IDENTIFICATION ACTIVE POCKMARKS USING THE COMBINATION OF SIDE SCAN SONAR AND SUB-BOTTOM PROFILER

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ABSTRACT

It should be suitable for direct inclusion in abstracting services and should not normally be more than 300 words. Geohazards assessments are important before any engineering activity as they could block facilities and cause millions of dollars in losses. Pockmark as geohazards is often observed on the seabed with various amounts, especially on the clayey seabed sediments. Pockmarks indicate that the gas escapes from below the seabed. Pockmark may cause the jack-up rig to be slipped, pipeline free-span, and even blow out while drilling if it has a gas trap below. Side scan sonar and sub-bottom profiler as the geophysical method using acoustic wave can be used to investigate the active pockmarks. By using these two datasets, the distribution of active and inactive pockmarks can be achieved properly. So that hazards that may occur in engineering activities in the future can be prevented.

Keyword: Geohazard, pockmark, side scan sonar, sub-bottom profiler

Introduction

Geohazards are disasters encouraged by natural processes or human activity [1]. Marine geohazards comprise any feature or process that might harm, endanger, or affect subsea facilities, risers, anchors, and others [2]. These include pockmarks that do not cause direct damage to societies but can affect engineered facilities. Pockmarks are seabed depressions with various morphologies, cone-shaped, circular, or elliptical. Pockmarks often occur on the top of marine gas hydrate zones.

Marine geohazard surveys have become increasingly relevant as exploration activities extend toward deeper waters [3,4]. The hydrographic and geophysical surveys are specifically performed to identify the geohazard using acoustical marine geophysical methods. The equipment is utilized underwater by sending and receiving acoustic waves from sound sources that are reflected, refracted, or scattered off the seabed. (Kenny et al., 2001). These techniques are the most reliable tools for examining and classifying seabed features using various processing and interpretation phases (Blondel, 2009). This study will use two variations of underwater acoustic imagery methods.

The Side-scan sonar (SSS) is a deep-towed acoustic system that is utilized to generate an image of large areas of the seafloor efficiently (Mulder et al., 2011), map the geomorphology and composition of the seafloor (Micallef, 2011). Side-scan sonar (SSS) emits low-incident angle sound beams of high-frequency acoustic pulse and receives the echo signal in the along-track direction, perpendicular to the direction of the survey line (Kenny et al., 2003; Ye Yincan et al., 2011).

The sub-bottom profiler (SBP) systems, also known as marine seismic reflection, are used to determine information on the sub-seafloor structure, including sediment thicknesses and stratigraphic structures. Sub-bottom profiler (SBP) uses the direct reflection of seismic energy and distinguishes the variance of acoustic impedance between different sub-seabed lithologies to generate reflected reverberations (Wu et al., 2021).

Breen et al., 1987, identified the first marine study using side-scan sonar in Indonesia about geomorphology investigation on Sumba Island. In recent years, many studies have been discussing hydrographic and geophysical surveys using side scan sonar and/or sub-bottom profilers in Indonesia. Lubis et al., 2017; Lubis et al., 2020 discussed seabed mapping using side scan sonar at Punggur Sea, Riau Islands. Santoso, 2021 studied wharf wall conditions identification using side scan sonar at Tanjung Perak, Surabaya. Manik et al., 2014 talked about object detection using a multi-beam echo sounder and side scan sonar at Kutai, East Kalimantan. Pratomo et al., 2021 discussed subsea pipeline free span identification using side scan sonar and dual-head scanning profiler. Oktaviani et al., 2021. Manik et al., 2021 studied seabed classification using side scan sonar at Teluk Bayur, West Sumatera. Amirullah et al., 2019 discussed sediments thickness mapping using a sub-bottom profiler at Alur Pelayaran Timur, Surabaya. Kurnio et al., 2015 researched seafloor faulting based on sub-bottom profiler data at Weh Island, Nanggroe Aceh Darussalam. Firdaus et al., 2021 talked about gas detection and quantification using a sub-bottom profiler and multi-beam echo sounder at Wareopen Basin, Papua [5-13].

However, no research in Indonesia has found the use of side-scan sonar combined with a sub-bottom profiler to detect potentially active pockmarks, which are very dangerous for any underwater engineering structure. The study aims to obtain an effective method to detect the existing active pockmarks on the seabed by using the combination of side-scan sonar (SSS) and sub-bottom profiler (SBP) as marine acoustic geophysical techniques. This helps us define the potential hazards for any subsea installations and facilities caused by active pockmarks.

