Seismic data interpretation for mapping the subsurface structure thickness of top and base parigi formation, Konro field, northern West Java basin

R Rafiandi, R F Indriani and M Mariyanto*  
Department of Geophysical Engineering, Faculty of Civil, Planning and Geo-Engineering, Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia

*mariyanto@geofisika.its.ac.id

Abstract. The Northern West Java Basin is one of the basins which has been proven to have oil content. In the exploration stage, we need an effective method in providing a description of seismic cross section model of the subsurface conditions of a study area. This study aims to map the thickness of the subsurface structure of the Parigi formation and understand the interpretation of seismic data in the time and depth domain. Seismic cross section has interpreted to determine the location of the alleged potential for hydrocarbon accumulation. In this study we focus on the top and base Parigi formation and obtain subsurface structure map in the time and depth domain. We use time to depth conversion (velocity interval method) to map the subsurface structure thickness. The results of the study show that there is anomaly built up which has potential as a gathering place for hydrocarbon on Parigi formation. The difference in thickness between the top and base Parigi is indicated by the differences in appearance of the structure map. The depth range shown on this map is around 1850ft-2135ft. So that the thickness of the Parigi formation in the study area is 285ft.

1. Introduction
The study area is included in the North West Java Basin. The North West Java Basin is in the northern part parallel to the north coast of West Java. North West Java published Sunda Shelf for the northern part. Whereas in the south it is bordered by the Bogor Basin, the eastern part is determined by the area designated by Karimunjawa and in the west is determined by the South Sumatra Basin. The research area is located in the northwest of Java Island geographically. This basin is one of the Back-Arc Basin in the Western part of Indonesia The North West Java Basin has abundant hydrocarbon potential, so it is not surprising that exploration continues to this day. In petroleum exploration, initial surveys are needed, one of which is seismic surveys. In this study, it discusses the interpretation of data from the results of seismic data processing that has been done [1].

The purpose and benefits of this study are to determine the thickness of the subsurface structure of the Parigi Formation and the difficulty of interpreting seismic data in the time and depth domains. The last research shows the evaluation and determination of hydrocarbon prospects but in the Batu Raja formation and the Talang Akar Formation [2].
2. Research Method
The research area in Figure 1 is in the northwest of Java Island geographically. The research area is managed by PT. Pertamina Hulu Energi ONWJ in this study the coordinates are disguised to uphold the company's code of ethics. The study area is in the north-west Java basin. This basin is one of the Back-Arc Basin in the Western part of Indonesia. As for this region, there are several formations, the first formation is the Parigi Formation. The Parigi Formation has limestone lithology, both clastic and reef limestone. This limestone deposition extends throughout the North-West Java Basin, and generally develops as reef limestone that overlaps in harmony above the Upper Cibulakan Formation. The depositional environment in the Parigi Formation is a shallow sea - middle neritic [3].

![Figure 1. Study Region](image)

The data used in this analysis are KONRO field seismic data in the format (Post Stack Time Migration), check shot data, and well data. The well-log data are used density, resistivity well marker, gamma-ray, P-wave, and sonic. The tools used in the research process consist of Personal Computer (PC) hardware and Powerview Software, Z-map. The following flow chart of this research in Figure 2 [4].

![Figure 2. Flowchart of research](image)
The first step is the creation of a synthetic seismogram using wellbore data and then the correlation in Z-Map plus software. To do gridding by inputting data horizon that has been selected both top Parigi and Parigi base. Gridding and contouring will show differences in contours (contour maps) according to the results of the Parigi Formation top horizon picking on the x-line and also in-line and Base Horizon of the Parigi formation. So that the output will get two-time structure maps namely top and base Parigi [4].

2.1 Picking Fault
At this step is marking indicates the existence of a fault structure contained in a seismic cross-section. In this study picking faults are performed on 3D seismic facies covering each inline and crossline with an increment of 5 so that the continuity of the fracture in the three-dimensional model in the form of polygons intersects a horizon. One of the other guides to determine a fault on the horizon is the 2D view that is seen laterally. This method utilizes the Z cross-section to see facies that are suspected of faults and can be subject to picking faults [5].

2.2 Picking Horizon
Picking horizon at this stage use well markers data guide in the target zone. In this study, picking was carried out in the target zone in the top Parigi and base Parigi. The picking horizon stage is the initial stage of working on depth conversion [5].

2.3 Time Structure Map
After picking fault and picking-horizon, mapping can be done. Mapping is done through the process of gridding and contouring on Z-Map plus software. To do gridding by inputting data horizon that has been selected both top Parigi and Parigi base. Gridding and contouring will show differences in contours (contour maps) according to the results of the Parigi Formation top horizon picking on the x-line as well as in-line and Base Horizon Parigi formations [6].

