

Identification of Detrital Carbonate in East Cepu High

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Abstract. East Cepu High is a part of horst – graben series which formed by extensional tectonic processes during Paleogene in North East Java Basin. Due to excellent paleogeography position, the carbonate build-up was growth very well and as the main reservoir in East Cepu High. Sea level change have important factor to provide variation of facies in each carbonate buildup, one of emerging facies is detrital carbonate. Detrital carbonate indicated by onlap horizon featured with carbonate build up body. Based on paleogeography, fluctuation of sea level change and sediment source, detrital carbonate formed in leeward area in lowstand or highstand phases. Distinguish between detrital carbonate facies with other facies, advanced seismic processing performed by using continuous wavelet transform (CWT) and seismic inversion. CWT is one method of spectral decomposition used to find the frequency that represent a facies. The result from seismic inversion will support the interpretation for facies distribution. As the result, seismic data which have interval frequency 10 – 45 Hz and Acoustic Impedance (AI) value above 35000 (from cross plot between acoustic impedance and gamma ray) can be interpreted as detrital carbonate. Based on seismic interpretation, detrital carbonate facies distributed along leeward area with geometrical spreading. The lateral facies change from detrital carbonate to shale was identified which causing this facies become potential as hydrocarbon reservoir with stratigraphic trap. Based on the earlier studies, North East Java Basin have a strong hydrocarbon migration to fill the reservoir, therefore the detrital carbonate have high chance to be a new hydrocarbon prospect in this area.

1. Introduction

East Cepu High is a part of horst – graben series which formed by extensional tectonic process during Paleogene in North East Java Basin¹. It is an excellent paleogeography position for reef growth and forming Isolated Carbonate Build-up (ICB) along platform during Late Oligocene until Early Miocene. It is surrounded by depocenter which are deep marine carbonate and re-worked material from carbonate build-up deposited.

ICB is the main reservoir in this area and it has various facies, one of them is re-worked carbonate build-up deposited well known as detrital carbonate facies. Environment and climate condition, sea level fluctuation, and basin configuration trigger re-worked and re-sedimentation in each carbonate build-up along platform and formed detrital carbonate on the slope in ICB. Based on regional geology detrital carbonate event occurred in Early Miocene^{2,3,4,5}.



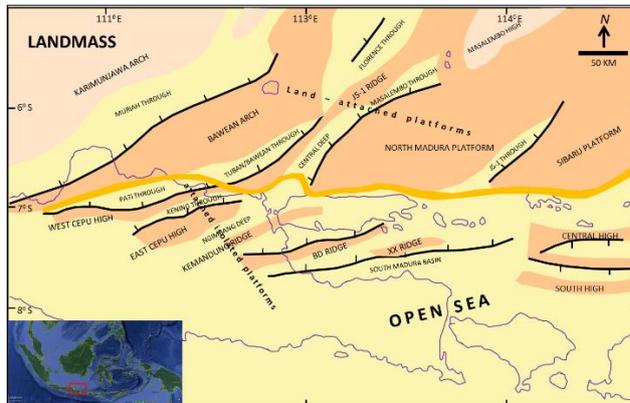


FIGURE 1. Horst and Graben configuration during Paleogene in North East Java Basin modified from Satyana¹

Detrital carbonate can be deposited in three way, margin collapse, off-bank transport, and contourite. Each process have different characteristic in outcrop section, but indistinguishable in seismic section. In addition, each process can be happened in lowstand system track (LST) and highstand system track (HST). Margin collapse usually occurred when sediment not fully lithified and followed by change of pore pressure in sediment and will cause scar evidence along pathway from source to depocenter. Second mechanism, off-bank transport is a common process in shelf area where sediment transport further away from shelf to open area. It has geometry sigmoid and oblique. The last one is contourite, which is a sedimentation process in below storm water base and it has characteristic thick and wider geometry.

Detrital carbonate in East Cepu High confirmed by penetration of J-2 well at flank of ICB J. Thin section from side wall core shown abundant of foraminifera mix with shallow marine bioclast from ICB. Most of the bioclast damaging and has orientation which is a characteristic of re-worked sediment. However, no conclusion about the dominant mechanism working in detrital carbonate ICB J and the thickness of detrital carbonate layer out of seismic resolution.

2. Method

Detrital carbonate penetrated by J-2 well at flank area from ICB J, the proven gas field in this area. The problem is the thickness of detrital carbonate out of seismic resolution. Advanced seismic processing performed by using continuous wavelet transform (CWT) and seismic inversion to distinguish between detrital facies with other facies in distribution mapping. Flow diagram of work can be seen in figure 2 below.

