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To cite this article: Ryan Bobby Andika *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **279** 012033

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# Limited off-set consideration in de-multiple process of seismic Lake Towuti

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**Abstract.** Multiple attenuation effect study in Lake Towuti seismic data is based on limited offset recording. The goal of this study is to better understand the sediments structure of Lake Towuti that layered above East Sulawesi ophiolitic and metamorphic rocks for stratigraphic interpretation. Surface-related multiple and internal multiple are a common noise signal that recorded in this seismic data, alongside the primary signal from the sediments layer. In order to get a representative subsurface image of the lake, a combination of some de-multiple method to suppress this noise signal has been applied in previous study. However, the line seismic that used in this seismic recording is less than 100 m. From our perspective, this limited offset line fact have to be considered carefully. It's because some application of de-multiple method in this case will not effectively suppress the noise. In this study, we give an alternative combination method in function to put out the surface-related multiple of the case. First, we enhance the S/N ratio and velocity analysis of the data by Common Reflection Surface (CRS) method. From this enhancement, CRS can give a direct advantage when applying some de-multiple method, especially in Predictive Deconvolution and SRME method. Moreover, we combine the application of de-multiple theory with the strict arrangement of Predictive Deconvolution, Surface-Related Multiple Elimination (SRME), and the last is F-K filter. Those combination methods precisely give a better imaging of Lake Towuti sediments layer in this seismic processing study.

## 1. Background

Lake Towuti is one of the lakes in South Sulawesi that are in the Lake Malili system. The sediment layer that coats the basin of the lake naturally is able to store uniqueness in reconstructing the ancient environment included in the center of the Indo-Pacific heat pool (IPWP) (Russell et al., 2016). So that in determining the drilling point, 2D sea seismic survey activities were carried out with the total length of the trajectory to reach the meter's height (Russell et al., 2016).

The seismic survey work carried out at Lake Towuti has a data recording configuration with an offset of less than 100 m. This is what makes the authors feel the need for consideration of limited offset (limited offset) in processing data. With the main objective of eliminating multiple signals, a combination of de-multiple methods such as Predictive Deconvolution, Surface-Related Multiple Elimination (SRME), and F-K filters are specifically combined with the use of Common Reflection Surface (CRS) methods. This CRS

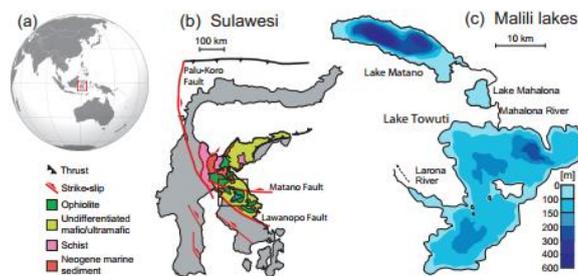


method is projected to enhance those de-multiple methods in order to eliminate the multiple signals that exist in Lake Towuti seismic data for line 04.

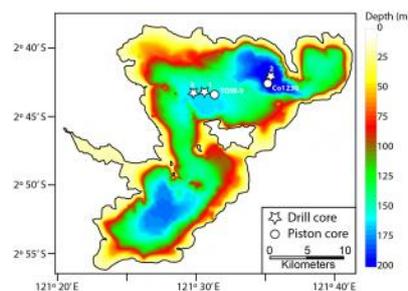
## 2. Methodology

### 2.1 Towuti Drilling Project (TDP)

Towuti Drilling Project (TDP) is a scientific project that has been carried out since 2012. This project was held with the aim to find out information about the long-term changes in the geomicrobiology of this system, including changes in climate, microbial geochemical cycling, carbon storage, metal deposition, and microbial processes operating at a depth of the lake sediment layer (Russell et al., 2016). From the results of the data acquisition, it was determined that the two main areas became drilling targets in this project. The selection of the two drilling locations, in short, is based on the subsurface image of the seismic recording results. The results show that the sediment layer in both locations has a relatively high thickness.



