INTERPRETATION OF A SHALLOW SEISMIC DATA IN A SITE INVESTIGATION FOR SUBSEA CABLE INSTALLATION AT A SITE IN THE GULF OF THAILAND

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ABSTRACT: Interpretation work very expensive and it is such specialized that only a small number of subsurface experts could handle. Spending a lot of money for one interpretation program is not a good reason to exact the information from a 2D-shallow seismic data. OpendTect an open source and it used worldwide by E&P companies and geoscientists for interpretation of seismic data and as a R&D platform is employed to utilized 2D and 3D data set in this study. The information was interpreted by the open source base and was convinced by plugin – licenses base.

Keywords*:* 2D – shallow seismic, OpendTect, Fault enhancing filter, Dip-steering median filter, Sequence stratigraphic interpretation system.

GENERAL INSTRUCTIONS

The Gulf of Thailand contains several structurally complex trans-tensional basins. These are made up of asymmetrical grabens filled with non-marine to marginal marine Tertiary sediments as old as Eocene.

Accurate mapping of the seabed is an essential requirement for the successful installation of a subsea cable. The cable route survey should identify the seabed topography and give an indication of the seabed soils. Some ground truthing of the geophysics survey data should be provide by sampling and in situ testing of the seabed sediments. The survey is undertaken to determine the final location for the cable and assess the potential for burial of the cable along that location. It will comprise a geophysical and geotechnical or burial assessment survey (BAS) element. Sub-bottom profiling system is one part of geophysical elements that is widely used for subsea cable installation, i.e., seismic profiling method, side scan sonar method and bathymetry as shown in Figure 1.

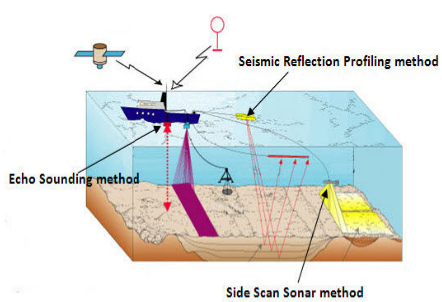

Figure 1 Shallow subsea survey

OpendTect is a seismic interpretation software system in an Open Source environment. It enables the user process, visualize and interpret multi-volume seismic data using attributes and modern visualization techniques such as stereo viewing and volume rendering. For more advanced work commercial and free plugins are available.

Sub-bottom profiling system

At the bottom of the ocean, there are layers of sediments that contain information about the Earth's history. Sound is used to map and characterize these sediment layers. The layers of the seafloor are examined with seismic reflection and refraction.

Sub-bottom profiling systems are used to identify and characterize layers of sediment or rock under the seafloor. They utilize the principle of seismic reflection. Echo-sounding is a basic type of seismic reflection. It is used to measure the depth of the water. A sound pulse is sent from a ship and that sound reflects off the seafloor and returns to the ship. Sonar system is used to images the sea floor. Sound waves sound waves detect underwater objects by listening to the returning echoes. The distance to the object or the seafloor can be calculated by measuring the time between when the signal is sent out and when the reflected sound, or echo, is received.

Seismic reflection uses a stronger sound signal and lower sound frequencies than echo-sounding in order to look deeper below the seafloor. Low frequency echo sounders can penetrate a short distance into the seafloor to study the upper sediment layers. The sound that penetrates the seafloor may also reflect off layers of sediment or rock within the seafloor. The reflected sounds travel back up to the surface as shown in figure 2. The time it takes the sound to return to the ship can be used to find the thickness of the layers in the seafloor and their position. It also gives some information about the composition of the layers.

