

# Petroleum system of Northwest Java basin based on gravity data analysis

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**Abstract.** Energy management in the upstream oil and gas sector becomes very important for the country's energy security. The renewal of energy resources and reserves becomes necessary and is a must. In the oil and gas industry, gravity data is usually used only for regional surveys, but with the development of instrumentation technology and gravity software development, this method can be used for assessing oil and gas survey stages from exploration to production. This study was conducted to evaluate aspects of petroleum system and exploration play concept in the part of Northwest Java Basin, covering source rock deposition regions (source kitchen area, migration direction), development of reservoirs, structural and stratigraphic trap, based on gravity data. This study uses data from Bouguer gravity anomaly map by filtering process to produce a residual map depicting sedimentation basin configuration. The mapping generated 20 sedimentary basins in Java Island with the total hydrocarbon resources of 113 BBOE (Billion Barrel of Oil Equivalent). The petroleum system analysis was conducted in the Northwest Basin section. The final map produced illustrates the condition of petroleum system and play concept that can be used as exploration direction, expectedly reducing the risk of drilling failure.

**Keyword :** energy management, gravity data, hydrocarbon resources, petroleum system

## 1. Introduction

Energy management in the upstream sector of oil and gas becomes very important for the energy security of a country. Indonesia is known today as an oil and gas producer with 60 sedimentary oil basins. The history of the number of oil basins in Indonesia shows the dynamics concerning the technological and geological concepts used [1].

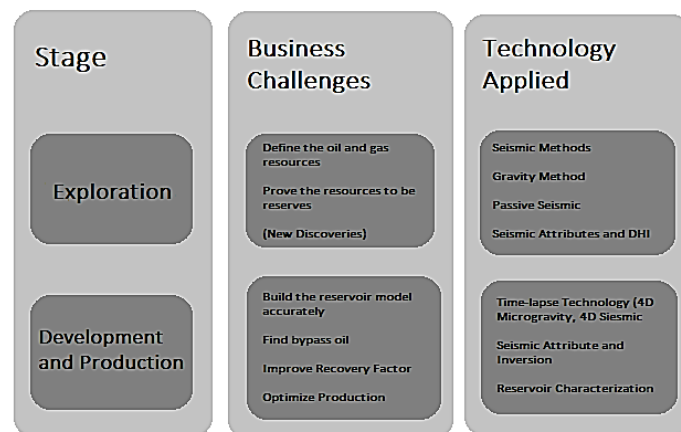
In the petroleum industry from the exploration to the production phase, there are challenges and opportunities that each has specific methods and technologies for its solution (see Figure 1). Each technology has advantages and disadvantages, but in principle must meet the requirements of the economy, can be applied in every field and geological conditions, as well as is environmentally friendly. The gravity method is considered excellent for use in the exploration phase until production from oil and gas fields. The gravity method can be used for surveys in every field and any geological conditions while being environmentally friendly and very economical at the same time [2].

So far, gravity data have been used only for regional surveys in oil and gas industries, but with the development of instrumentation and software technology and interpretation methods, they can be used for evaluation from the exploration phase to reservoir monitoring until the end of life of oil and gas field.

This paper attempts to study the petroleum system and play concepts in part of Northwest Java basin based on sedimentary basin map generated by gravity data. This study is expected to be a reference for the exploration in the area, as well as data base management of oil and gas energy.



