[PS]The Terrigenous Depositional Response During the Relative High Sea Level Period, Example from Ancient Delta System in East Kalimantan, Indonesia*

Erlangga Septama[1]

Search and Discovery Article #51672 (2020)**
Posted June 8, 2020

*Adapted from poster presentation given at AAPG 2019 International Conference and Exhibition, Buenos Aires, Argentina, August 27-30, 2019
 DOI:10.1306/51672Septama2020

[1]Research and Technology Center, Research and Technology Center, Pertamina (Persero), Jakarta, Indonesia (erlangga.septama@pertamina.com)

Abstract

It is generally assumed that deposition of the terrigenous sediment reached their peak in low sea level conditions where the shelf edge is at the shallowest state and most of the upper shelfal plains are exposed. Eventually, the high sea levels period was generally considered as a time of neglected sedimentation and thus were ordinarily interpreted to be associated with an abandonment phase of the terrestrial bedload deposit. On the contrary, our recent findings from outcrop and subsurface data in the Lower Kutei Basin, East Kalimantan has revealed a complex response in the fluvio-deltaic channel-fill development stages within relative high sea level periods (either authigenic or allogenic factors). Evidence has shown that some deposits certainly “survived” the abandonment period.

A three (3) km detailed transect was measured through several road cuts and open pit coal mines in the Samarinda Anticlinorium area. The well log, FMI, pressure analysis and core petrographical analyses permit an assessment of the subsurface pattern. The integrated biostratigraphy data (foraminifera, nannoplankton and palynology) are used to synthesize the regional marker. This study also benefitted from unmanned aerial vehicle (UAV) mapping, which created a high resolution (1-3 cm precision) 3D digital outcrop model (DOM). To complete the final perspective view, the recent channel deposits in the Mahakam Delta and Balikpapan bay are also used as a comparative model. These entire measurements and intensive amount of information are synthesized into the integrated geological model. We identify three (3) typical depositional models on the response to the high stand sea level that observed at the channel upper boundary, namely: (1) Drowned fluvial channel, (2) backfilled/keep-up channel, and (3) fluvial channel to shoreface rejuvenation. These types of sands have been long overlooked and currently become a new bypassed oil reservoir. This study also reveals new insights about the sedimentary processes and facies geometries in the Lower Kutei Basin, which is noteworthy toward the re-assessment of the geological model. This phenomenon was affected by a unique deltaic conditions such as (a) a large tidal prism area that covers the entire delta systems, and (b) a short (40-45 kilometers) fluvial to shelf sedimentation conduits, combined with (c) relatively high sedimentation fluxes.

The Terrigenous Depositional Response During the Relative High Sea Level Period, Example from Ancient Delta System in East Kalimantan, Indonesia

Erlangga Septama Erlangga.Septama@pertamina.com Research and Technology Center, Pertamina (Persero)

Abstract

It is generally assumed that fluvial depositions reached their peak in low sea level conditions and that high sea levels were generally considered as a period of neglected breaks in sedimentation and thus were ordinarily interpreted to be associated with an abandonment phase. In contrast, our recent findings from outcrop and subsurface data in the Lower Kutai Basin, East Kalimantan has revealed a complex response; either authigenic or allogenic factors in the channel-fill development stages within relative high sea level periods. Evidence has shown that some channels certainly "survived" the abandonment period.

A three (3) km detailed transect was measured through several road cuts and coal mines in the Samarinda Anticlinorium area combined with drone image. The well log, FMI, pressure analysis and core petrographical analyses permit an assessment of the subsurface pattern. The integrated biostratigraphy data (foraminifera, nannoplankton and palynology) are used to synthesize the regional marker. These entire measurements and intensive amount of information are synthesized into the integrated geological model.

We propose 3 new depositional models of transgressive channel due to their specific response at the channel upper boundary, namely: i) drowned fluvial channel, ii) backfilled/keep-up channel and iii) fluvial channel to shoreface rejuvenation. This study also reveals new insights about the sedimentary processes and facies geometries in the Lower Kutai basin. This unique phenomenon was affected by (a) a large tidal prism area that covers the entire delta systems and (b) a short (40-45 kilometers) fluvial to shelf sedimentation conduits, combined with (c) relatively high sedimentation fluxes. This new insight is noteworthy toward the re-assessment of the geological model.