2.4 Time to Depth Conversion
Converting seismic data or structural maps from the time domain to the depth domain is very important in the world of oil and gas exploration. Decision making for drilling programs within the time domain is very dangerous. Because, often interpretation in the time domain will result in misleading interpretations, especially in zones under high speeds such as sub-salt or sub carbonate,[7].

2.5 Time to Depth Conversion Using Velocity Interval
Without well information the only source of velocity data is through the seismic processing accompanying seismic reflection data. Velocity interval method in time to depth conversion, is the speed of propagation where the thick interval is divided by the vertical time interval. Seismic velocities have useful characteristics, they cover the survey area with relatively dense sampling. Seismic velocities are potentially inaccurate, insensitive to velocity changes in deeper layers and noisy. Because of the noise, seismic velocities should be filtered or smoothed before use.[8]

2.6 Depth Structure Map
At this stage is an advanced stage of the time structure map where the map is still in the time domain so it needs to be converted using a mathematical equation into a depth domain

\[
D(t) = \int V(t) \, dt \tag{2.1}
\]

\[
V(t) = \frac{dD(t)}{dt} \tag{2.2}
\]

\[
V_{avg} = \frac{\text{Depth Well}}{\text{Time}} \tag{2.3}
\]
3. **Result**

3.1 **Result of Picking Fault**
The result of picking fault in Figure 3 is obtained by cross-section Z to see facies that are suspected fault and picking faults can be done. The picking fault results are closures marked with a yellow box on the drawing results of picking faults. The existence of closure can be observed that the study area has a fault structure. From the results of this picking fault, we can also see the severity of the fault in the Parigi formation. There are some of large fractures in the study area.

3.2 **Result of Picking Horizon**
The picking horizon in Figure 5 and Figure 6 shows the difference in thickness between the Parigi and Base Parigi top horizons and the build-up phenomenon. In Figure 4 is one of the results of the Parigi picking top and base at one of the seismic cross-points where the build-up phenomenon is shown by the black circle having an increase in structure in the Horizon Top Parigi formation. The horizon obtained will be used to create a time structure map. Picking horizon is done at each inline and crossline with increment 5 so that it will form a dense grid and visible horizon formation in the target zone. Generally, a horizon with a value higher than the average will form a contour line feature that forms the height and lower in the opposite case. The results of the picking horizon are then followed in the time structure map making phase. In Figure 5 shows the results of the Parigi formation top horizon picking and in Figure 6 shows the results of the Parigi base picking horizon.

3.3 **Result of Time Structure Map**
In Figure 7 is a map of Parigi's top structure, this result alone shows two build-ups that look contrasted due to high velocity. The buildup also has potential as a place for hydrocarbon storage. But it needs to be corrected again and compared with the Parigi base map. In Figure 8 is the result of the Parigi base map, obtained a more complex contour pattern compared to the top Parigi because the top Parigi smoothing parameters are more propagated in order to eliminate the effect of the contours that are not clear. This results in good visual results of the map obtained, but the poor quality of existing data.

3.4 **Isochron Map**
In Figure 9 shows the results of the isochron map which in this case is a map that illustrates the thickness of the buildup. This Isochron map shows time (time) not yet domain depth. This map can also function to assist the process of converting structure maps from time to depth. Especially for the Velocity Interval conversion method (thickness difference data is required).

3.5 **Result of Depth Structure Map**
Depth structure map of the conversion results using linear regression method by utilizing checkshot data. The mathematical equation used can convert the time domain into a depth domain only with MD (Measure Depth) and TWT (Two Way Time) data contained in the checkshot data. So that the contour map has depth information. MD and TWT data are made as linear equations to produce a line equation. Equation lines obtained from MD and TWT are:

\[ Y = -3.1095x + 176.4 \]  

(3.1)

**Figure 3.** Result of Picking Horizon  
**Figure 4.** Result of Picking Top and Base Parigi xline 625 (build-up phenomenon)
Figure 5. Result of Picking Horizon on Top Parigi Formation

Figure 6. Result of Picking Horizon on Base Parigi Formation

Figure 7. Result of Time Structure Map Top Parigi

Figure 8. Result of Time Structure Map Base Parigi

Figure 9. Result of Isochron Map

Figure 10. Depth Map V. Interval Method Top Parigi

Figure 11. Depth Map Interval Method Base Parigi
4. Discussion
Depth Map on this method is also obtained by mathematical calculations using high velocity contrast data and speed differences in the expected zone as build up / anomaly. And utilize thickness difference data (Isochron map). From these calculations, a map of the Top Parigi depth structure is shown by Figure 10 and Base Parigi is shown by Figure 11. Both of them show different thickness but the continuity of the fracture between the top and base of Parigi is relatively the same, two build-ups are believed to be a gathering place for hydrocarbons. The depth range shown on this map is around 1850ft-2135ft. By using the velocity interval method, the depth figure is almost close to the well data with a range of 1895ft-2143ft. So that the thickness of the Parigi formation in the study area is 285ft.