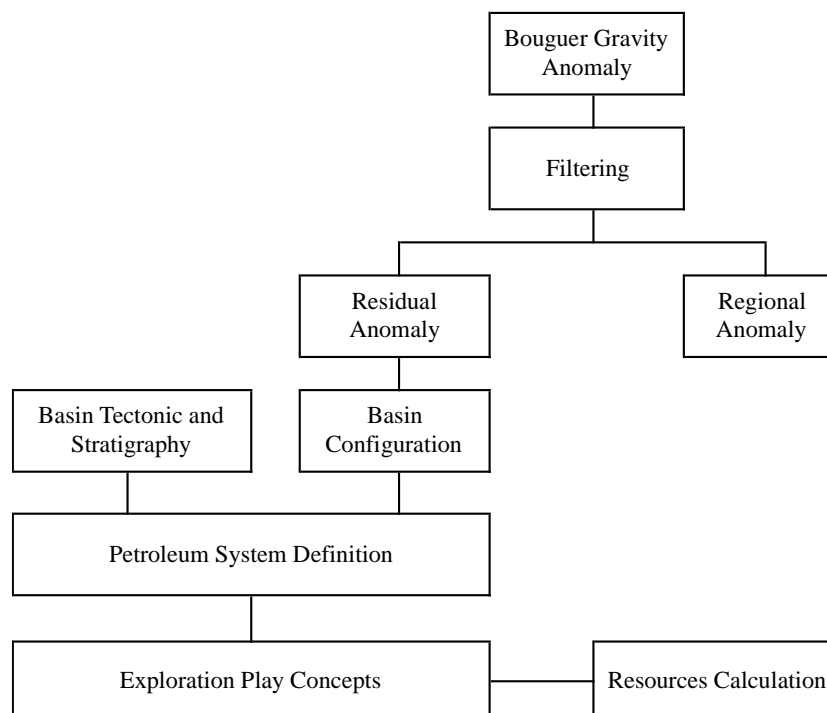




**Figure 1.** Oil and gas business challenges and technology application.

## 2. Research Method

The primary data used in this research are Bouguer gravity data. The frequency spectrum contained in the Bouguer gravity data has a quite wide range, covering density contrast layer response from shallow depth to the deepest [2]. Considering the objective of the research is to determine the basement of sedimentary basin, a further process is required. The methodology used in this research is filtering Bouguer gravity anomaly to produce regional and residual maps [3]. The resulting residual map will be an overview of the sedimentary basin configuration of the mapping area. In this research, sedimentation basin mapping is conducted throughout Java Island, but the focus of petroleum system analysis is carried out merely in Northwest Java basin. By combining tectonic elements and stratigraphy, the petroleum system and exploration play concept of Northwest Java basin can be defined. Figure 2 depicts the workflow of this study.



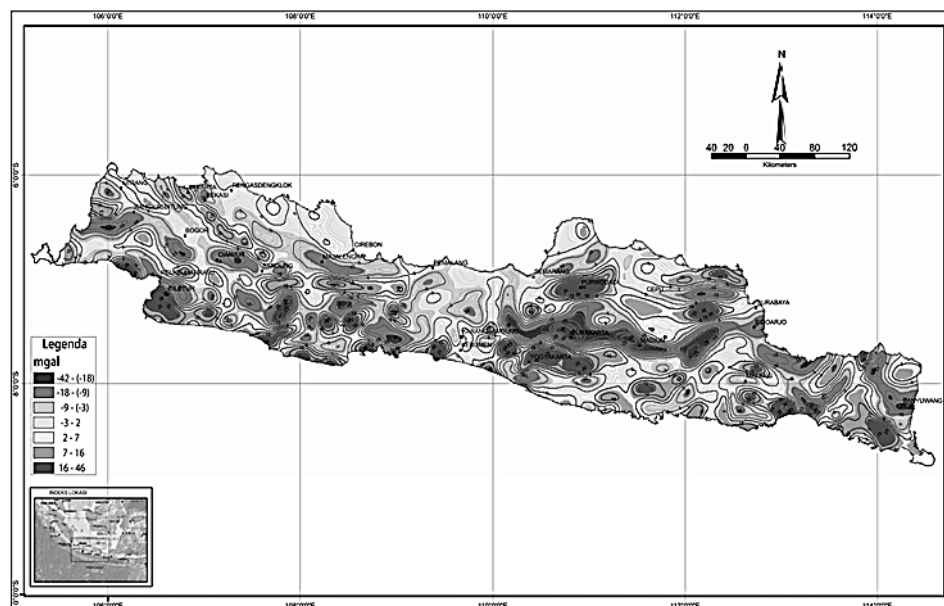
**Figure 2.** Workflow of study.