Area of interest

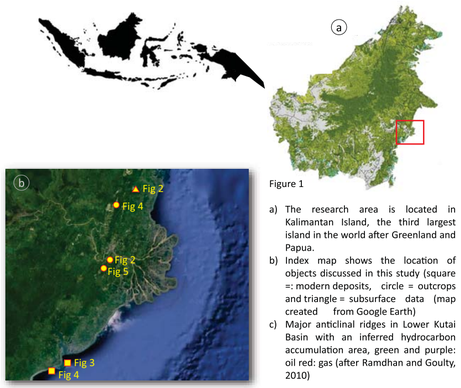
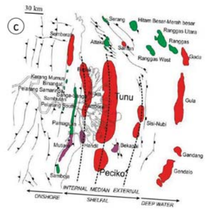


Figure 1

a) The research area is located in Kalimantan Island, the third largest island in the world after Greenland and Papua.
b) Index map shows the location of objects discussed in this study (square =: modern deposits, circle = outcrops and triangle = subsurface data (map created from Google Earth)
c) Major anticlinal ridges in Lower Kutai Basin with an inferred hydrocarbon accumulation area, green and purple: oil red: gas (after Ramdhan and Goulty, 2010)



Data Integration

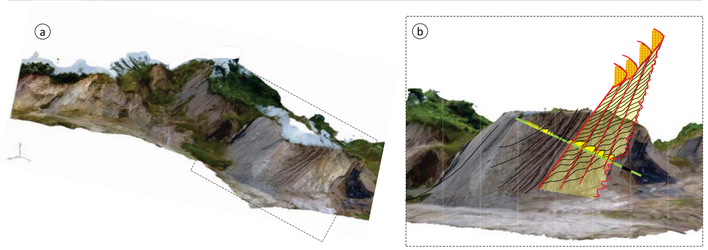
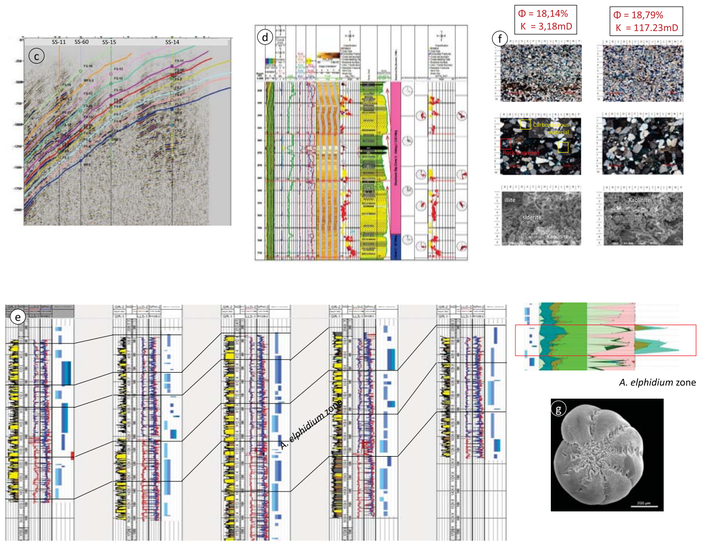


Figure 2 a) The unmanned aerial vehicle (UAV) mapping, which created a high resolution (1-3 cm precision) 3D digital outcrop model (DOM). b) The 3D drone photogrammetry, photography and photomosaic of the outcrop are taken to capture and identify the facies, size and geometry of the depositional element.



c) The chronostratigraphy framework was constructed based on the seismic data and controlled by d) The FMI data. The core data are acquired from two wells and recovered some 30 meters of mixed sandstone, siltstone and shale sediments. e) Well to well correlation also demonstrates that lateral facies variation strongly influenced the quality of the reservoir sand. f) The special core analysis (SCAL) shows that the presence of carbonaceous material controls the reservoir permeability, although the sand porosity is generally increasing toward the east, the reservoir permeability tends to be decreasing respectively, probably due to the presence of the tides origin shale laminae and carbonaceous material (e.g. leaves remains and wooden fragments). g) This sand group is constrained within biostratigraphy marker of *Ammonia elphidium* suggests the depositional of ancient proto-Mahakam delta system during middle Miocene age.

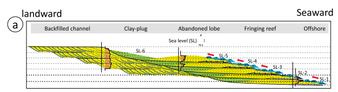
Modern transgressive deposit analog

Figure-3

a) A cluster of sand lobes in the southern isthmus of Balikpapan Bay (google earth image). The minimum distance to the present river mouth is 6 kilometers suggesting a significant sea level rise during the depositional period, a1) living coral colony on the lobes front, and a2) dead exposed coral in the shallow lobes front. a3) Sub-aerially exposure area of the sand lobes during the low tide consist of fine to medium grained sand with scattered coral thallus. a4) the marine shale at the base of lobe (18 m depth)
Coordinate: 475337.13 m E, 9846559.47 m S

b) The simplify cartoon of evolution of the abandoned lobes in the Balikpapan Bay, left: the river was normally flow and deliver terrigenous sediment (yellow) during the low sea level period. Middle: during the high sea level period the sand lobes deposition was terminated. The relief of the sand mound creates the barrier thus enable coral growth on the lee side of the slope. In the landward direction, the river is start to backfill toward upstream. Right: the coastal longshore current reworked the coral thallus into a barrier ridge with a North-South elongation.

