

Basin Play Applied in Deep Water Oil Exploration - Compared with Backscatter Seabed at Makassar Strait Indonesia

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<u>Abstract</u>

Oil exploration industry greatly depends on Geological and Geophysical (G&G) interpretation, still and all the interpretation science is estimation process that requires verification in ground truth with tangible fact. Niko resources as the largest exploration oil and gas company in Indonesia, tried to approach new perspective in order to enhance G&G outcome with Basin Play analysis using Geographical Information System (GIS).

Basin Play in GIS essentially using all basis data: Net Pay and Net Reservoir interpolation from Well Information enforce with geo-structural and stratigraphic interpretation as additional factor; Field Statistic; modeling of Seafloor Bathymetry, all overlay with Backscatter decibel map. The overlay distribution area solely use as hit area of coring plan location pointed along seabed geomorphology pattern. Different statistical model and data distribution will impact the analysis result; however with the exact variable and precise model, it should deliver proper output. Backscatter deStripe in this paper is acquired from Indonesia Multibeam Mega Survey I - (25 meter) Seafloor Ocean Mapping Project.

Makassar Strait area especially Kutei Basin is surrounding by Gas and Oil Field which based on USGS assessment minimum undiscovered field size in this basin would be 1 million MMBO (Oil) while Gas 6 million MMSCFG (estimated at 2000). Recent discovery in Kutei Basin is oil, located at north of basin in the contract area operated by Salamander Energy.



Makassar Strait separate Kalimantan (Borneo) island and Sulawesi (Celebes) island 200 km wide, the water depth vary between 0 - 2,500 m (Gebco 30 arc second grid), which the deepest area lies on northern part of the strait, and they open to Celebes Sea. While at South, Makassar Strait contiguous to Java Sea.



Makassar Strait primary constructed by Kutei Basin, also called Kutai Basin, which adjacent with Pater Noster Shelf and South Makassar Basin in the South; Suikerbrook Ridge at North; Karama and Lariang Basin, West Sulawesi Volcanic Arc to the East. Kutei Basin is the largest and deepest basin in Indonesia (Rose & Hartono, 1978), and estimated as the biggest hydrocarbon in Indonesia.



There are 113 fields in Kutei Basin: 31 fields in status Producing, 39 successfully at phase Discovery, and 13 going further to Developing level; also 6,231 well were drill in this area both exploratory and Development stage. About 17% of Indonesia's PSC occupy in Makassar Strait show this area is commercial area for oil and gas exploration.

Niko Resouces - deep water exploration Oil and Gas Company - has three PSC inside Makassar Strait, two of them operated: South East Ganal PSC and North Makassar Strait PSC; while North Ganal PSC is a joint block with ENI as block operator. As a commitment to Indonesia Government, North Makassar Strait drilled first well, Pananda-1 which spud dated 14 April 2013 with result non-commercial gas discovery. The well located on North Makassar Strait Area IV was drilled in water depth 7,433 feet to a total 19,685 feet that took 50 operational days. An 80 foot gas interval was identified in the upper section, and drilling confirmed the presence of hydrocarbon in a previously untested Middle Miocene turbidity package in a basin floor setting. A thick package of over 700 feet of very fine grained distal turgidities was drilled although poor reservoir properties indicate non-commercial at this well. The Pananda-1 well is situated approximately 40 kms southeast of the Chevron-led deep water development project at Gehem field. (Pananda-1 Exploration Well Press Release – Niko Resources 13 June 2013).

Basin analysis comprehends in statistical calculation from tabular database and interpolation of geospatial grid raster. Statistical analysis merely using attribute feature are often used to examine value distribution and summarize data. For example, Picture 2 (Part A) below is graph showing oil and gas recovery in four main field of exploration project in Makassar Strait (all field has uniform reserve estimation 1 - 10 million mmscfg/million bo): Bangka field, Gendalo field, Gehem field, and the most recent discovery: Jangkrik field; the graph show Gendalo has biggest oil recovery than other three field whereas Gehem has biggest gas recovery. Vertical bar at graph Part B represents correlation between financial drilling costs of well depth overlay with trend value from the two variables.



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Grid interpolation methodology represents a prediction from several sample location for regional overview, where completeness values will force high assumption that impact outcome differences which might be diverge. In exploration, well information such as Net Reserve and Net Pay are a material to calculate overview pattern. Interpolation model of Net Reserve and Net Pay which deliver surface gridding has been taken from well logging both Pre and Post drill report.

Interpolation model applied in this paper refer to geostatistical model: Spline methodology that referred to deterministic interpolation because they assign values to location base on the surrounding measure value on specified mathematical formula that determine the smoothness of resulting surface. This technique will describe the variability and uncertainties within any reservoir, specifically related to resource and reserve estimates.