Methodology

Data

The survey area will be at Madura Offshore (located at 6° 51' 09.76" S and 112° 57' 17.43" E), considering the geological region in that area. Primary data will be used using side scan sonar and sub-bottom profiler data. Side scan sonar data will be acquired using Side Scan Sonar EdgeTech 4200 dual frequency 300/600kHz with 3cm and 1,5cm across track resolutions, respectively [14]. Side scan sonar will be towed using a winch system with cable tow 3x water depth. A beacon from a USBL system will be attached to the side scan sonar towfish for underwater positioning. EdgeTech Discover software will be used to record the side-scan sonar data. A rub test will be performed before deploying the side scan sonar to ensure the sensor works properly.

Figure 1. Side scan sonar 4200 systems [14]

Sub-bottom profiler data will be gathered using Sub-bottom Profiler Innomar SES-2000 (frequency band 85 – 115kHz) with 2cm vertical resolution in a 100kHz transmitter pulse setting [15]. The sub-bottom profiler will be installed at the side of the ship. A heave compensator will be applied to correct the wave effect on the sub-bottom profiler data. ISE software will be used to record the sub-bottom profiler data. Prior to running the survey, a wet test is performed.

Figure 2. Sub-bottom profiler SES-2000 [15]

A sound velocity value, measured by sound velocity profiler systems, will be applied to the side scan sonar and sub-bottom profiler in the processing phase. Vessel's speed will be maintained at 3 – 4 knots to optimize the data quality recorded by the side scan sonar and sub-bottom profiler. Digital navigation satellite systems will be utilized for the vessel's positioning.

Research Methodology

Data selection

The data selection will be performed to filter the noisy and incomplete data. Therefore, only good-quality data will be processed.

Data Correction

1. **Navigation correction**
   Both side scan sonar and sub-bottom profiler will be applied with the navigation correction to correct the navigation error caused by DGNSS jumping position, system delay, and others.
2. **Bottom tracking**
   Bottom tracking will be applied to correct the altitude and actual seabed detected on the side scan sonar and sub-bottom profiler.
3. **Slant range correction**
   slant range correction to measure the actual lateral object distance from the sensor.
4. **Time varying gain**
   Both side scan sonar and sub-bottom profiler will be applied with time-varying gain to get the equalized gain/brightness within the data.
5. **Coverage validation check**
   The side scan sonar and sub- bottom profiler coverage will be checked to ensure data completeness.
6. **Side scan sonar image mosaic**
   The mosaic image of the side scan sonar will be created to easier the seabed features interpretation.
7. **Seabed scan sonar image mosaic**
   The seabed features found will be picked using reference of side scan sonar mosaic.
8. **Sub bottom profiler anomaly picking**
   The shallow anomaly that may indicate the possibility of gas existence will be picked.
9. **Side scan sonar and sub bottom profiler correlation**
   The pockmarked activity found in seafloor features is validated with data between the side scan sonar and the sub-bottom profiler, which will be compared. When a pockmark is found in the side scan sonar image, then there is an anomaly observed by the sub-bottom profiler beneath the pockmark so that it will be categorized as an active pockmark. Vice versa, when a pockmark is found in the side scan sonar image, then there is no anomaly observed by the sub-bottom profiler beneath the pockmark, so it will be categorized as an inactive pockmark.