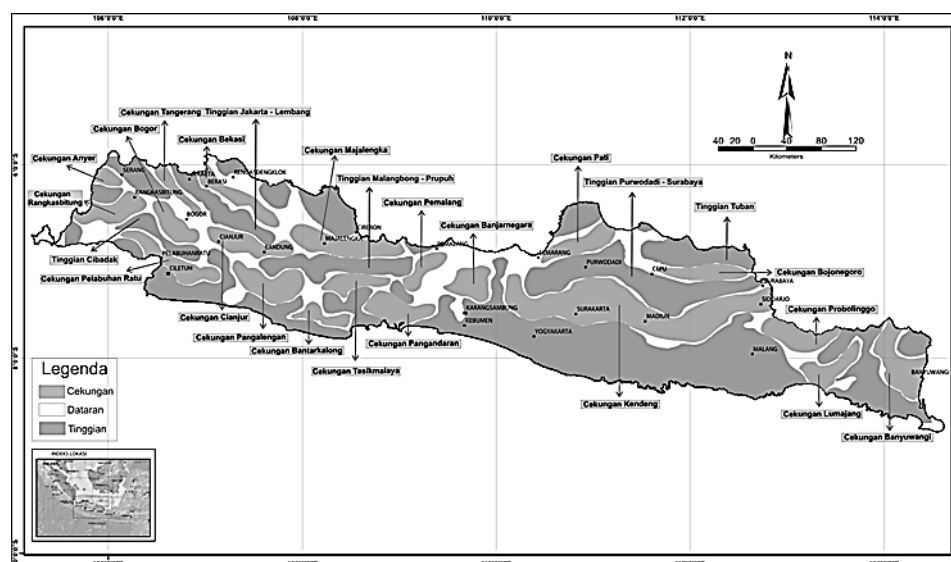
### 3. Results and Discussion

#### 3.1. Gravity maps

Mapping of sedimentary basins in Java Island using gravity data has been done [4]. Figure 3 shows the Java Island's residual gravity map of the Second Vertical Derivative (SVD) process result that describes the configuration of sedimentary basins in Java. On the other hand, in Figure 4 as the depiction and naming of sedimentary basins in Java based on the residual map (Figure 3), it can be seen that there are 20 sedimentary basins in Java Island. This outcome shows that there is always a need for a renewal based on the technological developments and increasing data.



**Figure 3.** Residual gravity map of Java Island based on SVD process [1].



**Figure 4.** Sedimentary basin map of Java Island [1].

The total speculative hydrocarbon generated in the basin can be calculated using [2]. The average case of total hydrocarbons generated and trapped is 113 BBOE (Table 1).



**Table 1.** Hydrocarbon resources calculation of Java Island [1].

AREA	BASIN	SPECULATIVE HYDROCARBON TRAPPED (BBOE)		
		Minimum	Maximum	Average
West Java	ANYER	0.345	1.565	0.936
	BANTARKALONG	0.350	1.755	1.064
	BEKASI	1.264	5.881	3.316
	BOGOR	0.441	1.940	1.243
	CIANJUR	0.657	3.565	2.085
	MAJALENGKA	2.684	14.384	8.935
	PANGALENGAN	1.125	6.991	4.072
	PELABUHAN RATU	1.382	8.037	4.910
	RANGKASBITUNG	1.992	7.034	4.732
	TANGGERANG	1.252	8.086	4.915
	TASIKMALAYA	0.436	2.495	1.672
Central Java	<b>Sub Total</b>	<b>12</b>	<b>62</b>	<b>38</b>
	BANJARNEGARA	0.321	1.187	0.753
	PANGANDARAN	0.712	3.600	2.414
	PEMALANG	1.543	8.131	4.730
East Java	<b>Sub Total</b>	<b>3</b>	<b>13</b>	<b>8</b>
	BANYUWANGI	2.018	7.616	4.449
	BOJONEGORO	0.830	5.528	3.347
	KENDENG	18.463	76.080	45.876
	LUMAJANG	0.274	1.471	0.918
	PATI	0.865	5.001	2.749
	PROBOLINGGO	4.405	16.600	9.695
<b>Sub Total</b>		<b>27</b>	<b>112</b>	<b>67</b>
<b>TOTAL</b>		<b>41</b>	<b>187</b>	<b>113</b>

