THE DYNAMICS AND DEPOSITIONAL SYSTEM AS RESERVOIR ANALOGUE CASE
STUDY OF OPAK ESTUARY, SOUTH COAST OF YOGYAKARTA

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ABSTRACT
Research on sedimentology of Opak estuary has been conducted using shallow coring and grab sampling around the estuary of Opak River at the coastal area of Depok Beach, Special Province of Yogyakarta. The result indicates the wave had dominated the process of depositional system on Depok Beach. Shallow coring is done at 8 point of lagoon, point bar, estuary and foreshore. Based on the core data, lagoon facies show the domination of dark mud with high organic contained. Finning upward pattern and sharp contact of pebbly sands material indicates there was a changed in the depositional environment. The lagoon facies at present could be interpreted as an active channel that connected with the fluvial system at past.

Estuary Facies is generally dominated by brownish sands but further to the west area mud contained is highly increasing, the fluvial control ran down and environment became deeper are consider as causal factor of the issue. It clearly show on the result of shallow coring that showing of the grains and mud, it indicates that the suspension here was developed better than on the east side near the fluvial and the inlet.

Prograding of sands at washover barrier is dominated by thick and wide geometry of planar cross bedding sands. At Foreshore area the main control is marine process with the domination of wave from Indian Ocean that produce clean sands with sedimentary structure of planar cross bedding. SE-NW orientation of the wave had made the Opak River deflected to the west and create a barrier by the sedimentation result of the river itself.

Comprehension on modern depositional environment could help as a guide for subsurface interpretation of hydrocarbon exploration. The result of the research on modern estuary environment show Opak Estuary produces the good quality of sands material with its wide and thick geometry with some characteristics of sedimentary structures. Washover barrier and foreshore are two both facies that potential to be the best reservoir at environment system which dominated by wave. The pattern and distribution of the sands is controlled by the energy of the particular depositional environment.

I. INTRODUCTION
Oil and gas are the most important natural resources for energy consumption to maintaining the national energy security of Indonesia. Both oil and gas in long term definition have been known as renewable resources because the geological process in nature always runs all the time, but once process of forming oil and gas through the petroleum system needs million years (Laurence Robb, Blackwell). Oil and gas are always formed nearly at the same time. Oil and gas that have been consumed in this era was formed at least 30 million years ago at oligocene, so both oil and gas are non renewable resources in short term definiton if they were compared with human life span. Exploration in Indonesia is needed to find new oil fields since Indonesia only has 6 oil fields which in 2011 could produce 900 thousand barrels daily but consumption was more than 1300 thousand barrels daily. Based on SKK Migas data Indonesia holds proven oil reserves of 4 billion barrels but consumption oil reserves has limited 18 days, it means no more oil reserves could be used at nineteenth day if
production was stopped at all for example in case of natural disaster. This Limitedness has led the government to awareness of exploration needed.

But exploration of oil and gas is not an easy work. Exploration needs competency towards geological concept. Geological competency in exploration of oil and gas is needed to comprehend wether or not a basin is potential to be a reservoir. Many explorations of oil and gas have failed and ended up with dry hole results, and it is a big deal. Dry hole results may caused by misinterpretation of the origin of reservoir rocks. It could be happened because many types of sand deposits as reservoir rocks have a lot of resemblance in sedimentary structures, compositions, or characteristics. Distinguished the origin of reservoir rocks could comprehended on how the petroleum system works.

Many studies on modern sedimentation environment of which discusses the sediment transport in the Mahakam Delta (Allen & Chambers, 1998), sediment dynamics and depositional system on the Mahakam delta (Salahuddin & Lambiasse, 2013) and the dynamics of the Mahakam delta (Bachtir et.al, 2010 ). The study is used as an analog understand sedimentation, distribution and quality of the reservoir rock. This study focuses on the aspects of hydrodynamics and modern depositional fases in opaque estuary.

II. GEOLOGICAL SETTING

South Coast is the Indian Ocean where the wave energy is quite large compared to the northern coast of Java is relatively small (Yusliandi et.al, 2015). It affects the process of sedimentation and morphology of the coastal plain, The influence of such waves is clearly visible, especially in the research area. Sediment deposited material is generally derived from volcanic material, due to the setting of the basin located in front of the volcanic arc. In addition provenance also came from volcanic and sedimentary rocks of Tertiary hill country of south of Yogyakarta. The interesting thing in coastal environment is dominated by waves where the waves are generated clean sand and be a good reservoir rock. Opak river slope tipped volcanoes where the material is transported is the result of the eruption of volcanoes which deposited along the river and beach. Tidal sea level in Opak Esturay occurred ranged from 06.00 am to 17.00 pm in November 2014, the process affects the body's system of sedimentation in the estuary. Forming barrier in the Opak river is influenced by the direction of the waves in the Indian Ocean oriented SE-NW, it causing of turning Opak river towards the west. The high sediment supply strongly influence the process of sedimentation and morphological changes in the Opak River.