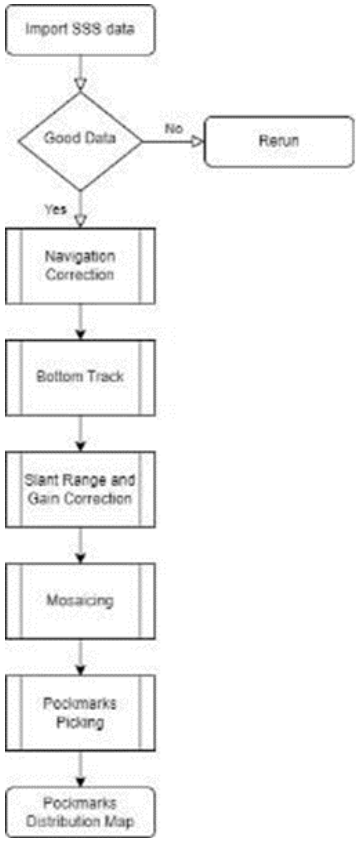

Figure 3. SSS Processing Flowchart

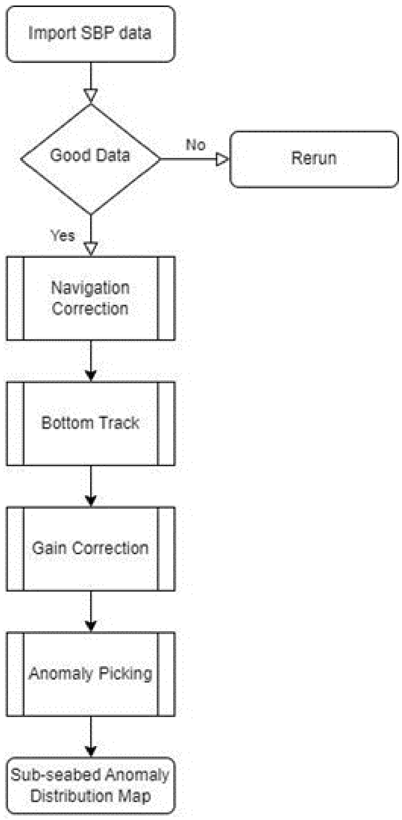

Figure 4. SBP Processing Flowchart

Result and Discussion

Due to the original data not being yet acquired, side scan sonar and sub-bottom profiler data used in this research are simulations only.

Pockmarks were clearly defined in the side scan sonar data. Some pockmarks have a high sonar return, indicating a possible gas escape from the sediment. Referring to the sub-bottom profiler data, the pockmarks with high reflections in the side scan sonar image will also have the anomaly in the seismic as sub-bottom profiler data records.

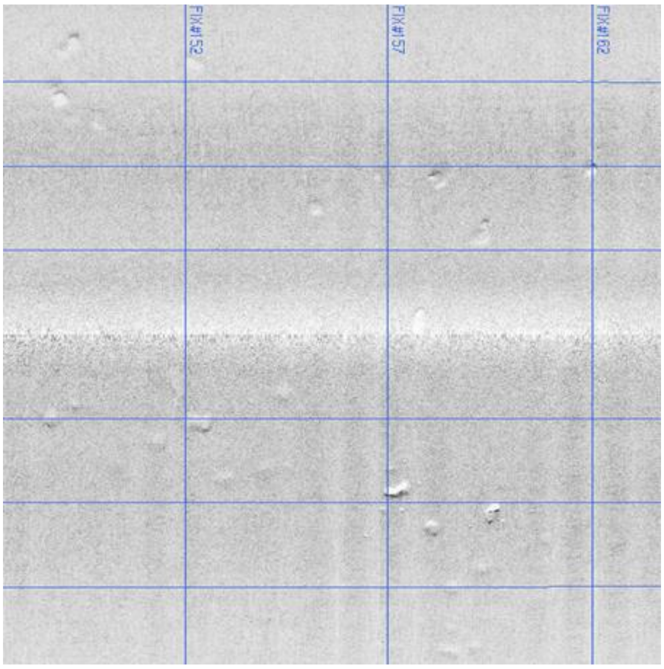

Figure 5. Side scan sonar image shows the number of pockmarks

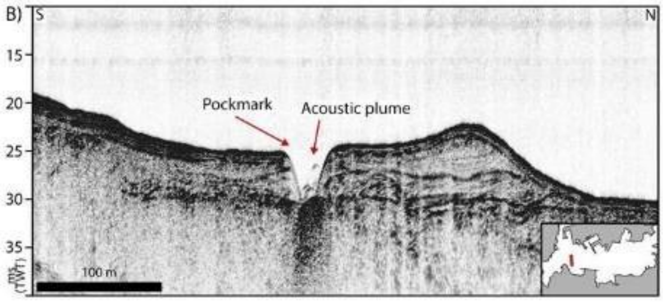

Figure 6. Sub-bottom profiler image shows acoustic plume as anomaly beyond the pockmark

Conclusion

Active pockmarks can be distinguished using SSS and SBP data combined. It is crucial to assess this feature since it may be a hazard for any subsea engineering activities. The MBES data is recommended for further investigation to achieve a better position.

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