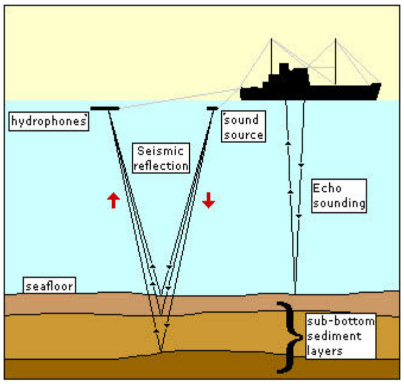

Figure 2 Seismic reflection profiling schematic

STUDY LOCATION

The purpose of this study is to determine subsea information for laying electric cable that operated by Department of Mineral Resources of Thailand (DMR) and was authorized by Provincial Electricity Authority of Thailand (PEA). This survey study located in offshore that started at Laem Ngob district to Koh Chang district. The plan of survey started at shore in Laem Ngob district to shore in Koh Chang . The base line has distance about 9 kilometres, and there are two corridor lines parallel with base line as shown in figure 3. The spacing between the base and corridor line are 25 meters. In addition, the eighty five cross lines are perpendicular to base line, they are 100 meters long and the spacing between them is 100 meters.

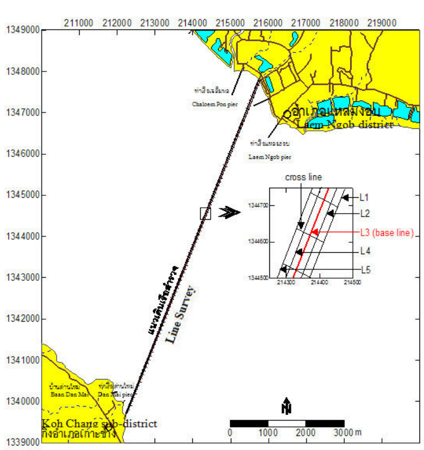

Figure 3 Map location

The seismic data files on SEG-Y were acquired from GeoPluse sub-bottom profiler that performed to be both transmitting and receiving equipment.

SEISMIC DATA ACQUISITION

The sound waves are generated by seismic sound wave source and then the sound waves are transferred to the processor equipment. This equipment is used to control the frequency of sound wave for transmitting and receiving. The suitable frequency is transferred to the transmitting equipment for transmitting into the subsurface. The reflected sound waves reflect to receiving equipment. Some equipment can be both transmitting and receiving in the same equipment. It transfers the sound waves to the processor equipment again. The processor equipment is used to control and chooses the suitable sound waves. The suitable sound waves are stored and created in SEG Y format (Figure 4).

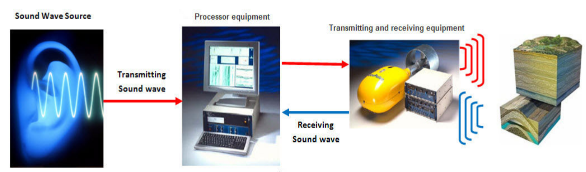

Figure 4 Seismic reflection profiling (High resolution) data acquisition

SEISMIC DATA PROCESSING

Although the seismic reflection profiling, using the high frequency, is the high resolution seismic data, it is still processed to remove some unwanted information such as noises. After processing it is also improved the seismic traces visibility. OpendTect has many attributes to process the seismic data, one type of processing attribute is called Fault enhancing filter that is in the open source base and the other type is in the plugin-license base, which is called Dip steering median filter.

Fault enhancing filter

Fault enhancing filter can help sharpen, suppress non-fault discontinuities, stable, easy tunable and fast. Two standard filters for data enhancement in OpendTect are Diffusion and Median dip filter. Diffusion uses a position attribute while Median dip filter uses the volume statistic attribute.

Fault enhancement filter utilizes a combination of attributes to extend seismic events into noisy fault-zones, enhancing fault visibility. Where it want to sharpen and magnify the faults, there where it want to laterally smooth the seismic to suppress noise in Similarity and a transition zone in between. This is easily done using in the

OpendTect's mathematics attribute. The smoothing is than done using a structurally oriented Median Filter (MF), or Averaging Filter, implemented using volume statistics attribute.

