Identification of gas hydrate on bottom-simulating reflector characteristics with 2D seismic pre-stack time migration of North Bali Waters

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Abstract. Gas hydrate is a physical compound composed of gas molecules that are formed in a seabed layer characterised by high pressure and low temperature. It is known as one of the alternative non-conventional hydrocarbons besides petroleum and natural gas. One of the identified areas of gas hydrate stability zone is in the North Bali Waters. The North Bali Waters is part of the North East Java Basin, which has oil and gas exploration and production, both conventional and non-conventional. One method of identifying the content of gas hydrates is by looking at the appearance of the Bottom Simulating Reflector (BSR) as shown on the Pre-Stack Time Migrated seismic sections. The detection of gas hydrate zone is determined by the presence of high amplitude, reversed polarity reflection and cross-cut reflection of sedimentary layer. This study aims to determine the existence of a BSR in the waters of North Bali. The procedures for analysing the existence of Bottom Simulating Reflector in this study are pre-processing, processing, and interpretation of 2D marine seismic data. The result shows gas hydrates found with indicated Bottom Simulating Reflector on CDP 35-812 at TWT depth of 1526-1582 ms, characterised by high amplitude-reverse polarity.

Keywords: Bottom-Simulating Reflector, gas hydrate, north Bali waters, pre-stack time migration

1. Introduction
Underwater acoustic technology is an underwater detection technology that uses a mechanism release sound energy and receives the reflected sound waves returned by underwater objects. There are many applications of underwater acoustic technology, and the one application is to detect seabed sediment layers that contain mineral resources [1]. An example of resources that used to be alternative non-conventional energy is gas hydrates. Gas hydrate (Methane Hydrate) is a physical clathrate compound on which the compounds are trapped in a crystal cell consisting of water molecules held in place by the strength of hydrogen bonds. The formation of gas hydrates occurs when the environment of water and natural gas is at low temperature and high pressure. This condition often occurs in oil and gas well exploration areas [2]. The process of identifying gas hydrates is marked by finding a Bottom Simulating Reflector (BSR) as an early indicator of the presence of gas hydrates in the seabed sediment layer [3]. BSR is located at the bottom of the hydrate stability zone, where the pressure and temperature conditions are at the phase boundary between the hydrate and the free gas [4]. The application of a low frequency acoustic in the seismic method causes the penetration ability of the
sound energy into the sediment layer [5], so that the reflection seismic which is considered suitable in detecting oil and gas resources also useful to detect gas hydrates. This study focuses on the identification of gas hydrate area through BSR identification on 2D seismic cross-section from the North Bali Waters.

2. Material and Methods
The study area is located in North Bali waters (Figure 1). The data used in this study are one 2D seismic profile.

![Figure 1. Study area map of North Bali Waters.](image)

2.1 Data Processing Methods
Seismic data is processed in ProMAX 2D software and consists of several steps. The processing steps can be seen in the flow chart (Figure 2). Pre-processing consists of data inputting, geometry check, trace editing, recovering true amplitude, surface wave attenuation, signal deconvolution and F-K Filtering.

Data inputting is the initial step in seismic data pre-processing, where raw data in SEG-D format feed into ProMAX 2D software. Geometry check step was carried out by entering several acquisition parameters (Table 1). The aim is to provide detailed information about the parameters during seismic data acquisition. Trace editing consists of trace muting aimed to clean noise generated in the water column; trace length cut, aimed to cut the length of traces, so only the data needed will be processed further; and bandpass filtering which is aimed to select certain frequency bandwidth. The type of Bandpass Filter used in this study is the Ormsby Bandpass Single Filter with the values are 5, 8, 73 and 83.5 Hz.

True Amplitude Recovery is a process of adjusting the amplitude in order to compensate for signal attenuation [6]. Surface Wave Attenuation is the process of forming low frequency arrays to attenuate noise that comes from surface waves [7]. Deconvolution is a process of wavelet compression that aims to improve the temporal resolution of seismic recorded data. F-K Filtering is a process of noise attenuation through transforming seismic data in the time and range domain into the frequency and wavelet number domain using Fourier transform [8]. The type of filter used in this process is an...
arbitrary polygon which refers to a shape of the picking. The polygon-shape picking will filter out noise outside of the picking area.

