Analysis of Common Surface Reflection (CSR) Methods 2D Multichannel Data in Morowali Sea Waters

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Abstract. One of the processes contained in this seismic data processing is Stacking. The conventional Stacking process uses CMP which is at the same midpoint point. In other words, the reflector fields that are in the same point will be combined. This process is called the NMO correction process (normal move out correction). This CRS Stack is a conventional method of CMP Stack erby using different approaches. The purpose of this study is to process 2D seismic data at Morowali Sulawesi waters using the Common Reflection Surface (CRS) method so that it gets an overview of the Morowali Sulawesi Aquatic structure. In CDP 770-1782 above we can see various differences in cross-section. But in the CRS aperture operator with a value of 887.5 (far offset) and 0-0, 1000-179, 2000-416, 3000-568, 4000-713, 5000-48 radius of the Fresnel zone) there is no significant difference, this because basically if 5400-887.5 (TWT-Aperture) TWT is between 0 to 5400 the Aperture value is between 0 to 887.5. This parameter has covered the entire area.

1. Introduction

The geophysical method that uses in underwater exploration is a seismic reflection method. This the seismic method utilizes propagation, reflection, and refraction of sound waves [1]. In the underwater exploration process, there are three stages used, those are data acquisition, data processing and data interpretation [2]. With the development of computing technology that supports the processing of seismic data, underwater exploitation imaging can produce better accuracy and resolution [3]. The purpose of seismic data processing is to produce a good cross section with a good signal to noise ratio without changing the shape of the reflections, so that interpretation of the shape of the layer under the earth's surface can be interpreted as it is [3-4]. Thus it can be said that processing seismic data is a process of increasing the signal and suppressing noise so that the processing data can help the interpretation process. One of the processes contained in this seismic data processing is stacking. Stacking is a summation or trace merge process. In every signal and noise with the stacking process, the signals will mutually reinforce while noise will be muted.

The conventional stacking process uses CMP which is at the same midpoint point. In other words, the reflector fields that are in the same point will be combined. This process is called the NMO correction process (normal move out correction). However, this process can only be done if the reflector plane is horizontal. If the reflector has a certain slope, DMO correction (dip moveout correction) is performed [1,5]. But in certain circumstances, many reflectors that have a high slope and the medium is not homogeneous so the DMO correction has an unfavorable accuracy. In cases like this where a complex cross section can be done DMO (Common Reflection Surface) stack. This CRS stack is an extension of conventional CMP stack gather methods using different approaches, namely by adding several parameters related to the properties of the reflector, such as location, direction, and curvature.
2. Common Reflection Surface (CRS)

Common Reflection Surface (CRS) stack is one of stacking method that produces Zo section [1]. If the conventional method requires the right speed model, the CRS stack method is free from the velocity model because what is needed is the near-surface velocity [6]. The conventional method requires NMO and DMO correction to the data that will be stacked, but the CRS method, stacking can be directly done on the data, without NMO and DMO corrected. The conventional method relies on one stacking parameter, the CRS stack depends on three wave attributes obtained from the method of coherence analysis. tang ree collected at point P0 (Common Reflection Point). This concept approaches the actual subsurface shape using an arc in 2D data can be seen in the picture that this method can approach the subsurface shape better than conventional methods [1,6,14].

3. Fresnel Zone

By using information from the reflection response around the Zo point along the Fresnel Zone, it will get one stacking surface for each Zo point [7]. By summarizing the stacking surface area, a CRS stacking section will be obtained. Stacking operation in the CRS stack is determined by the width of the segment from the reflector or the aperture of the reflector, then this Fresnel Zone is within the optimum aperture in stacking CRS [7-8]. AA' and Z are depths and λ are the dominant wavelengths. The Fresnel Zone concept is in the depth domain, while the data is in the time domain. First interface Fresnel Zone in the identic time domain with the projection of the first interface of the Fresnel Zone in the depth region. This relationship can be used to obtain the optimum CRS operator aperture. Seismic sources were fired, resulting in a Fresnel Zone of AA'[9]. Using all points around the reflector, the reflector zone can be derived from one point. The Fresnel radius equation can be written as follows:

\[ R_f = \frac{AA'}{2} \]

By changing the variable AA’ then it is obtained the following equation:

\[ R_f = \frac{2\lambda}{2} \]

Z is a distance which is a function of speed and time while λ is a velocity function and frequency. Fresnel zone radius can be written as follows:

\[ R_f = \frac{v}{2} \sqrt{\frac{1}{f}} \]

4. Conventional Stacking

The conventional stacking method does not use all multi-coverage data, this method uses only a few gathers in the stacking process. A large number of neglected traces can be used to describe subsurface. Besides conventional stacking is not able to approximate the response of reflection quickly [3].