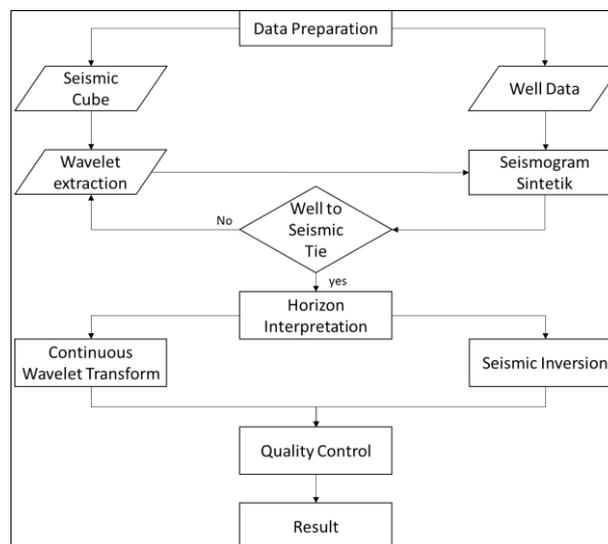


FIGURE 2. Workflow Diagram

3. Seismic Data Interpretation

Seismic data interpretation using analog from Ruby Field in Makassar Strait⁶. Seismic response of detrital carbonate is positive bright amplitude anomaly and indicated by onlap horizon featured with carbonate build-up body. Distribution mapping started from J-2 well tied and interpreted in 3D seismic cube area. Detrital carbonate existence very strong in flank of ICB K. There are two event with positive bright anomaly which onlap to ICB, upper detrital and lower detrital. In lateral succession, the positive bright anomaly has disappear, it is interpreted as lateral facies change from detrital carbonate to other facies with low impedance like shale. The connection between detrital carbonate and main body of build-up play an important role as well as lateral facies change to preserve hydrocarbon as hydrocarbon trap when migration occurred.

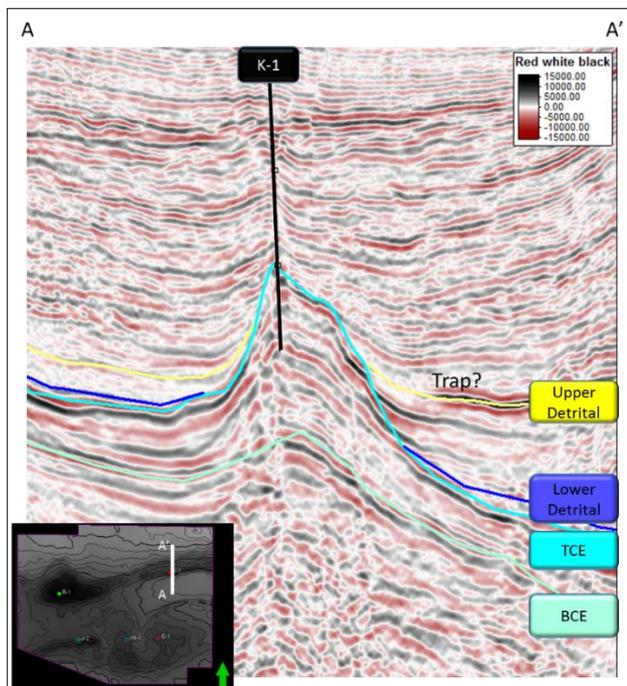


FIGURE 3. North – South section from ICB K there are two event detrital carbonate, upper detrital and lower detrital. In upper detrital event can be seen positive bright anomaly amplitude gradually disappear to the main body build-up and interpreted as lateral facies change. This lateral facies change play important role in stratigraphic trap reservoir like detrital carbonate.

4. Seismic Advance Processing

Lateral facies change will be identified with seismic advance processing which are continuous wavelet transform and seismic inversion.

4.1. Continuous Wavelet Transform

Spectral decomposition using to confirm the connectivity between detrital carbonate and main body build-up. There are many spectral decomposition method and this paper using Continuous Wavelet Transform (CWT). CWT analysis perform using TF Signal to analyzed frequency contain in trace seismic⁷. There are two area to be analyzed, detrital carbonate located in ICB J, where the detrital carbonate is penetrated and the best prospect of detrital carbonate in ICB K.