There is no universal definition of Net Pay; still knowledge of Net Pay is important in the volumetric estimation of hydrocarbon resources. Net reserve are estimated remaining quantities of oil and natural gas and related substances anticipated to be recoverable from known accumulations, from a given date forward, based on (i) analysis of drilling, geological, geophysical and engineering data; (ii) the use of established technology; and (iii) specified economic conditions, which are generally accepted as being reasonable, and shall be disclosed.

There are more than six thousand well in Kutei Basin, half of them drilled offshore and only 220 of them lies at deep water zone. Definition of deep water well is the process of drilling took more than 500 meter of water depth. The deep water well at Kutei Basin varies between 500 - 2,800 meter of water depth. Difficulty in collecting data and limited



access to well report generate only selected well will be as an object in interpolation process, even when they are not well distributed in study area.

Study area is 6,500 sq.km cover three Niko PSC and open area surrounding, there are 60 well available inside study area, but only 10 well contain Net Reserve data and only 9 well with Net Pay data. In modelling Net Reserve data, there are two different result of grid pattern when fault input as an influence variable.

Raster output represent well distribution on study area where value more complex at south west of the area which interpolated from 6 wells (Ga1, Ga2, Ge1, Ge2, Ge3, Ge4), while on the east and south east area display modest value since there are only 2 well assign around location (Pa1 & Pu1). This pattern generate different curve on grid result because additional barrier factor: structural fault which run north south on east part of the area shown as black thick line (see picture 3).

The output grid with structural barrier represents better accordance to actual condition, which able to be seen on the right part of picture 3 below, where red grid which mean high value standstill along fault line at the western part, unlike the picture on the left where no barrier input as a variable, the grid pattern has standard interpolation result. The pattern reinforce by field conformation, where Gas and Condensate field has similar form with grid at structural barrier and lays on parallel shape inside the high value area at western North Ganal PSC. The field has estimated gas recovery of 3 million mmscfg. At the south west, there is Oil and Gas field which cover well Ge1, Ge2, Ge3 and Ge4, with estimated oil recovery 30 million mmbo.



Net Reserve Interpolation

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Net Reserve Interpolation



For company purpose, North Ganal Area 3 PSC at the eastern part and South East Ganal I PSC at the north east area will be area of interest for detail prospect investigation. Backscatter dStripe data show a scattered high value spot at this area of interest, which considerate as more focus area in core spot location to be sample before drilling.

Drop coring Program that Niko planned for 2014 in Makassar Strait area will use the interpolation scheme as one of the considerable guidance in determining a coring location. The geochemistry analysis from coring program taken in 2007 show Gas (Biogenic) and Oil that acquire at the north west of South East Ganal I PSC (see picture 4 below). The two joint coring of the archive and new acquisition will interpolated and develop as new input variable to G&G exploration analysis.



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Backscatter is a reflection of waves back to the direction they came from. The term backscatter data is used to describe the intensity of returning sound waves (dB). The seafloor backscatter is defined as the amount of acoustic energy being received by the sonar after a complex interaction with the seafloor. Backscatter acquisition in the same time with bathymetry survey.

In processing seafloor acoustic data such as backscatter, it is common to have stripe noise and speckle. There is other method to eliminated and corrected the noise that could improve the quality of multibeam data products. This method needs enhanced process and software, the backscatter that lack of the stripe result called backscatter dstripe.

Bathymetry on the other hand, provides seafloor depth information and is computed by measuring the time that it takes for the signal to return to the sonar. Definition of bathymetry is underwater equivalent to topography. Bathymetric data is the same as depth data.

Niko Resources conduct Indonesia Frontier Project that survey in 2006 until 2008 to collect subsurface data: Bathymetry & Backscatter with resolution 25 meter and coring sample with geochemical analysis. The project "Indonesia Mega Survey (Part I)" continue with "Indonesia Mega Survey (Part II)" which conducted in 2011 until 2014 as plan to get the same data: Bathymetry & Backscatter only with better resolution 15 meter and drop coring that covered open area where not covered in first Indonesia Mega Survey.

Bathymetry and Backscatter acquired using Multi-Beam Echo-Sounder (MBES) technology which transmits a fan of a large number of acoustic impulses (beams) into the water. Therefore a wide stripe of seabed perpendicular to the ship track can be scanned by multiple simultaneous soundings. This way, larger seafloor coverage of depth soundings is achieved than with the employment of Single-Beam Eco-Sounder (SBES) that more widely used in seabed survey (Lurton, 2010).