Velocity Analysis is a process to pick the best acoustic velocity value in the sediment for stacking the traces. The type of velocity analysis is a conventional semblance used to estimate NMO velocity as a function of zero-offset time [9]. Surface-related multiple elimination (SRME) is a method to remove surface relative multiple. SRME predicts all surface-related multiples, assuming that the surface is perfectly reflecting boundary and the input data have been regularised prior to the application of SRME [10]. ProMAX 2D SRME consists of several modules, such as SRME regularisation, SRME Macro, SRME Un-regularization, SRME Match Filter, and SRME Adaptive subtraction. Pre-Stack Time Migration (PSTM) is the last step of the seismic data processing used to migrate the seismic data before stacking. The type of the PSTM used was Prestack Kirchhoff 2D Time Migration. Since SRME process attenuates the amplitude of corresponding signals, a process called true amplitude recovery (TAR) was carried out.

Table 1. Acquisition parameter of seismic line data DS-12.

| Acquisition parameter         | unit | Line DS-12 |
|-------------------------------|------|------------|
| Shot Point                    | -    | 1491       |
| Shot Interval                 | m    | 25         |
| Group Interval                | m    | 12.5       |
| Active Channel                | -    | 48         |
| Near/Minimum Offside          | m    | 150        |
| Nominal Source Depth          | m    | 6          |
| Nominal Receiver Depth        | m    | 7          |
| Sail Line Azimuth             | degree | 0          |

Figure 2. Illustration of the marine seismic data acquisition.
2.2 Identification of Bottom Simulating Reflector

The method used to identify gas hydrate is to check the presence of a Bottom Simulating Reflector (BSR) following the data processing. The position of gas hydrate stability zone is above the BSR in 2D seismic sections and characterised by amplitude blanking. Acoustic energy reflected by sediment containing gas hydrate is usually weak. Therefore, there is an anomaly zone with a low frequency below the BSR [11].

3. Results and Discussion

Figure 4 shows a 2D seismic section that has been PSTM processed. The Kirchhoff algorithm used in this PSTM proved to be helpful to solve complex problems, which include time, angles, and distances contained in the seismic data and hence increases the signal to noise ratio (SNR) [12].

The DS-12 seismic line below has been processed and analysed for the presence of BSR. The interpreted BSR can be seen in the visualisation of Figure 5.
Figure 4. Trace display of 2D Line seismic cross-section (DS-12) after carried out the PSTM Kirchhoff method.

Figure 5. Trace display of 2D Line seismic cross-section (DS-12) after zooming.

The BSR can be observed at CDP 35-812 and t\text{tot} depth 1526-1582 ms. The BSR above is characterised by high-amplitude reverse-polarity waveform parallel to the seabed reflector. The polarity of the seabed reflector is positive, while the reflector polarity of the BSR is negative \cite{13-14}. BSR has many characteristics such as high amplitude, cutting stratigraphy, and polarity reversal. Such criteria match the BSR found on seismic line DS-12 \cite{15}.

Gas Hydrates zone will only be formed if there is free gas below the BSR cross-section. Gas hydrate accumulation can also be identified by its transparent amplitude on the seismic profile \cite{11}. The presence of gas hydrate is influenced by several factors, such as temperature, pressure, composition, and type of stratification. Gas hydrates may also be found in shallow sediments with high gas saturation levels. Gas hydrates can accumulate and be trapped in coarse sediments because of their high porosity and permeability.

4. Conclusion
The PSTM method used in this study has produced a good quality 2D seismic section. The presence of gas hydrates on the seabed in the waters of North Bali is indicated by BSR on the 2D seismic section.
DS-12 line, at CDP 35-812 and TWT depth 1526-1582 ms. The BSR shows high amplitude, cutting stratigraphy, and inverted polarity.

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