In trace seismic which penetrated main body build-up of ICB J has interval frequency 10 – 50 Hz with anomaly frequency in 10 Hz (Figure 4.a red line and red circle). In trace seismic which penetrated detrital carbonate has interval frequency 10 – 45 Hz with anomaly in 10 Hz and 25 Hz (Figure 4.a green line and green circle). In second area, trace seismic which penetrated main body build-up ICB K has interval frequency 10 – 25 Hz with anomaly frequency in 10 Hz (Figure 4.b white line and white circle). Next trace seismic to be analyzed coming from upper detrital carbonate event and it has interval frequency 10 – 45 Hz with anomaly frequency in 25 Hz (Figure 4.b green line and green circle). Both result showed consistency with ICB J. Last trace seismic to be analyzed in the position when upper

detrital carbonate event gradually disappear and interpreted as lateral facies change from detrital carbonate to shale (Figure 4.b red line and red circle).

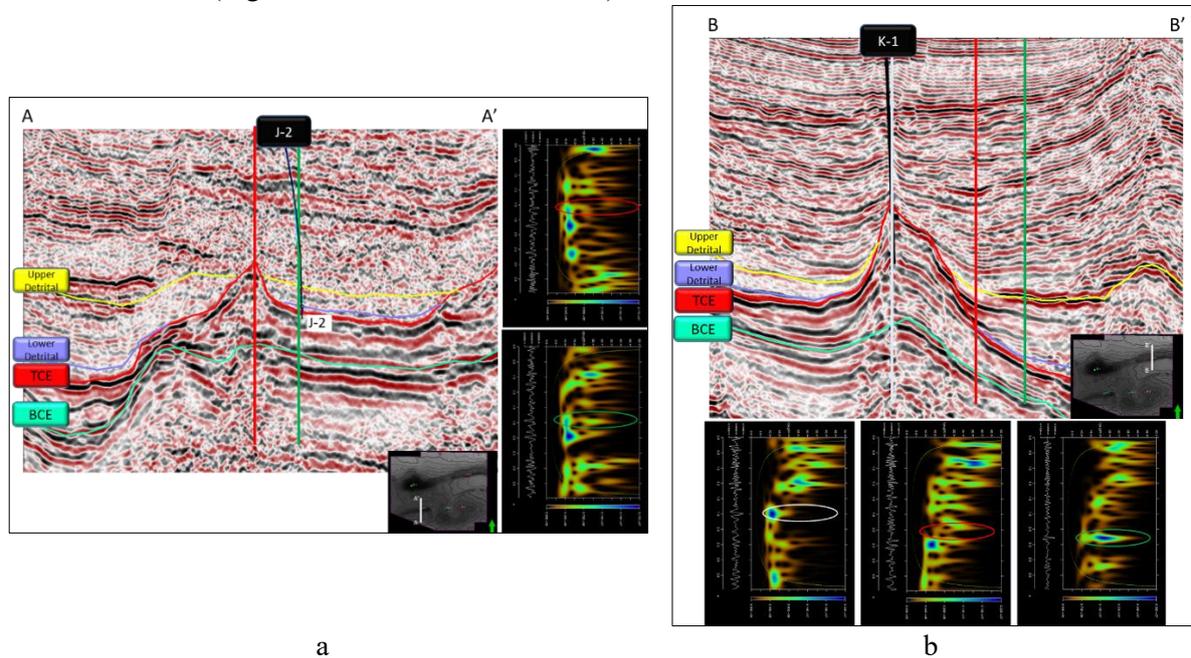


FIGURE 4. Continuous Wavelet Transform using Kristekova⁷. In section ICB J, two trace seismic derived and in section ICB K, three trace seismic derived. The frequency from CWT may vary but have similarity in the same lithology.

Frequency anomaly on 10 Hz can be interpreted as Direct Hydrocarbon Indicator (DHI) in this area. Frequency anomaly on 25 Hz can be represented as detrital carbonate and not yet hydrocarbon proven. Lastly, shale doesn't presented by any anomaly frequency.

4.2. Seismic Inversion

Seismic inversion using to re-check and conform about detrital carbonate present in each anomaly shown in RMS Attribute and CWT. Cross plot AI vs density from J-2 shown detrital carbonate and shale can be separated. Detrital carbonate properties are AI more than 35000 and density more than 2.5 gr/cm³.