The seafloor is covered by water force different methodology and technique to observe as Earth's (land) surface. Light radar technology penetrates shallow coastal area, therefor deep water seafloor collect surficial data use sound signals. These signals are not absorbed by water and can be directly used for seafloor investigation. The approach of remote seafloor classification has the advantage over conventional sediment investigation methods of being much more efficient as it covers a large continuous area.

Bathymetry allows us build landscape mapping to extract information about geomorphology and drainage. Geography Information System (GIS) help modelling bathymetry over the seafloor morphology which in petroleum exploration industry used to reconstruct paleogeographic feature, geohazards mapping and examine subsurface flow into traps. Understanding the surface flow in a region can identify drainage suggesting potential for flooding events. Basin sedimentary processes can suggest provenance and sediment pathways to basin deposition.



Basin analysis in exploration reconnaissance usable for mapping tectonics and mapping assessing potential geo hazards areas. The mapping of catchment or watershed, in fault footwall topography can indicate seismic geohazards and combine with aspect and slope maps can indicate the area of potential land sliding.

GIS desktop provide hydrology scheme: modeling and toolset, which useful in basin analysis and can be accessed within toolbox. Hydrology tools assist in modeling the movement of water across terrain surfaces. These tools run through workflow that generates derived products from the one input dataset (depth data). Nevertheless this paper limited to basin analysis and petroleum play fairway mapping workflow using ArcGIS desktop techniques rather than the science of techniques themselves.

Basin and watersheds are land areas that drain to a Hydro Network. The determination of their boundaries is necessary when modeling a hydrologic system. Basin or drainage basin delineation defined by flow direction where watershed also known as catchments, are physically delineated by the area upstream from a specified outlet point. In simple word, watershed delineated from flow direction and stream link which process after basin delineation.

There are differences between basin and watershed. A basin is an extent of land where water from rain or snow melt drains downhill into a body of water, such as a river, lake, reservoir, estuary, wetland, sea or ocean. The basin includes both the streams and rivers that convey the water as well as the land surfaces from which water drains into those channels, and is separated from adjacent basins by a drainage divide. The basin acts like a funnel, collecting all the water within the area covered by the basin and channeling it into a waterway. Each drainage basin is separated topographically from adjacent basins by a geographical barrier such as a ridge, hill or mountain, which is known as a water divide.

In the technical sense, a watershed refers to a divide that separates one drainage area from another drainage area. Drainage basins drain into other drainage basins in a hierarchical pattern, with smaller sub-drainage basins combining into larger drainage basins. Both basins and watersheds are areas of land that drain to a particular water body, such as a lake, stream, river or estuary. In a river basin, all the water drains to a large river. The term watershed is used to describe a smaller area of land that drains to a smaller stream, lake or wetland. There are many smaller watersheds within a river basin. However, in the United States and Canada, the term is often used to mean a drainage basin or catchment area itself.

One of the keys to deriving hydrologic characteristics about a surface is the ability to determine the direction of flow from every cell in the raster. This is done with the Flow Direction function. Using hydrology tools, it possible to simulate pouring water over the DEM surface and use neighborhood analysis (moving kernel) to determine the flow vector direction for each elevation cell. As complete process for watershed delineation, Flow Accumulation execute after Flow Direction has finished. The Flow Accumulation calculates accumulated flow as the accumulated weight of all cells flowing into each



downslope cell in the output raster. The output from Flow Direction will determine the connectivity of the flow direction in order to produce a flow accumulation dataset. This is achieved by accumulating the flow direction cell values for all cells that flow into each downslope.



The workflow extended to map fetch and accumulation areas to identify structural topography ponding areas. GIS term is calculate sink where a cell that does not have a defined drainage value associated with it and Fill it which is used to remove any imperfections (sinks) in the digital elevation model. Geostatistical formula applied to calculate structural closure. Structural closure is vertical distance from the apex of a structure to the lowest structural contour that contains the structure. Measurements of both the areal closure and the distance from the apex to the lowest closing contour are typically incorporated in calculations of the estimated hydrocarbon content of a trap.



The closure must be considered as a barrier to the migration hydrocarbon in other words the passage from a porous and permeable facies to a fine-grained sediment exhibiting an injection pressure which is greater than the outward thrust exerted by the fluids. Thus the closure has obligatory to compare to the hardness of seabed rock composite.

Backscatter as an information that can be used to determine bottom type, because different bottom types "scatter" sound energy differently. For example, a softer bottom such as mud will return a weaker signal than a harder bottom, like rock. The aim is to use this information for obtaining sediment properties (e.g., grain size) by analyzing the backscattered response. The simple word in describe Backscatter data is: Higher the value means harder the rock composite.

Picture 6 below display final result of basin analysis which output is structural closure overlaid with backscatter deStripe raster data. High value of backscatter deStripe represent in red color that mean 'hard rock' in some area has structural closure that show in purple color.



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