**Figure 1.** The appearance of the TDP study area map showing (a) the location of Sulawesi Island, (b) regional geology around the study area, (c) Lake Malili system complex (Russell et al., 2016)



**Figure 2.** Lake Towuti bathymetry map and drilling locations (Russell et al., 2016)

### 2.2 Predictive Deconvolution

Predictive deconvolution is a method for estimating the value of a series of signal amplitude values at a certain lag. In its application to the concept of the de-multiple method, Predictive deconvolution can be used to predict multiple signals. This is because multiple signals, on the results of recording, are generally described as having a certain period of occurrence.

$$\begin{bmatrix} a_0 & \cdots & a_{n-1} \\ \vdots & \ddots & \vdots \\ a_{n-1} & \cdots & a_0 \end{bmatrix} \begin{bmatrix} f_0 \\ \vdots \\ f_{n-1} \end{bmatrix} = \begin{bmatrix} a_a \\ \vdots \\ f_{a+n-1} \end{bmatrix} \quad (1)$$

### 2.3 Common Reflection Surface (CRS)

Common reflection surface (CRS) is a method for approximating traveltimes from a reflection response point ( $X_m$ ) around the midpoint ( $X_0$ ) point on the seismic line (Hocht et al., 1999). In principle, CRS is a stacking method that is carried out on reflection data, similar to stacking on Conventional CMP. But in the CRS method, the stack process and results use more traces than the CMP gather (Mann, 2007). This is what makes the CRS stack able to increase the S / N Ratio compared to the conventional stack (Mann, 2007).

$$t_{hyperbol}^2(x_m, h) = ((t_0 + \frac{2\sin\alpha}{v_0}(x_m - x_0))^2 + 2t_0 \frac{\cos^2\alpha}{v_0} (\frac{(x_m-x_0)^2}{R_N} + \frac{h^2}{R_{NIP}})) \quad (2)$$

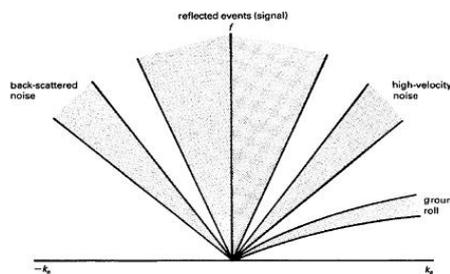
### 2.4 Surface-Related Multiple Elimination (SRME)

The Surface-related multiple elimination method is a method that is specifically applied to emphasize the presence of multiple surface-related multiple types. The method proposed by D.J. Verschuur is simply made to predict multiple waves on the results of recording. The prediction is done by convolution of each trace from a gather, with the whole gather the result of recording in an area. After that, we just subtract the input data with the multiple prediction by SRME to get the data with no multiple interference.

$$X_0(z_0, z_0) = X(z_0, z_0) - r_0\{X_0(z_0, z_0)\}^2 + r_0^2\{X_0(z_0, z_0)R^-(z_0)\}^3 - r_0^3\{X_0(z_0, z_0)R^-(z_0)\}^4 + \dots \quad (3)$$

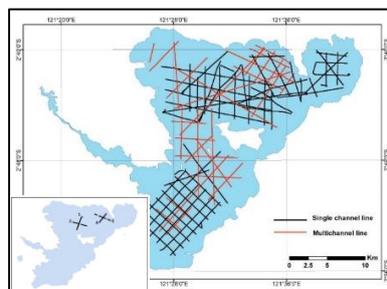
### 2.5 F-K Filter

In its orientation to reduce the noise signals in the form of multiple, transformation into the frequency domain - wave number (F-K domain) is one of the right things to do. With this domain change from X-T, and applying NMO correction to the data, the primary signal is in the form of a reflector field and multiple noise can be distinguished based on the wave number and frequency in more contrast.



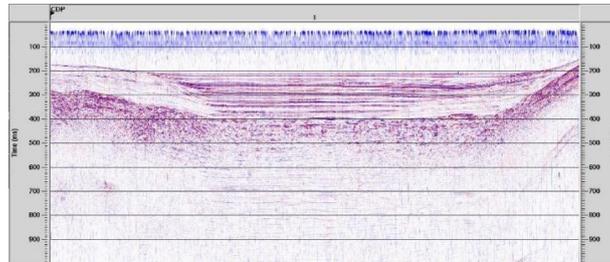
**Figure 3.** The response of seismic signals to F-K domains theoretically (geosci.xyz, 2017)

## III.1 Data



**Figure 4.** Seismic trajectory map at Lake Towuti (Hafidz, 2017)

In this study, the authors specifically carried out the treatment of Lake Towuti seismic data on the line-04 line, with the initial subsurface image and data recording parameters as follows:

