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Challenges of 4C seismic acquisition and processing offshore Sarawak

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Marine seismic has so far being dominated by 2D and multi streamer 3D seismic acquisitions. However in recent years it has diversified to include ocean bottom recording. In November 1999 Sawarak Shell acquired six 2D four component (4C) ocean bottom cable (OBC) lines over carbonate fields. In this paper we will describe the acquisition and processing of the survey.

Acquisition

The acquisition was carried out by Schlumberger Geco-Prakla from 16th November 1999 to 26th November 1999. Two survey vessels were utilised during the operation, one recording vessel and the other a source vessel. All data were acquired using the Geco-Prakla developed multiwave cable, known as the PXYZ cable. A seismic source is towed over a pre-plotted sail-line by separate source vessel. Each shooting sequence consists of the following: 1) seismic spread (receiver line) move using drop-drag technique, 2) positioning of receivers, and 3) a source vessel shooting pass (shot line). A three km cable with 120 receiver groups at 25 m interval was used. Line length are typically multiple of cable length.

Processing

The processing was done using Shell's Standard processing package interleaved with specially developed tools for multi component processing. In particular the Hydrophone-geophone combination processing and combined PSDM solution for pp and ps data.

P and Z component

The main reason for hydrophone-geophone combinations is deghosting. Since receivers are deployed at the sea floor, the spectrum notches caused by receiver ghost and reverberation from water layer generally fall in the signal band. As geophone measures a vector quantity, and can discriminate between up and down going energy. In time domain reflection from sea surface ($R \sim -1$) exhibit a polarity reversal on hydrophone but not on the geophone. In frequency domain, their corresponding spectra are complementary and their combination gives a flatter spectrum. After combination the two components i.e. p and z becomes one which we refer to as PZ.

PS–X (inline) component

In marine seismic surveys, the initial energy are generated as P waves and are converted to S waves at the interfaces. Here we looks at the PS converted waves in the inline direction since they are the dominant S converted energy. The main pre-processing steps in PS data are residual statics and de-reverberation of P-reverberation energy generated at the source. Finally, as ray path of PS data are asymmetric special tools are required to properly image the common conversion point in contrast to common mid point for PP data. The common conversion point varies with both offsets and Vp/Vs ratio. In our processing we solve this by doing pre-stack depth migration whereby we derived both p and s velocity model in a single step. For the PS data we migrated the positive and negative offsets separately since their ray path are asymmetrical positive and negative imaged would inhibits lateral shifts if the velocity models are not right. Therefore the positive negative PS images are a good quality control of the final PS migrated data.

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PS-Y (crossline) component

In the 2D survey the Y component of the PS converted energy should consist of noise as the source-receiver azimuth are aligned in the in line direction, no Y signal energy would be generated except for: 1) off plane converted PS energy where there will be PS-Y component, 2) polarisation of S waves. For this component we merely make a common conversion point (assuming a constant Vp/Vs ratio) stack.