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BASIN CLASSIFICATION BASED ON QUANTITATIVE GEOLOGICAL RISK FACTORS

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ABSTRACT

Indonesia's oil and gas reserves are small and certainly will run out quickly if production is not followed by additional efforts. Exploration activities are not only one effort but also the first step of all efforts to increase reserves through the discovery of oil and gas resources. Efforts are needed to attract exploration investment interests, including access into available data, presentation of results from exploration activities and geological risk.

The present research aims to study the characteristics of the geological risk in several basins based on the quantitative geological factors. In conducting the quantitative analysis, there are some factors of petroleum system that have to be recognized inter alia, source rock, reservoir, seal, trap, migration, fault and fold.

For this purpose, six basins were selected representing frontier, semi mature and mature basins. Three basins were taken from the western part of Indonesia, and three others from the eastern part.

***Keywords**: exploration, petroleum system, quantitative analysis, geological risk factors, six basins.*

INTRODUCTION

Geological risk is an assessment used in order to make a classification of basins to assist the policy making of a successful oil and gas drilling. Therefore the analysis of basin classification has an important role in determining geological risk, because it aims to increase the efficiency of assessment of the petroleum basin based on the characteristics of the geological risk factors.

The parameters used in the classification are source rock, reservoir, seal, trap, migration, and the sstructures, which will produce a map delineating the group of geological risk factors.

METHODS

The quantitative data of geological aspects taken from each basin were analyzed. It composes of part of the petroleum system namely source rock, reservoir, seal, trap, migration, and the quantitative structures. The parameters are used to assess the available data resulting in the classification of risk categories namely very high, high, moderate, low, and very low (Table 1).

Table.1 Risk Categories by Weight of Assessment

WEIGHT OF ASSESSMENT	RISK CATEGORY
WA ≥ 18	Very Low Risk
18 > WA ≥ 12	Low Risk
12 > WA ≥ 6	Moderate Risk
6 > WA ≥ 3	High Risk
3 > WA	Very High Risk

The data obtained were analyzed using descriptive statistical approach.Visualize the results of analysis in the form of tables and map. The scheme of the research method is shown in (Figure 1.).

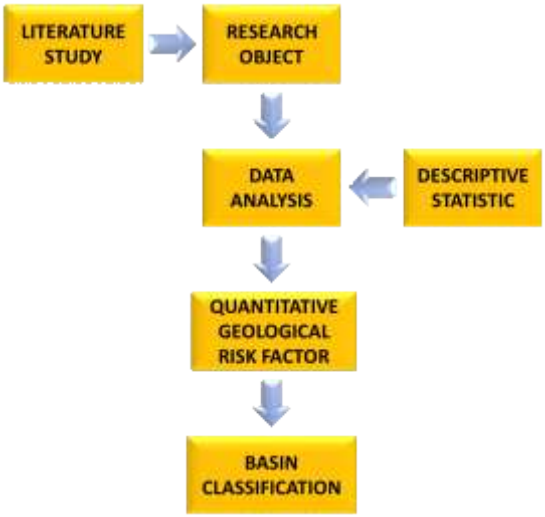

Figure 1. Flow chart of research methods.

This quantitative method is beneficial in terms of time efficiency and simplicity, which will be very important for policy makers.

The research is focused on six petroleum basins in Indonesia, namely North West Java Basin, Pati Basin and Ujung Kulon Basin representing the western part of Indonesia. As for the Eastern Indonesia Basin it includes Salawati Basin, Seram Basin and South Makasar Basin (Figure 2).

Figure 2. Location of the study area in the map of basin in Indonesia (IAGI, 1985).

RESULTS AND DISCUSSION

From the regional geological data analyzed in each basin, the grouping of quantitative data is carried out. From the quantity weighted results of the analysis on geological characteristics a total weight can be summarized to identify the levels of the risk (Table 2 & Table 3).

The results of the analysis are described as follows:

a. In **North West Java Basin**, five formations have the potential as Source Rock, namely: Banuwati Formation, Jatibarang / Talangakar Formation, Eocene Formation, Parigi Formation, and Cisubuh Formation, five formations have the potential as Reservoir namely: Talangakar Formation, Baturaja Formation, Formation Cibulakan, Main Formation, and Parigi Formation, four Seal / Cap Rock namely: Cisubuh (Shale), Upper Cibulakan (Mudstone), Baturaja (Shale), Talangakar (Shale), four types of traps in the basin namely: Structural, Anticlinal, Fault and Stratigraphic (USGS, 2000), (Pertamina BPPKA,1996). Also major faults and folds are found in the basin (PERTAMINA and BEICIP FRANLAB, 1992) as shown on Figure 3.