III. METHODS

The method used in this study include shallow coring in eight locations covering point bar facies, abandoned channel / lagoon facies, estuary and foreshore facies. It also does grab sampling at two locations on the body of estuary to determine hydrodynamics and sedimentation of the estuary profile. Outcrop observations on tidal boundary limit, character of bedform and washover barrier sand was also conducted to determine the depositional models and geometry of each facies. And other methods the contruction of test pit on the barrier body to determine the characteristics of sediments and sedimentary structures that exist (Figure 2). From all of these methods and then it was built a model of sedimentation that includes the power of energy, sediment grain size and geometry facies.

IV. RESULTS

- Hydrodynamics and Depositional Fasies
Observations hydrodynamics and sediment transport based on cores, grabs sampling and field observations. There are 6 facies based on the characteristics and depositional environment, consist of:

- **Point Bar Facies**

  At the point bar facies shows the lithology dominated by thick mud, many found (rootlet) and little organic material and there are some silty sand material that shows a low energy deposition, interpreted deposited on the flood plain environment. At the bottom of the lithology encountered coarse sand and pebbly sand with andesite fragments were interpreted derived from material from the eruption of Merapi and limestones derived from sedimentary wonosari formation, there are imbrication and bad sorting as well as showing the pattern of finning upward. It shows the process of sedimentation with high energy, environmental interpreted deposited on the active channel. The most base lithology is very coarse sand that form a pattern of upward coarsening. Results of this study indicate the bad potential as the reservoir rock that might be caused by several factors such as the lava flood event of Merapi volcanic materials as well as transport distances are relatively close resulting in a relatively non-uniform sand. Interpreted this location is part of the lateral accretion in point bar (Figure 3).

- **Abandoned Channel/Lagoon Facies**

  This environment is composed of mud contains rich organic, thick with dark colors, characterize sedimentation quiet (suspension) with supplay organic material derived from plants such as marsh nearby. Closed water circulation (reduction) was able to preserve the remains of plants that has run into sedimentation. At the bottom of gravelly sand encountered interpreted deposited on the fluvial environment of active channel/ distributary channels with the high energy environment prior to the formation of sedimentation lagoon. Stacking patterns show finning upward, with some traces of animals High content of organic material allows lagoon sediments could be a candidate as source rocks on brackish sedimentation system.

- **Fluvial Facies**

  Upward coarsening sedimentation patterns with a predominance of very coarse sand and moderate-bit gravelly, moderate sorting to bad sorting and granules with rounded forms sub angular - angular. Sedimentary structures formed planar cross bedding and predominantly mafic minerals. At the top there is a slightly gravelly sand with environmental washover interpreted formed at remembering the location of shallow coring fan is located adjacent. Fluvial sedimentation environment reflects the relatively high traction energy, especially on the thalweg, it affects the amount of grain and grain sorting deposited. Appearance bedform ripple - ripple mega also observed in the field and could be a hint towards sedimentation, there is little effect of tidal currents are generated from inlet bedform affect the type and direction of sedimentation. Sand quality as reservoir rocks show a fairly good level. Distributions that are not so widely spread yet long enough quite promising as the reservoir rock.

- **Estuary Facies**

  Environment estuary we studied quite interesting given the differences in the estuary which in general are often formed and into the reservoir rock in many oil and
gas fields in Indonesia and the world are dominated by the tide, it is very different from the characteristics of rock sediment to the estuary are dominated by wave as the object of study this. The effect of the strong dominance of the wave is influenced by geographical location that is directly related to the Indian Ocean. Direction of the wave was very clearly observed on satellite image as well as from the appearance of the field where there is a barrier of sand which washover to obstacle and make a winding river flow direction to the west. This can be interpreted influence the direction of the wave on the environment sedimentation oriented SE-NW. Two shallow coring of data on the environment shows an increase in the content of mud and sedimentation patterns are formed, where the influence of fluvial increasingly towards the west progressively reduced so that energy sedimentation of the suspension began to dominated. Sedimentary structures formed planar cross bedding, massive, as well as graded bedding and the presence of the shell. Fine grain size and uniform compared with fluvial environment. At the core 4 and 5 show the pattern of upward fining and the gradation reduction in energy intensity of sedimentation. Coarse grains is still a question that is likely deposited on the environment or body washover fluvial fan. Grab sampling results showed a similar thing where the apparent increase in clay content and grain towards the western part of the increasingly refined. The body of the estuary which is not always dominated by clay which to showed energy low sedimentation. Where the results show that the grabs sampling sediment transport is dominated by traction current and growing into a suspended western section (Figure 4 and 5).