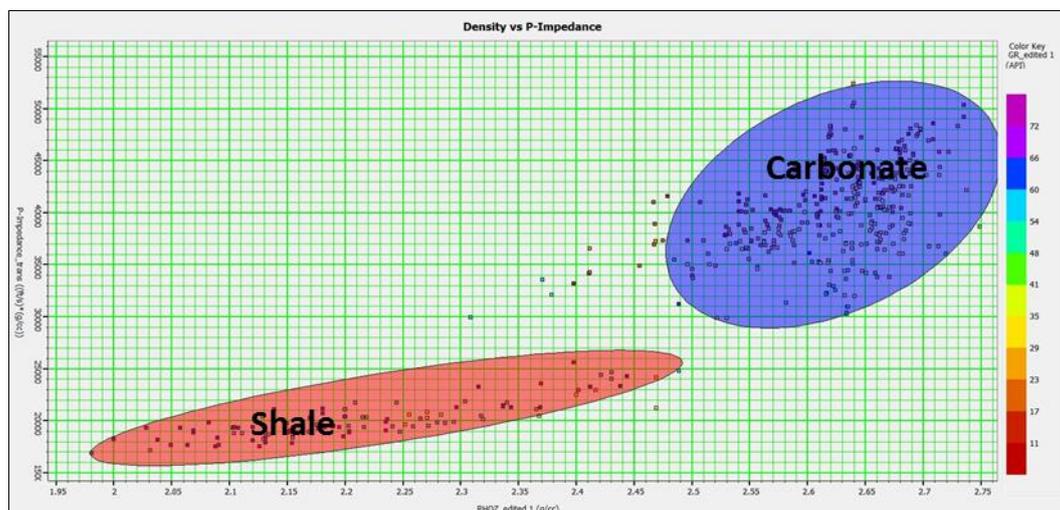


FIGURE 5. Cross plot AI vs density from well penetrated detrital carbonate

Seismic inversion running by model based method and the result show consistency with CWT result. P-impedance distribution shows the existences of lateral facies change from detrital carbonate and unconnected between detrital carbonate and main body build-up in detrital carbonate ICB K.

5. Discussion

Two advance seismic processing methods has been running and both shown similarity result. Detrital carbonate located in leeward area of each ICB. In theory, detrital carbonate can be deposited in three way, margin collapse, off-bank transport, and contourite. Each process have different characteristic in outcrop section, but indistinguishable in seismic section, in addition each process can be happened in lowstand system track and highstand system track.