modern lobes vs. subsurface data



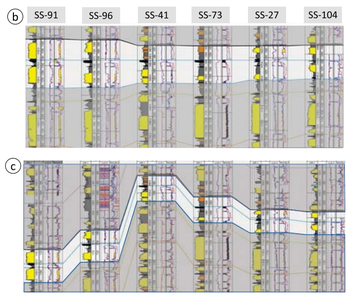
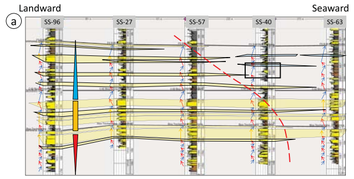


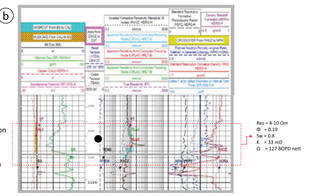
Figure-4

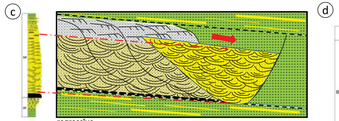
a) The idealized cartoon section of the abandoned lobes and backfilled channel deposit based on the modern analog in the Balikpapan Bay. SL = Sea Level. Coordinate: 465976.40 m E, 9844878.07 m S

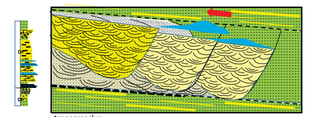
b) West to East cross section through C-03 reservoir in structural and c) flattened view in the North Kutai Lama field. Noted the gradual change from blocky high resistivity logs character in the West to thinner bell shaped logs with low resistivity in the East. Logs shown are gamma ray, resistivity, density and neutron. Top marker is A. elphidium horizon (due to data confidentiality .

Sequence Stratigraphy and depositional model









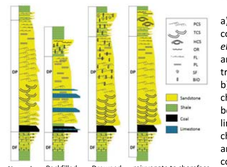
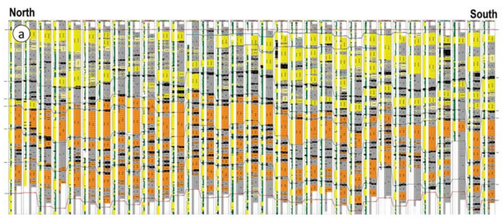
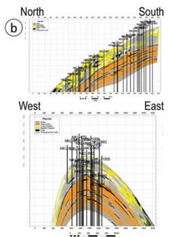


Figure-5

a) 4th order sequence stratigraphy correlation of wells focused on the *A. elphidium* marker, the bypassed oils are mostly found within the transgressive package interval.
b) Type log of the backfilled tidal channel, the spike character in the bottom part of the channel is a thin limestone layer. This log characteristics are often qualitatively and quantitatively overlooked and are considered as a non-attractive interval.
c) Comparison between hypothetical processes of the normal channel avulsion and transgressive channel avulsion.
d) The idealized depositional sequence of fluvial-deltaic cycle in Mahakam based on their response to the mixed tidal and wave influence. (1) normal (2) backfilled channel (3) drowned channel and (4) channel to shoreface rejuvenation. Abbreviations: PCS= planar cross stratification, TCS, trough cross stratification, HCS= hummocky cross stratification OS=oscillation ripple, FL= Flaser, SF= shell fragment, BIO= bioturbation. DP = Delta Plain, DF = Delta front.

Geological Model reconstruction





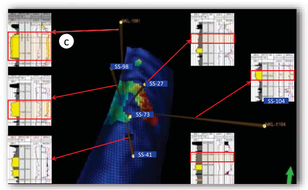


Figure-6
a) The sequence stratigraphic framework for the entire wells in project is established based upon the key marker. b) the facies model embed into the 3D reservoir model. This model will be used to determine the tank development strategies. c) The example of static model of X-03 sand with the lateral facies variation.

Conclusion

The outcrops and modern deposit shows evidence that deltaic channels sometimes do survive the high sea level condition. We propose 3 new genetic depositional sequences of transgressive channel due to their specific character at the channel upper boundary, namely: i) drowned fluvial channel, ii) backfilled/keep-up channel and iii) channel to shoreface rejuvenation.

These unique phenomena are likely caused by (a) low slope gradient of the delta plain area that creates a large tidal prism area that covers the entire delta systems, from delta front through the head of deltaic facies, (b) a relatively short (40-45 kilometers) fluvial to shelf sedimentation conduits combined with (c) relatively high precipitation and sedimentation fluxes. This new insight could be used for the re-assessment of the geological model.

The present study has enriched our knowledge on various type of transgressive or highstand sand deposits geometry which has been long concealed. This study contributes to improve the field production through some additional bypassed oil reserve.

(Please find the list of references in extended abstract)

Acknowledgment

This paper is a part of an ongoing research program and field works done by Pertamina EP Asset-5 exploitation department team. We are indebted to review by Pertamina EP board of director, Pertamina EP Asset-5 management and the exploitation division of SKK-Migas. We are also heartily thanks all field assistances who help us during the field works.