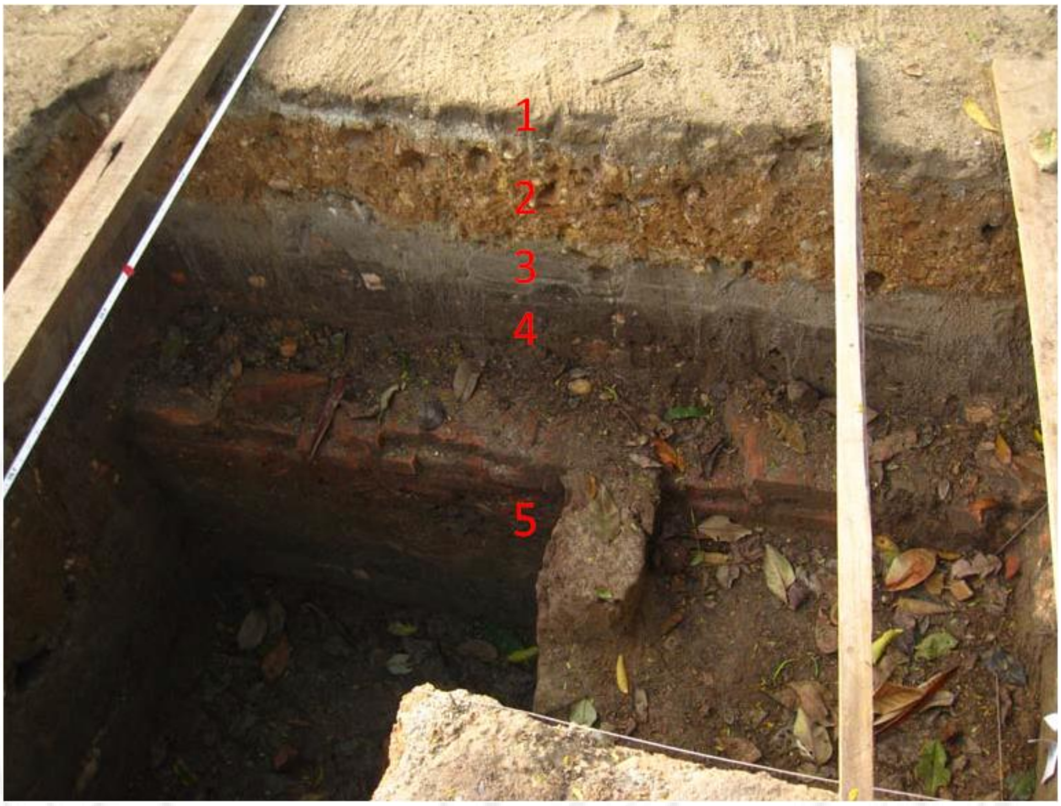

Figure 1-4. The sample excavation at the site with layers labeled at Wat Pan Sao.

A recording instrument SIR-20 with 200 MHz center frequency antenna manufactured by Geophysical Survey System Inc. (GSSI) from Department of Mineral Resources, Thailand, was operated with 1.0 meter source-receiver offset, 128 stacks per record and line separation of 0.5 m. The data set was time-zero correction prior to recording. An example of a GPR section in the Figure 1-5 shows the problems which need to be eliminated by data processing to enhance signal to noise ratio.

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Table 1-2 Parameters of GPR data acquisition.

Options	Parameters used
Source - receivers spacing	1 meters
Record length	100 nanosecond
Center frequency antenna	200 MHz
Sampling interval	1 nanosecond
CDP trace	128 stacks per record
Source type	SIR-20
Data format	SEG-Y

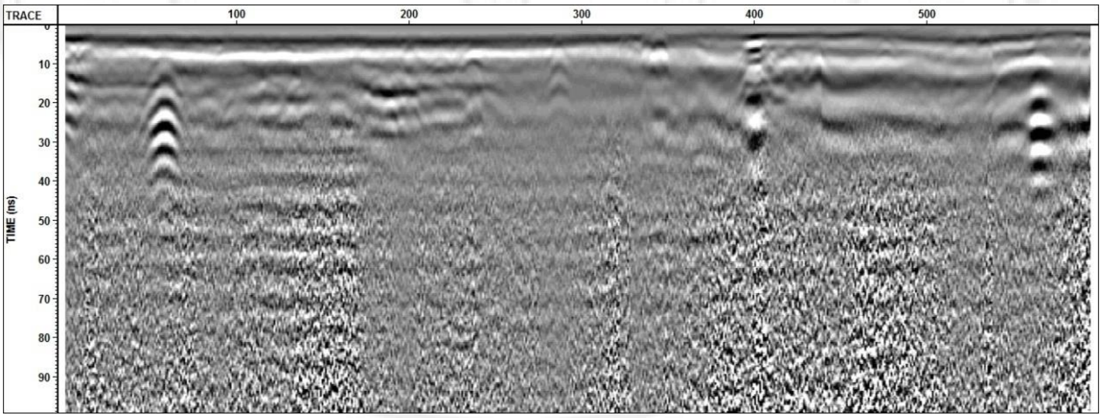

Figure 1-5. An example of GPR section from study area Wat Pan Seo study area after time-zero correction and DC remover.