Referring to the purpose of research in determining the thickness of the target layer in this study is the thickness of the top and base Parigi formations. In this formation there is an anomaly built up which has the potential as a gathering place for hydrocarbons. But re-correction / further research is needed. The map results in Figure 10 and Figure 11 are already in the depth domain so that further correlation / interpretation can be done with well data. The map before conversion to depth map is a structure map in the time domain. The results of the map conversion show a possible appearance. The difference in thickness between the top and base Parigi is shown by the difference in appearance of the two structure maps in the depth domain.

Research on the conversion of the structure of the time domain thickness into the depth domain has been done with the time depth conversion velocity interval result method of error (the difference with the well data of 54 meters in the top formation and 176 meters of the base formation [8]). When compared with the results of this study, differences in the results of seismic data thickness and well data are 45 ft at top formation and 8 ft at base formation. The velocity interval method is an effective method in converting time domain structure maps into depth domains.

5. Conclusions
From this study obtained as follows, the S Horizon that were targeted in this study were the Parigi horizon top and base formation. The result of this horizon is that there is an anomaly built up that has the potential as a gathering place for hydrocarbons. The difference in thickness between the top and base of Parigi is shown by the difference in appearance of the two structural maps. Using the velocity interval method in this study shows the results of the appearance of thickness maps at a depth of 1850ft-2135ft with well data of 1895ft-2143ft. Thickness ratio of seismic data is used to make it easier to interpret with well data. With the known formation depth domain, it can proceed to the correlation stage with the depth in the well data. The results of this structure map as a reference in drilling. But further and detailed research is needed so that results are more optimal.

Acknowledgments
In compiling this study, we would like to thank PT. Pertamina Hulu Energi has provided opportunities in conducting research and publications by upholding the company's code of ethics in terms of research publications. As well as several parties who have participated and provided their support during the preparation of the results of this study. We would also like to thank the ITS Geophysical Engineering Department and the Sepuluh November Institute of Technology Surabaya Campus for facilitating this research.

References
[1] Dadan D., Kamtono, Karit L. Gaol. Yayat Sudrajat 2014 Identifikasi Batas Cekungan Jawa Barat Utara Di Wilayah Cirebon, Berdasarkan Anomali Gayaberat Dengan Teknik Gradien Dan Analisis Spektrum. Bandung Pusat Penelitian Geoteknologi LIPI
[2] E. Debora 2009 Interpretasi Seismik 3D untuk Evaluasi dan Penentuan Prospek Hidrokarbon Daerah X, Jawa Barat Utara. Depok. Universitas Indonesia
[3] Isman. D. Permata 2018 *Geologi dan Penentuan Zona Prospek Lapisan Permata, Formasi Cibulakan Atas, Lapangan “Mata”, Cekungan Jawa Barat Utara*. Yogyakarta. UPN Veteran Yogyakarta

[4] Haryo A 2018 *Interpretasi Data Seismik pada Cekungan X : Studi Kasus Eksplorasi Geofisika untuk Mencari Area Prospek Migas Depok*, Universitas Indonesia

[5] A. Irham 2017 *Aplikasi Atribut Sweetness untuk Menentukan Sebaran Reservoar Batu pada Lapangan Texaco, Meksiko*, Malang, UIN Maulana Malik Ibrahim.

[6] Al-Chalabi M 2014 *Principles of Seismic Velocities and Time-to-depth Conversion*, Citeseer

[7] Wildan M. M. Imam. S. Sudarmaji 2013 *Seismic Time to Depth Conversion and Uncertainty Analysis for Horizon Prediction in A Proposed Well-Site of Sungai Gelam Field, Jambi Sub-Basin*, Jakarta. *The 37th Indonesian Petroleum Association (IPA) Convention and Exhibition*

[8] Siwei Li, Sergey Fomel 2015 *A robust approach to time-to-depth conversion and interval velocity estimation from time migration in the presence of lateral velocity variations*, Geophysical Prospecting