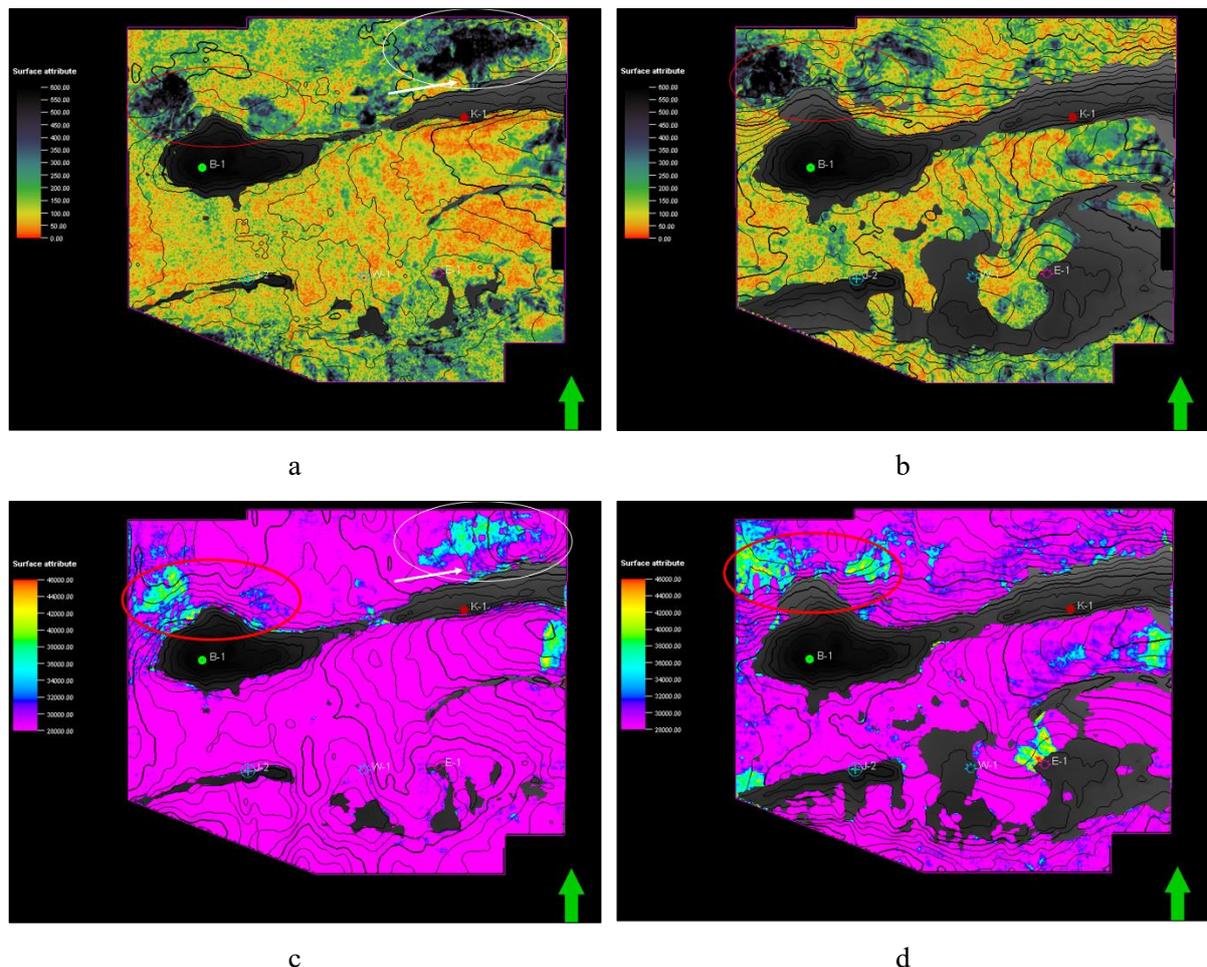


FIGURE 6. Top Carbonate Envelope (TCE) Map overlay with Detrital Carbonate Map with CWT frequency 25 Hz. a) Upper detrital carbonate b) Lower detrital carbonate. Top Carbonate Envelope (TCE) Map overlay with Detrital Carbonate Map with P Impedance. c) Upper detrital carbonate d) Lower detrital carbonate.

Depositional process interpretation could be derived from geometrical of detrital carbonate deposit. In general geometrical spreading in detrital carbonate ICB B (red circle) or ICB K (white circle) can be seen. Detrital carbonate ICB B spreading in north – south direction and most likely attached to main body build-up. On other hand, detrital carbonate ICB K spreading in east – west direction and most likely not fully attached in main body build-up. It resemblance difference process between both of them. Detrital carbonate ICB B interpreted deposited by margin collapse process only, it shown by narrow

spreading and attached with main body build-up. Detrital carbonate ICB K encounter various process to be deposited. It has wider area with east – west direction and a part of detrital carbonate attached with main body. It is like main body build-up has margin collapse in narrow space and the re-worked sediment spreading by contourite when it going to unconfined area.

Result from seismic advance processing strengthened the interpretation. In Figure 6.a and 6.c, there is a pathway feature in ICB K flank (white arrow). That pathway transport clastic sediment from margin collapse in body build-up to wider area. In ICB B detrital carbonate (red circle), there is no pathway seen. Seismic inversion also has similarity result and clearly showed closure of detrital carbonate in ICB K and attached detrital carbonate in ICB B. Detrital carbonate in ICB J which have been penetrated by well can't be discussed because out of seismic resolution. Existing field in surrounding area of detrital carbonate prospect make opportunity to be filled by hydrocarbon when migration occurred.

6. Conclusion

Oligocene – Miocene Carbonate in East Cepu High consist of various facies, one of them is detrital carbonate facies. Detrital carbonate in this area formed differentially and have different characteristic in each of ICB as main source. In general detrital carbonate in this area formed by margin collapse and sometime followed by contourite process. Detrital carbonate can be distinguished by other feature with anomaly frequency at 25 Hz and has property AI more than 35000 and density greater than 2.5 gr/cm³. The lateral facies change from detrital carbonate to shale was identified which causing this facies become potential as hydrocarbon reservoir with stratigraphic trap. Based on regional geology and other publication, North East Java Basin have a strong hydrocarbon migration to fill the reservoir, therefore the detrital carbonate have high chance to be a new hydrocarbon prospect in this area.

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Acknowledgments

The authors wish to thank Directorate General Oil & Gas of Indonesia, SKKMIGAS for data and publication. The Pertamina EP Cepu management, EMCL and BKS for the support.