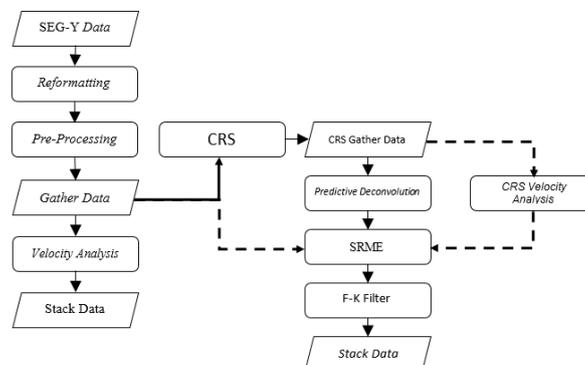


**Figure 5.** Lake Towuti seismic data image for Line-04

**Table 1.** Data recording configuration parameters on Lake Towuti for Line-04

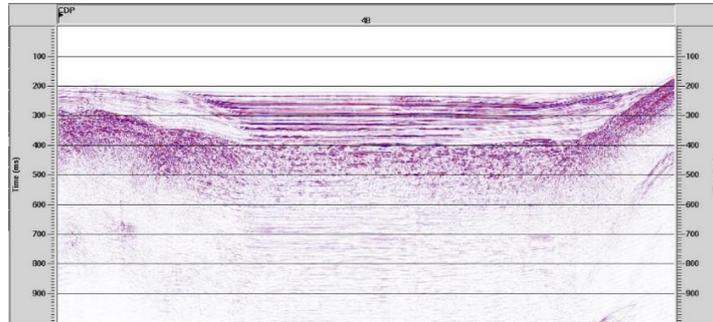
Parameter	Keterangan
Total Receiver	24
Total Source	1163
Shot / Receiver Spacing	3.5 : 3.125 (meter)
Near Offset	25 m
Far Offset	96.875 m
Configuration	Off – End

### 3. Data Processing



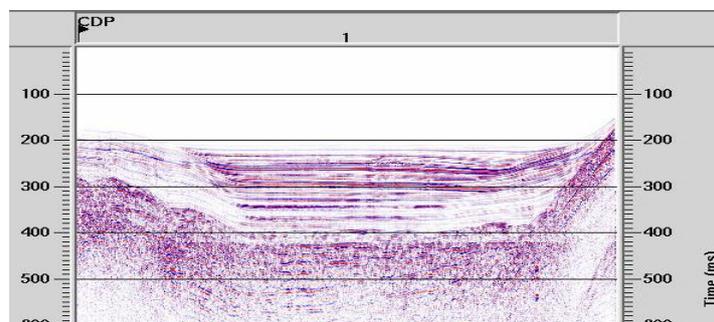
**Figure 6.** Research flow chart.

In general, data processing deals with the application of de-multiple methods such as F-K Filter, Surface-Related Multiple Elimination, and Predictive deconvolution. But before de-multiple processing is done, the Common reflection surface method is applied to seismic data. It aims to increase the S / N Ratio first from the data to be processed so that the use of multiple-method will be more effective, especially on the application of Predictive deconvolution and Surface-Related Multiple Elimination.



**Figure 7.** Data stack results from the application of pre-processing using conventional background velocity.

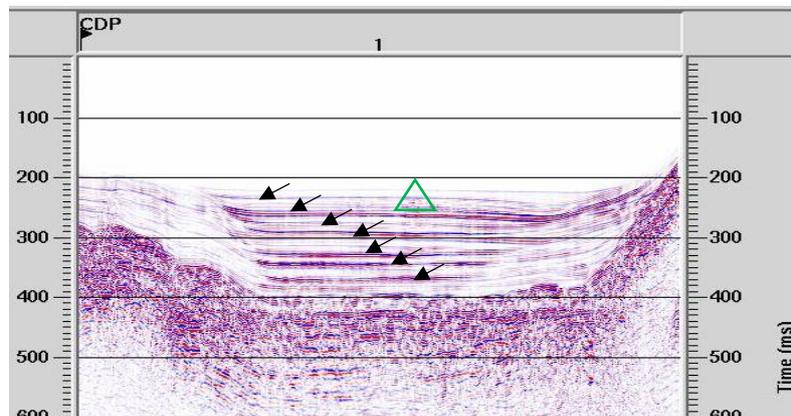
The authors projects that the use of the CRS method as the kernel for the use of the Predictive deconvolution method will produce a representative output in predicting multiple signals. Furthermore, in this study, multiple signals that have been predicted by the Predictive deconvolution equation are not directly used as a component of the extraction of the initial data or input. With relatively thin sediment layering conditions for seismic surveys, as well as limited seismic line facts (limited-offset), the authorss suspect that the predicted signals may also be present along with the primary signal. To reduce this possibility, further predictive data will be taken to the multiple prediction process using the Surface-Related Multiple Elimination (SRME) method named SRME Macro.