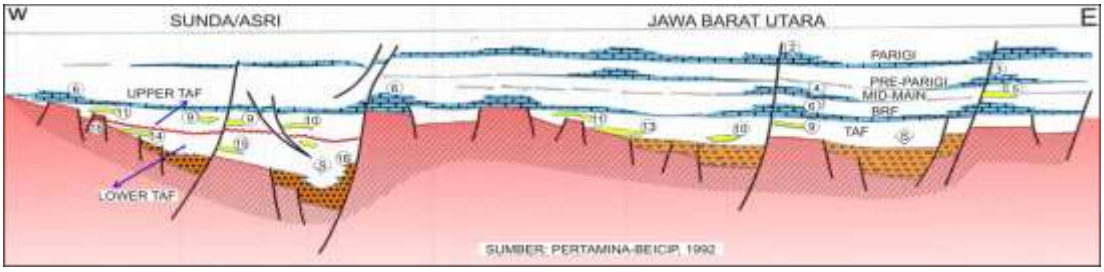

Figure 3. Play concept North West Java Basin (PERTAMINA-BEICIP, 1992).

From the results of the quantitative analysis of the geological aspects, the North West Java Basin is categorized as a basin that has a Very Low Risk (Table 2 & Table 3).

b. In **Pati Basin**, two formations have the potential as Source Rock, namely: "CD" Formation, and Kujung Unit II Formation, four formations have the potential as Reservoir, namely: "CD" Formation, Unit Kujung Formation, Unit III Kujung Formation, and "OK" Formation, 4 Seal / Rock Cap namely: "GL" (Shale), Lower "OK" (Shale), Kujung Unit II (Shale), "CD" (Shale), three types of traps in the basin namely: Structural, Stratigraphic, and Mix (Patranusa Data, 2006), as shown on Figure 4.

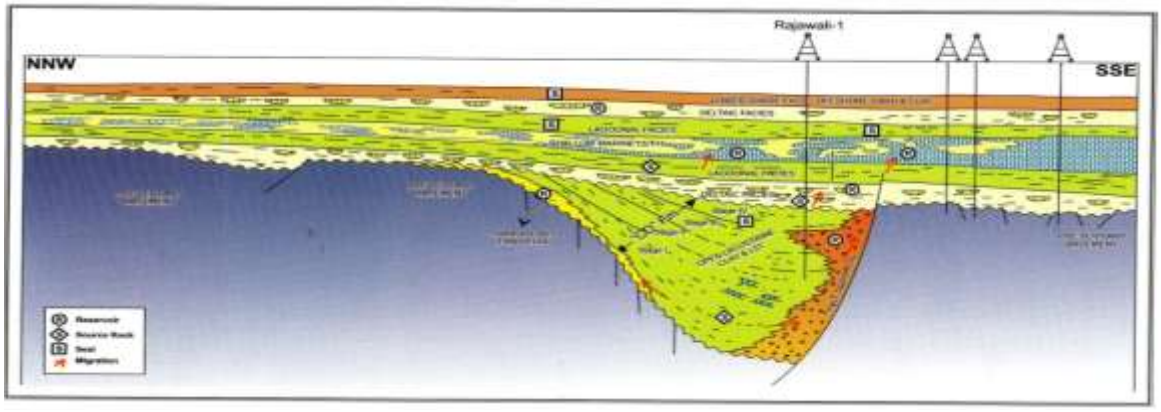

Figure 4. Hydrocarbon Play of Pati Basin (Patranusa data, 2006)

Major faults are found in the basin. From the results of the quantitative analysis of the geological aspects, the North West Java Basin is categorized as a basin with Low Risk (Table 2 & Table 3).

c. In **Ujungkulon Basin**, one formation has the potential as Source Rock, namely: Batuasih Formation, two formations have the potential as Reservoir namely: Bayah Formation, and Rajamandala Formation, one Seal / Rock Cap namely: Upper Batuasih (Shale) one type of trap namely: Structural (PERTAMINA-BEICIP, 1992, and Yulianto et al., 2007) as shown on Figure 5. Major faults are found in the basin. From the results of the quantitative analysis, the geological aspects of the Ujungkulon Basin are categorized as basins with Low Risk (Table 2 & Table 3).