- Foreshore Facies

Sedimentation environment foreshore shows the influence of the strong waves of the Indian Ocean, thus affecting the quality of the sand is clean (clean sands), sorting the good and the rounded shape. Sedimentary structures that consist of planar cross bedding with upward coarsening pattern. Composed of mafic minerals are dark brown and white that characterizes of quartz mineral, the composition provenance that resulted from the volcanic eruption that probably came from volcanoes. Based on the results of the shallow coring sand proved a good quality reservoir rocks analogues to the foreshore environment. The presence of shell fragments and traces of the animals (Burrow) which is one of the physical aspects of the environment penciri foreshore.

- Washover Barrier Facies

This facies to obstacle between body estuary to the sea, which is composed of sand to gravelly size, planar cross bedding, graded bedding with sorting pretty good. The distribution spread is quite wide and thick that looks directly in the field, the appearance washover fan is also evident that formed in a certain period of storm surge. Inlet migration is very interesting to learn and be the link between the body estuary and sea. Washover barrier which showed the presence parasequences progradation where each parasequence consist of gravelly sand that are observed in the field. In this facies test pit was also conducted to determine the characteristics and structure of the sediment, ripple and planar cross bedding noticeable in test pit with grain size of sand are medium - coarse contains mafic minerals.

- Depositional Model and Sand Quality
Sediment transportation and distribution of facies indicated Opak Estuary is dominated by the influence of the wave with little tide and fluvial. Tidal limit can observed directly in the field at the bend in the river NE Opak that form bedform ripple with sand being - as well as the pebbly rough on the sand bar. Abandoned channel/ lagoon formed when sand bars begin to cover thus making distributary channel dead. Sand bar will continue to form and migrate towards the north on the curve of the river Opak. Wave influences greatly affect the geometry of the barrier and the inlet is formed. Flow suspended is highly developed in the western part of the body estuary that makes quality sand for the worse due to the silty material. Progradation presence on the washover barrier sand evident in the field which composed by sand grain size medium, coarse and sometimes gravelly with sediment structure planar cross bedding, interestingly in every bedding sometimes show the graded structure and inverse grading. It is explain this environment has a strong sediment transport by waves influence from Indian Ocean. Quality of sand on each facies sedimentation is very diverse, it illustrates the existing sediment transport.

V. DISCUSSION
The concept of modern sedimentary environments analogues is helpful in interpreting the data and an indication of subsurface reservoir rock distribution patterns. Fore arc basin is affected by sediment material volcanics, thus making quality of reservoir rock becomes less good. Further research is needed to determine the effect of tidal does salinity measurement, analysis and heavy mineral granulometry to obtain the results of sorting level, and the provenance. Sedimentation generally very complex environment considering the rapid changes in morphology and sedimentation processes that may make interpretation deviate from actual results.

VI. CONCLUSIONS
There are several things that can be inferred related to the process of sedimentation in sedimentation environment in the location where the research that can help us in exploration activities especially oil and gas:

- The object of research is the sedimentation environment dominated by wave located at the mouth of the Opak river, Bantul DIY.
- Sediment transport is dominated by wave currents and traction, especially on the fluvial environment, distributary channel washover barrier, foreshore, while developing facies suspense lagoon and estuary. The influence of tidal currents observed in the field are clearly visible due to the connection via the inlet.
- The presence of morphological changes of facies distributary channel sedimentation into the abandoned channel/ lagoon.
- Good sand quality by sorting and clay content lies in the lack of fluvial facies with extensive geometry, washover barrier sand which has a geometry throughout the body as well as the estuary foreshore very wide and elongated.
- The influence of energy sedimentation greatly affect the quality of the resulting sand sedimentation in which energy is getting to the west of the estuary on the wane and cause high content of clay that make the quality of the sand to be bad.

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REFERENCES


FIGURES

Figure 1. Location Map of Research Area.
Figure 2. The research method consists of shallow coring (above), test pit on the body washover barrier (middle right), grabs the sampling and profile estuary (middle left) as well as the observations on outcrops washover sand barrier.
Figure 3. Core photograph of point bar facies.

Figure 4. Methods of grab sampling and estuaries profile in the eastern part.

Figure 5. Methods of grab sampling and estuaries profile in the central part.
Figure 6. Core photograph (bottom) and progradation washover barrier sand ((top).
Figure 7. Core Correlation of Lagoon Facies.

Figure 8. Sand and shale ratio
Figure 9. Depositional model of modern Opak estuary

Figure 10. 3D Depositional model and facies distribution of modern Opak estuary