**Figure 8.** Results of stack application of Predictive deconvolution and SRME on Lake Towuti line-04 seismic data.

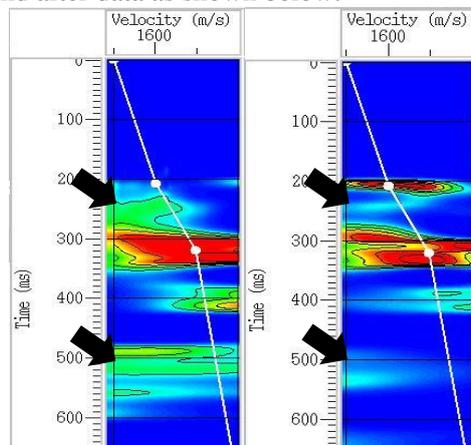
After obtaining the output data from the prediction process (SRME Macro), the SRME Match-Filter process of the data is carried out with conventional data gather which is not applied by the Common reflection surface (CRS) method. It aims to represent multiple predictive data on its original purpose, maintain data authenticity, and the subtraction process in the Adaptive Subtraction process can produce good output and be free from multiple signals. After that, authors apply F-K filter to attenuate the multiple signals.

#### 4. Analysis and Discussion



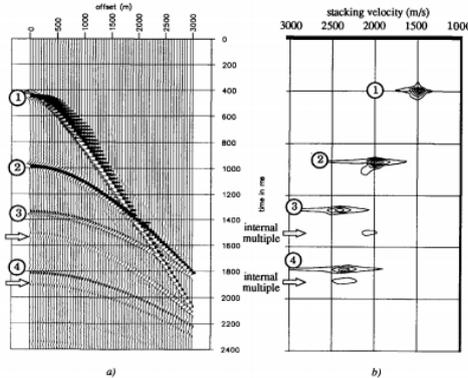
**Figure 9.** Data stack application results of Predictive deconvolution, Surface-Related Multiple Elimination (SRME), and F-K Filter on Lake Towuti line-04 seismic data.

In general, the authors interpreted the presence of seven markers with a slump material. To strengthen the accuracy of the processing results in reducing multiple of seismic data and its interpretation, the writer analyzes the data from the initial and after data as shown below.