Volume statistic is the one type of attributes, which is used with Median filter (MF) or Averaging filter of Fault enhancing filter. It returns statistical properties, which is used in fault enhancing filter. The input values are collected from a cube or cylinder around the reference point defined by parameters, time-gate, shape, and Inl/Crl stepout. It is quite easy to see the difference between the before and after processing Fault enhancing filter. The vertical lines are the noise of seismic trace so the median filter (MF) of Fault enhancing filter sharpens the horizon and is closely the noise. In addition, the seismic traces were done to more sharpen when they are compared with the seismic traces before processing Fault enhancing filter. Figure 5 shows the seismic traces before processing Fault enhancing filter and after processing Fault enhancing filter.

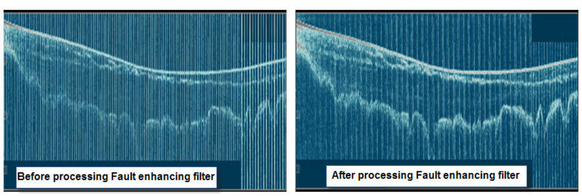

Figure 5 Seismic traces before and after processing Fault enhancing filter

Dip steering median filter

Dip-steering is a mechanism of OpendTect in commercial plugin to accurately follow the local dip and azimuth of seismic events in 2D and 3D data. Dip-steering is used for structurally oriented filtering, improving multi-trace attributes, and to calculate some unique attributes.

The steering plugin for OpendTect supports two different modes of data-driven steering, Central Steering and Full Steering. The steering cube is created by BG algorithm and then the specified input data is filtered with the commonly used Fast Fourier Transform (FFT) or Butterworth filter. The difference between using the FFT or Butterworth filtering method is that, for the FFT, one considers the complete trace while the Butterworth filter, only a small segment, depending on the selected number of poles, is taken into account. It has to keep in mind that using the Butterworth Filter results in a small shift in the seismic data. In BG algorithm, Noise problem is solved using Median Filter (MF) during the creation of steering cube. The vertical noises were significantly eliminated when the comparison with the seismic traces before processing Dip steering median filter. The seismic traces after Dip steering median filter was performed looks more clearly so the interpretation is easier to be done and the final results were more accurate. Figure 6 shows the seismic traces before processing Dip steering median filter and after processing Dip steering median filter.

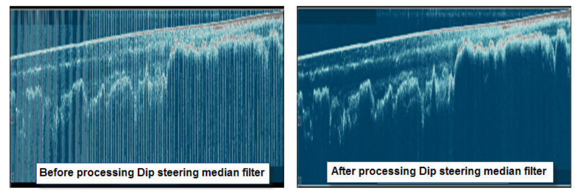

Figure 6 Seismic traces before and after processing Dip steering median filter

DATA INTERPRETATION

Seismic interpretation is the process of determining information about the subsurface of the earth from seismic record that was processed. It may locate new prospects for drilling, or may guide development of an already discovered field. The basic purpose of seismic interpretation is to extract all available geologic information, including includes structure, stratigraphy, rock properties, and perhaps reservoir fluid changes in space and time.

OpendTect is a one program that can interpret the seismic data with the open source platform. Horizon tracking is a function that was used for data interpretation of this study. A mapping horizon is the most common activity in seismic section interpretation. A horizon is a reflection that appears on sections over some geographical extent. The horizon infer that the type of sediment must have changed, this change of sediment was due to a change of relative sea level, a change of sediment source, a change of climate, a change of the direction of sediment transport and cataclysmic events far from the area of deposition-never to a purely local circumstance.

The horizon tracking is the operation which identifies the sequence of the sediment. The layers are separated into three layers for the interpretation. The topmost horizon is represented the sea bed, the layer below the topmost horizon and the middle horizon is called 'Sedimentary Layer 1'. The middle horizon separates the layers into two layers. This first layer (the upper layer) is the sedimentary layer 1 and the second layer (the lower layer) is called 'Sedimentary Layer 2'. The lowest horizon is used to separate between the sedimentary layer 2 and the layer below the lowest horizon is called 'Sedimentary Layer 3'. Figure 7 shows the interpretation of seismic traces using Horizon tracking.