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1.4.1 Study Area

In the past, Finearts Department of Thailand found the old wall in the smell area of Wat Pan Sao. An area to collect GPR data (green box) is located in Wat Pan Sao, Chiang Mai city, near Maharaj Nakorn Chiang Mai Hospital with grid size 30×30 square meter, 60 lines (north to south) as shown in Figure 1-6. This GPR data set was recorded during Geoscientists Without Borders (GWB) project held in Thailand at the end of 2010.

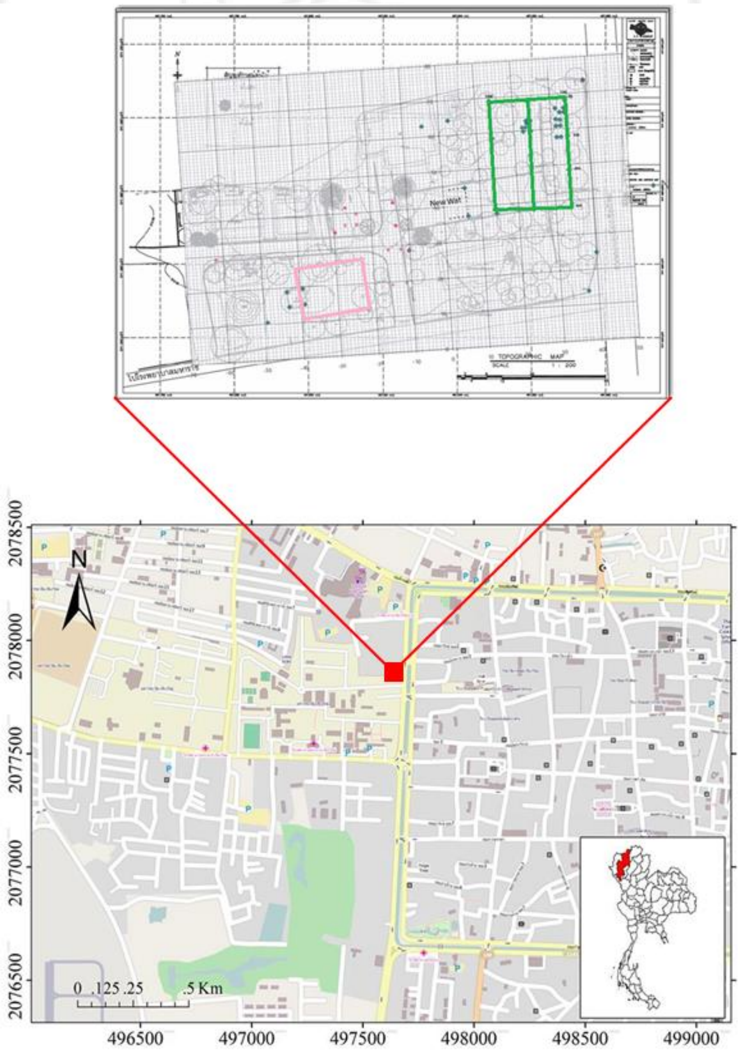

Figure 1-6. Map of GPR data acquisition area at Wat Pan Sao. The green box shows the coordinates in the study work field (modified from Google Inc, 2013).

1.5 Literature Review

Freire and Ulrych, (1988) applied vertical seismic profiling (VSP) using SVD filter. The first few values of eigenimages of VSP section contained the contributions of the horizontally aligned downgoing waves. The last few values of eigenimages contained the contributions of uncorrelated noise. This filtering presented the method of upgoing- and downgoing-wave separation in VSP sections. They proposed that the eigenimages represent a very useful and interesting decomposition of the input data.

Bekara and Van dar Baan, (2007) used SVD filtering to improve the signal to noise ratio of stacked seismic sections. SVD filtering was compared with f-x prediction and 2-D median filters on a set of synthetic and real data sections. SVD filtering is better than f-x prediction and 2-D median filters. The random noise can be suppressed in seismic sections after filtered by SVD filtering. They suggested that SVD filtering is a good method, easy to implement and convenient to use because its performance depends on few parameters but SVD filtering performs less well in enhancing weak events or events with conflicting dips.

Kim et al., (2007) tested removal of ringing noise in GPR data by f-k filter, deconvolution, radon transform and SVD filter. The comparative analysis results show that the SVD filtering was successful and more effective than f-k filter, deconvolution and radon transform. The ringing noise can be successfully removed by the SVD filtering method with less distortion of GPR signals.

Chiu and Howell (2008) used SVD filtering to separate a coherent noise in a localized time-space window on common shot gather and performed the noise attenuation by adaptively subtracting the noise from the input data. They suggested that various filtering methods were developed to suppress source-generated noises.

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Traditional, global filtering methods such as f-k and tau-p filters show limited success in attenuating ground roll or scattered energy because of spatial aliasing and irregular spacing in the data. In addition, global filtering tends to create amplitude artifacts by smearing the amplitudes spatially. The usual method in attenuating air wave is surgically mutes to remove both the signals and noises completely but the SVD filter is effective in attenuating various types of coherent noises including ground roll, near-surface scattered events, air wave, and random noises.

Cary and Zhang, (2009) presented a method of applying SVD filtering to the problem of attenuating coherent noise on a seismic shot records. By each shot records within ground roll cone is assumed to consist of the sum of coherent noise and signal. The number of eigenimages is related to the signal separation. The ground roll was effectively attenuated by the first eigenimages. This method is better than traditional filtering methods such as f-k filtering or tau-p filtering. The method of applying SVD filtering to the problem of attenuating coherent noises on seismic records is able to automatically remove coherent noise and preserve signals.

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