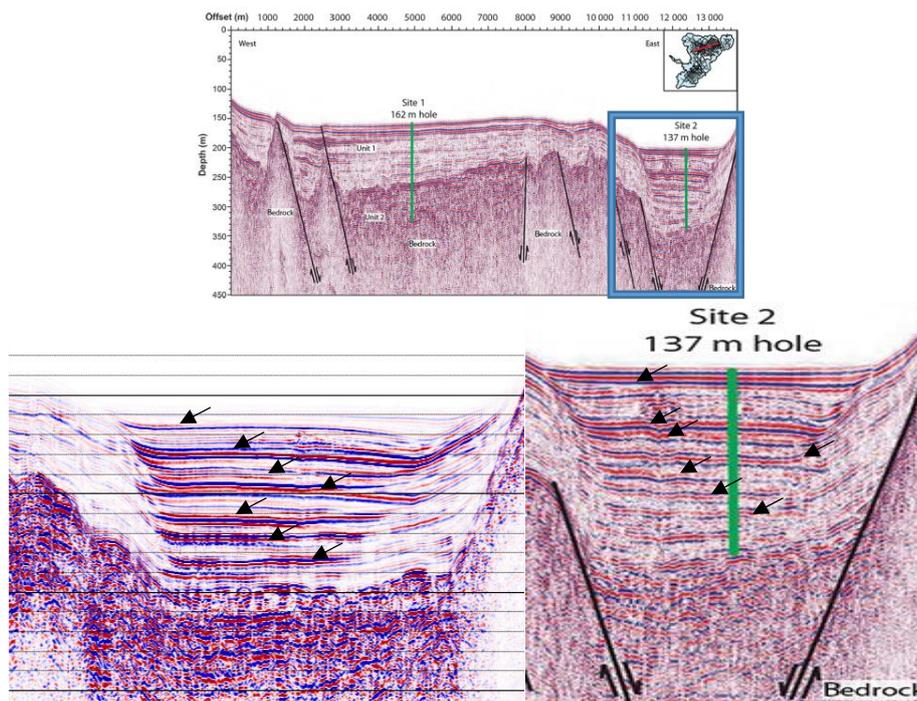


**Figure 10.** Semblance CDP 201 for before (left) and after (right) processing seismic data of Lake Towuti line-04.

From Figure 10, it can be shown that a reduction in the value of Semblance in the area marked by a black arrow after data processing is performed. These removals, based on images, are entirely in areas with low velocity and TWT in which indicate the removal of multiple signals. Based on theory, the presence of semblance which has a decrease in velocity value, and when the TWT value increases, is a common feature of the presence of multiple signals in seismic data. This is in accordance with the following theoretical



**Figure 11.** *Semblance CDP gather* dimana panah nomor 4 menunjukkan kehadiran *multiple* pada data seismik (Verschuur,1991).

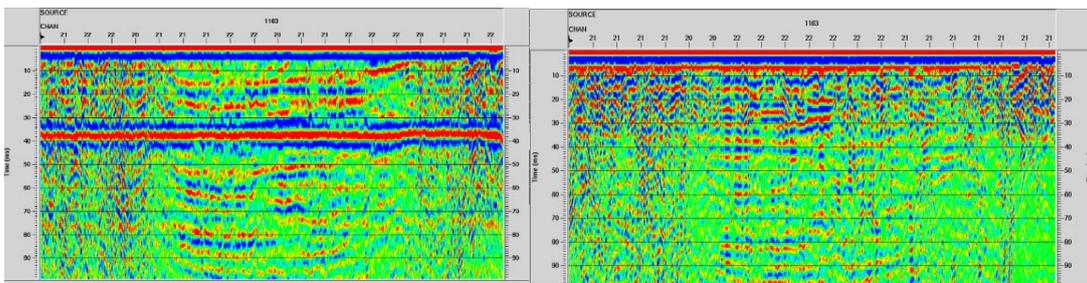


**Figure 12.** Comparison between the authors's data processing line (left) and data processing by Russell et al. (right) with different azimuths (Russell et al. 2016).

Furthermore, the authors also compares the results of data processing that has been done with data processing that has been carried out in previous studies by Russell et al. (2006). Data processing that has been done previously has the same target area as the authors, but in the direction of a different recording azimuth. It can be seen that there are 7 markers on the target sediment layer.

For the last, the authors re-autocorrelated the Lake Towuti data stack after de-multiple processing was carried out. From the processing data stack, it can be seen in the picture below that the seismic peak

from water bottom lake Towuti (0 ms lag) is relatively weak, tends to disappear, at 37 ms lag as in Figure 13. This proves that the processing carried out by the authors has succeeded in reducing multiple signals in the Lake Towuti seismic data.



**Figure 13.** Autocolerogram on the data stack from the initial data gather before (left) and after (right) the application of Preprocessing and conventional velocity background which shows a lag of 37 ms.

## 5. Conclusion

Based on the results of the processing of seismic data from Lake Towuti for line 04, the following conclusion points are obtained:

1. The results of seismic data processing by the authors to eliminate multiple signals (increase S / N Ratio), and delineate markers for Lake Towuti on line 04 are relatively good and representative.
2. Using a combination of Common reflection surface application methods on seismic data with de-multiple methods in the form of, sequentially, Predictive Deconvolution, SRME, and, F-K filters were able to image sediment markers for Lake Towuti on line 04 well.

## 6. Acknowledgement

Token of appreciation and gratitude goes to Institut Teknologi Bandung, Pertamina Hulu Energi, Parents of first Author, Abdul Hafidz, and Haritsari Dewi who helped a lot during the making of this project.

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