Seismic reflection comes from several pairs of sources and receivers which are reflected at the same bounce point and are known as common depth points, and then in one CDP gather. The CDP gather is then sorted in one order of offset (time). To correct the effect of the distance offset between the source point and the receiver on a trace that comes from one CDP (Common Depth Point), the Normal Moveout (NMO) and Dip Moveout (DMO) are performed [10][8]. NMO correction or dynamic correction is used to correct the influence of the difference in location between the source and receiver on the CDP gather data. Parabolic reflector after NMO correction will look flat [11]. NMO correction in the flat layer can be reduced by the interval velocity equation, that is

\[ V = \frac{\Delta z}{\Delta t} \]

Where \( \Delta z \) is a depth difference and \( \Delta t \) is a time difference. Substituting \( T = T_o + \Delta t \) then:

\[(T_o + \Delta t)^2 = \frac{x^2}{V^2} \]

or

\[ T^2 = T_o^2 + \frac{x^2}{V^2} \]
Where $T_o$ is zero offset travel time. By subtracting each signal received by the receiver at distance $x$ from the source, the position will be in line with the normal reflection of the incident. For a field reflector with a small dip (reflector slope), DMO correction is used for a reflective point (Reflection Point Smear) which is caused by the dip on the reflector. The equation for dip reflectors is:

$$T^2 = T_o^2 + \frac{x^2 \sin^2 \theta}{v^2}$$

NMO/DMO correction can be divided into two parts. First, NMO correction on CMP gather is done to determine the estimated speed. Then, DMO correction is used for the reflector with a not too large dip [12]. DMO correction eliminates dips that depend on VNMO. $Z_o$ section is obtained by stacking all signals that are at the corrected travel time. One conventional data processing method is the migration to $Z_o$ (migration to $Z_o$, MZO). This method aims to correct the effect of offset from reflection events on CMP and CO gather in generating $Z_o$ section [7]. MZO sums up all the amplitude along the CRP path for all reflections on isochrone $Z_o$. The stack results are collected at point $P_0$. The MZO form is a reflection response of isochrone $Z_o$. To get MZO, NMO, DMO and stacking are needed. The picture above shows the surface of the NMO/DMO stacking operator. The working principle of stacking using this method is the addition of a number of NMO/DMO operators. The NMO / DMO operator is identical to the reflection response of the isochrone $Z_o$ from the $P_0$ point. When the reflector form is a planar horizontal or oblique layer, the application of this method is still appropriate. But for the case of a reflector with a certain curvature, this method is no longer relevant [7,12].

5. Study Area

The field data collection process was carried out by The Center of Marine Geology Research and Development (PPPGL) Bandung, located in the Eastern Morowali Sea Waters, Indonesia. Data acquisition was carried out on Line GM3-Morowali-09. Data processing was processed in April - June 2018 at the ProXmax Laboratory in The Center of Marine Geology Research and Development, Ministry of Energy and Mineral Resources, Bandung.

![Figure 1](image)

**Figure 1** Line Map *Marine Seismic GM3-Morowali-09* (red line)

6. Data and Methods

The method used in this research is multichannel Seismic Reflection. The device is used in the form of computer hardware with a Linux operating system with ProMAX 2D R5000.0 © 1989-2008 Landmark Graphics Corporation software. The material used is secondary data with the excites SEG-D which can generate magnetic tape recording on the acquisition of seismic data by Geomarine Research Ship 3. The seismic data processing itself uses several steps such as follow [13]:

- **Preprocessing:** This step includes the elimination of noise and the correction of the incident angle of the seismic wave.
- **Stacking:** Stacking is done to increase the signal-to-noise ratio and improve the image quality.
- **Migration:** Migration is used to correct the effect of offset from reflection events on CMP and CO gather in generating $Z_o$ section.
- **Gain Control:** This step adjusts the intensity of the seismic signal to improve the visibility of the dataset.
- **Quality Control:** This step checks the consistency and accuracy of the processed data.
6.1. Data Input (demultiplexing)
Acquisition data is obtained from the SEG-D format field, so it needs to be changed in the SEG-Y format. This process is called demultiplexing where data previously based on sequential series is changed to time series. The output of this process is raw data which is used as the basis for processing seismic data in the next process.

6.2. Geometry
The geometry process is carried out by entering parameters such as measurement direction, source and receiver distance, source interval, receiver interval, etc. This is conducted while the data is processed exactly like the real situation in the field.

6.3. Preprocessing
True Amplitude Recovery (TAR) aims to generate weak seismic wave amplitude. This is conducted to get more representative amplitude in the investigation area. Deconvolution is part of the preprocessing stage, which aims to form signals, increase the resolution of seismic data and suppress coherent noise. Predictive deconvolution (spiking/predictive deconvolution) the best wavelet shape. To get the parameters used autocorrelation. In this study, the length of the 200 deconvolution operator and the prediction distance of operator 100 are obtained.

6.4. Velocity Analysis
Velocity analysis is a trial-error process in order to get the appropriate speed value. This is conducted using Semblance Velocity which has a plot of signal coherence in the velocity field with Two Way Traveltime (TWT), then displayed in the form of contours with color with a cross-section. Picking velocity is done by taking the maximum Semblance value.