### 3.2. Petroleum System of Northwest Java Basin

Northwest Java basin is one of the largest oil and gas producing basins in Indonesia. Hydrocarbon resources are present in several sub-basins located both in onshore and offshore of Java Island [1].

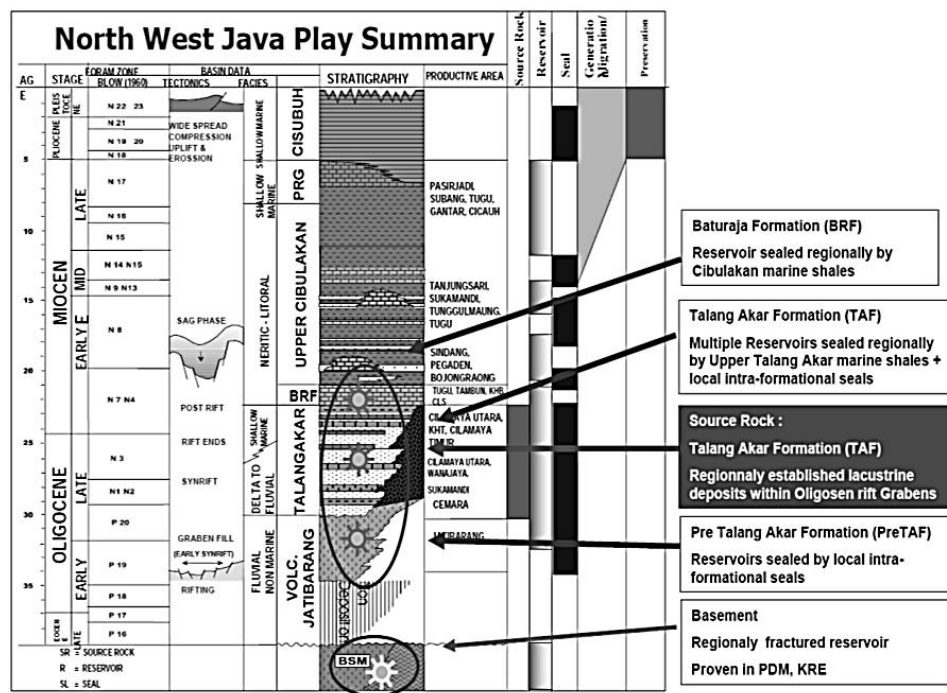
A key component of a petroleum system is the presence of an effective source rock. In Northwest Java basin, there are three main types of source rocks: lacustrine (oil prone), coal and fluvial deltaic (oil and gas prone), as well as marine shale (bacterial gas). A brown to gray lacustrine shale, deposited during the syn-rift period, is an excellent source rock as an oil producer.

In the Northwest Java Basin, almost all formations, ranging from the basement to limestone of Parigi Formation, are very potential reservoir rocks. Talangakar and Cibulakan Formations of the upper part are the reservoirs with the largest hydrocarbon production. In some fields, Baturaja Formation also contains significant hydrocarbons. In Jatibarang Field, oil is produced from layers of volcanoclastic rocks of the Jatibarang Formation as well as the clastic sediments of the Banuwati Formation that are good reservoirs [3]. Hydrocarbons can migrate from the source rock either laterally or vertically. Lateral migration occurs within the bedding of sedimentary rocks, which have decent horizontal permeability.