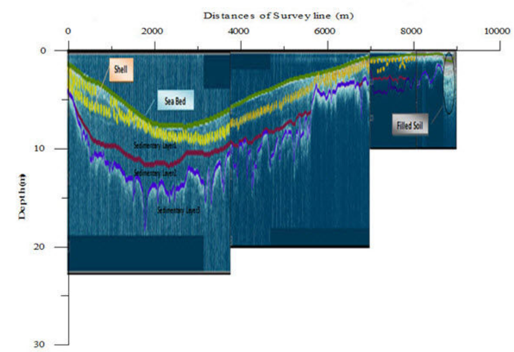

Figure 7 Interpretation of the seismic traces using Horizon tracking function

Sequence stratigraphic interpretation system (SSIS)

Sequence stratigraphy, the method that originated from the study of seismic patterns in the 1970's, considerably improved our insight in the accumulation and preservation of sediments in sedimentary basins to sequence stratigraphy (Catuneanu, 2002). Sequence stratigraphic interpretation system (SSIS) is a licensing plugin of OpendTect. Unique capabilities in SSIS are automated tracking at sub-seismic resolution of chrono-stratigraphic horizons, Wheeleer transformations of 3D seismic data, and systems tracts interpretation. The basic concept of OpendTect SSIS is that all stratigraphic events are auto detected by the system and placed in to stratigraphic order (Ligtenberg et al., 2006).

The OpendTect SSIS workflow is an iterative process that consists of four basic steps, i.e., tracking, assign chronostratigraphy, wheerler transform, and interpretation. The tracking step is a step, which is done for tracking horizon boundary of area of SSIS. The assign chronostratigraphy step is a crucial step in the approach as it determines the accuracy of the wheeler transform and the wheerler transform step is a step, which transforms the seismic volumes to the wheerler domain. Finally, the interpretation step is a step for visualization as overlays over sections in the normal and wheeler transformed domains.

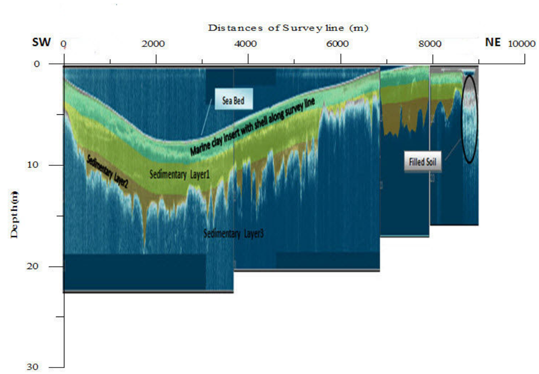

Figure 8 Interpretation of seismic traces using SSIS

SSIS separated the layers of the area, which was difficult to identify, into three layers by colors. The areas between the topmost horizon and the lowest horizon were divided into three layers as represented by the color. The green color represented the shell layer and the yellow color represented the sedimentary layer 1. The sedimentary layer 2 was represented by the orange color. Figure 8 shows the interpretation of seismic traces using SSIS.

DISCUSSIONS AND CONCLUSIONS

The data processing were performed by two operations, Fault enhancing filter and Dip steering median filter, which preceded the interpretation step. The data enhancement by Fault enhancing filter enhanced the horizon visibility, while the data enhancement by Dip steering median filter removed the noises of seismic data (Vertical noises). They two filters need to be operated together to provide the optimal results.

The interpretation with horizon tracking was performed under the horizon creation. The sedimentary layers were divided by the horizons and the texts and annotations could be added for completed interpretation.

SSIS separated the sedimentary layers in color by the system tracks interpretation process that the layers were divided with color. The annotations and texts could also use to complete the interpretation with SSIS.

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