6.5. NMO Correction
NMO correction is the correction needed to bring the reflection wave from the Non-Normal Incidence to the normal reflection (perpendicular). Correction changes the direction of the curve to be flat.

6.6. Stacking
Stacking is a summation process of several seismic traces that have been scratched by NMO. Some of the traces that have been corrected and become the base will be summed so that the resulting amplitude will be greater.
6.7. Common Reflection Surface (CRS)
There are three stages in this CRS process, those are CRS Z0 Search, Precompute CRS, and 2D CRS Stack. CRS Z0 Search is done to get the reflection dip value in the Z0 stack section data. The values included in this study are dip search aperture 250, time search spacing 20 and surface speed 1500. Dip search aperture is a Fresnel zone radius. Time search spacing is used to determine the location of dip analysis.

6.8. Filtering
Filtering is the process of separating signals from noise. Filtering can be done at various stages from the geometry process to the migration process depending on the needs. Filtering used in this study is muting, editing and bandpass filters.

7. Result and Discussion
The stages in order to get a cross-section in accordance with the actual situation can be done in various ways. To test the stacking method of the Common Reflection Surface (CRS), conventional stacking stages are also carried out. When compared with conventional stack cross-sectional images, the cross-section of the Common Reflection Surface (CRS) stack provides better imaging. This is because the number of traces involved in stacking is more than processing data using conventional methods. In addition, the conventional stack operator method is used only at velocity, while the CRS operator stack method is used dip (\( \alpha \)), Normal Curve Radius (RN) and Normal Incident Point (RNIP) Curvature Radius.

![Figure 3](image)

**Figure 3** The comparison of Stack cross section (a) Conventional Stack Cross-section (b) CRS Stack Cross-section

Basically, Morowali data on track 09 has a weak signal because it only has 48 active channels and near far offsets that is 300 m, so this CRS stacking method is very suitable with this data type compared to conventional stacking methods. The CRS stacking process uses several parameters. These parameters are determined according to the cross-section data. CDP search spacing used in this research is 2. CDP search spacing is the determination of the number of spaces used in each CDP point in the search operator. While the search aperture dip used is 200.

This parameter is used to find the magnitude of reflector slope which is limited by the radius of the Fresnel zone. In order to get a better image, at the aperture, the CRS operator is carried out in four variations, i.e. near offset, middle offset, far offset and Fresnel zone value.
Aperture CRS Operator Values

| Aperture CRS Operator Value | Comparison Result |
|----------------------------|--------------------|
| Aperture CRS operator Near Offset | There is still a discontinuity and noise 2.5-5 s |
| Aperture CRS operator Middle Offset | There is still a discontinuity and noise 2.5-5 s |
| Aperture CRS operator Far Offset | Continuity looks and noise at 2.5-5s is quite clean |
| Aperture CRS operator Radius Fresnel zone | Continuity looks and noise at 2.5-5s is quite clean |

This data has an offset of 300-887.5 m so that variations are tested at Aperture 300, 500, 887.5 and radius of the Fresnel zone.

Figure 4. Cross-section comparison of Common Reflection Surface (CRS) in various Aperture CRS Operator value (a) aperture CRS operator Near Offset (b) aperture CRS operator Middle Offset (c) aperture CRS operator Far Offset (d) aperture CRS operator Radius Fresnel zone.
### Table 2 Fresnel Zone Radius Valu

| TWT (s) | v (m/s) | f (Hz) | Fresnel Zone (m) |
|---------|---------|--------|------------------|
| 1       | 1433    | 15.9   | 179              |
| 2       | 2418    | 16.9   | 416              |
| 3       | 2698    | 16.9   | 568              |
| 4       | 2935    | 16.9   | 713              |
| 5       | 3126    | 16.9   | 848              |

In CDP 770-1782 above can be seen the various differences in cross-section, but at the operator's CRS aperture with a value of 887.5 (far offset) and 0-0, 1000-179, 2000-416, 3000-568, 4000-713, 5000-848 (radius of the Fresnel zone) there is no significant difference, this because basically if 5400-887.5 (TWT-Aperture) TWT is between 0 to 5400 the Aperture value is between 0 to 887.5. This parameter covers all areas, but in this study also used the Fresnel zone radius parameter to get a clear cross section at each depth.

### 8. Conclusion

The CRS better than conventional stacking methods. This is because conventional stacking methods only add trace (stacking) at the same bounce point or CDP while CRS uses all multi-coverage data. The use of the operator's CRS aperture with a value of 887.5 (far offset) and 0-0, 1000-179, 2000-416, 3000-568, 4000-713, 5000-848 (radius of the Fresnel zone) no significant difference, because basically if 5400-887.5 (TWT-Aperture) TWT is between 0 to 5400 the aperture value is between 0 to 887.5.

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