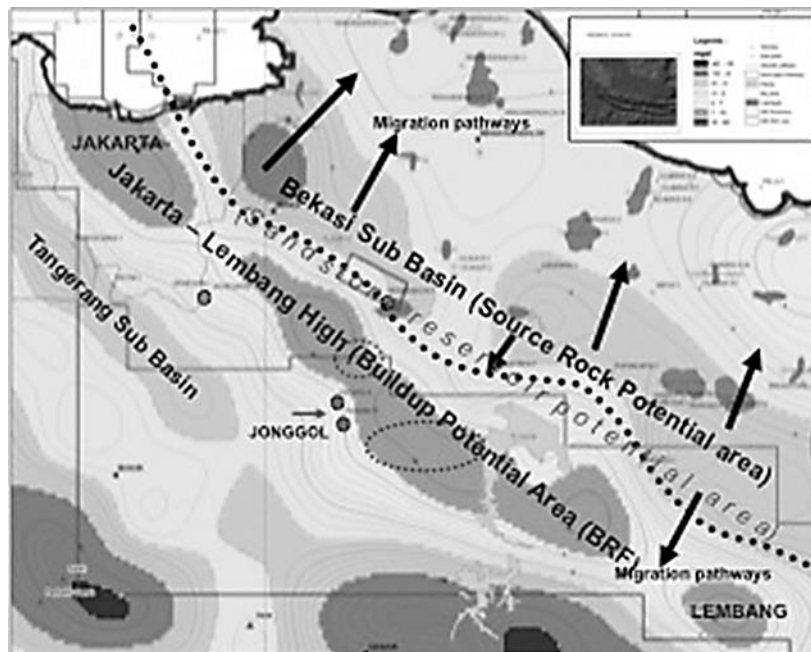
### 3.3. Exploration play concept of Northwest Java Basin

Exploration play concept is a particular combination of a reservoir, seal, source, and trap associated with proven hydrocarbon accumulations. In the Northwest Java basin, all existing formations including basement have been proven as hydrocarbon producers. From the type of rock view, starting from metamorphic rocks, igneous rocks, volcanic rocks, sandstones, and limestone, all can be a good reservoir. Thus, exploration play concepts in West Java can be categorized as basement play type, volcanic play type, sandstone play, and reef play type (Figure 5).





**Figure 5.** Exploration Play summary of Northwest Java Basin [4].



**Figure 6.** Exploration Play Concepts of Jakarta – Lembang area based on residual gravity map [1].

The case study of gravity map usage for evaluation of exploration play concept in Jakarta – Lembang area, part of Northwest Java basin (Figure 6).

Based on the play type model in Northwest Java Basin, the research area is expected to have sandstone play type and Baturaja reef play type. The development of limestone reefs is strongly affected by environmental factors of sedimentation, one of which is the depth factor that is relatively shallow compared to the surrounding area. Since the sedimentation basin map in Figure 6 is a representation of the depth of basement configuration, the development of the Baturaja Formation reef is still influenced



by the map. Thus, it can be estimated that the basement high of the Jakarta–Lembang directed NW–SE is a potential area as the development of Baturaja reef. This appraisal has been proven by several drilling wells that were discovered as limestone reef reservoirs such as the Jatinegara well and the excellent reef indication of seismic data in Jonggol area.

The development of sandstone play type can be found on the slopes of the basement height located in the west and the east. This evaluation is expected to be a reference for hydrocarbon exploration in the area to reduce the risk of failure.

#### 4. Conclusion

The gravity method is one of the methods used in the oil industry, from the exploration to the production phase. Other prime properties of this approach are its lower price than seismic methods, as well as its environmentally friendly being. All aspects of petroleum system can be analyzed with gravity map to be used as the reference in exploration activities in the area. For the future, it is advisable to use more gravity methods for oil as well as gas field exploration and development activities.

#### References

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