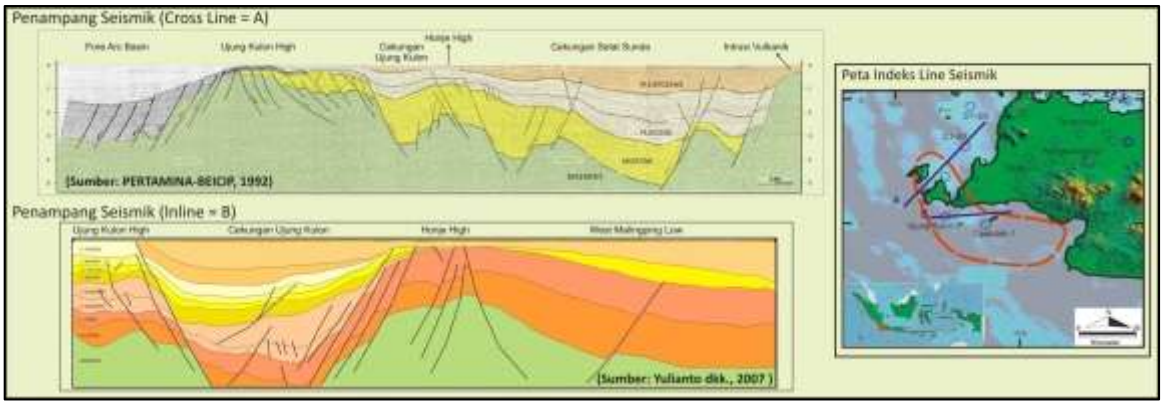

Figure 5. Seismic Cross Section Map of Ujung Kulon Basin (PERTAMINA-BEICIP, 1992), (Yulianto et al., 2007)

d. In **Salawati Basin**, 3 formations have the potential as Source Rock, namely: Sirga Formation, Klasafet Formation, and Klasaman Formation, 2 formations has the potential as Reservoir namely: Faumai Formation, and Kais Formation, 1 Seal / Cap Rock namely: Kais (Clay / Marl) 1 type of trap in the basin, namely: Structural (Patranusa Data, 2006), and (Satyana, 2009). as shown on Figure 6. Also found aspects such as Major faults in the basin (Patranusa Data, 2006), (Satyana, 2011). From the results of the quantitative analysis of the geological aspects, the North West Java Basin is categorized. From the results of the quantity analysis, the geological aspects of the Salawati Basin are categorized as basins with Very Low Risk (Table 2 & Table 3).

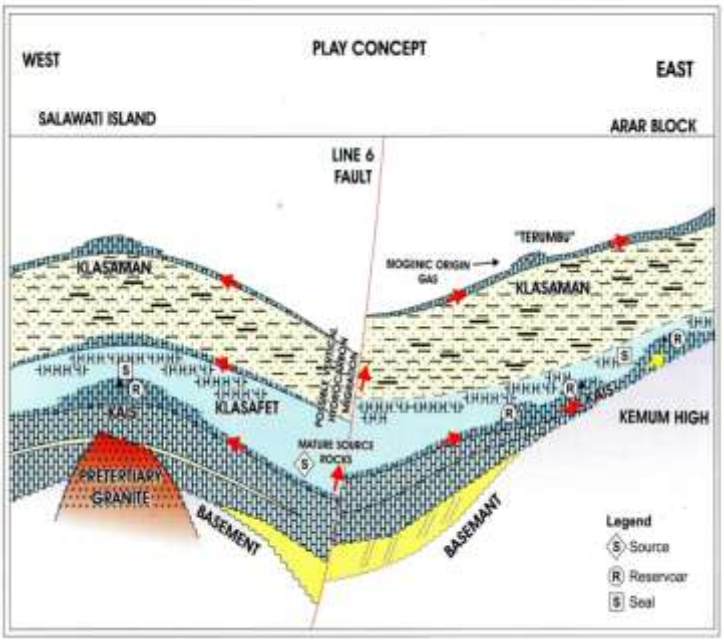

Figure 6. Hydrocarbon play model of Salawati Basin (Patranusa Data, 2006).

e. In **Seram Basin**, 4 formations have the potential as Source Rock, namely: Kanikeh Formation, Manusela Formation, Nief beds Formation and Saman Saman Formation, 2 formations has the potential as Reservoir namely: Kanikeh Formation, Manusela Formation, 1 Seal / Cap Rock namely: Kanikeh (Clay) 1 type of trap in the basin, namely: Structural. Also found aspects such as Major faults in the basin (Patranusa Data, 2006). From the results of the quantitative analysis of the geological aspects, the North West Java Basin is categorized. From the results of the quantity analysis, the geological aspects of the Seram Basin are categorized as basins with Low Risk (Table 2 & Table 3).

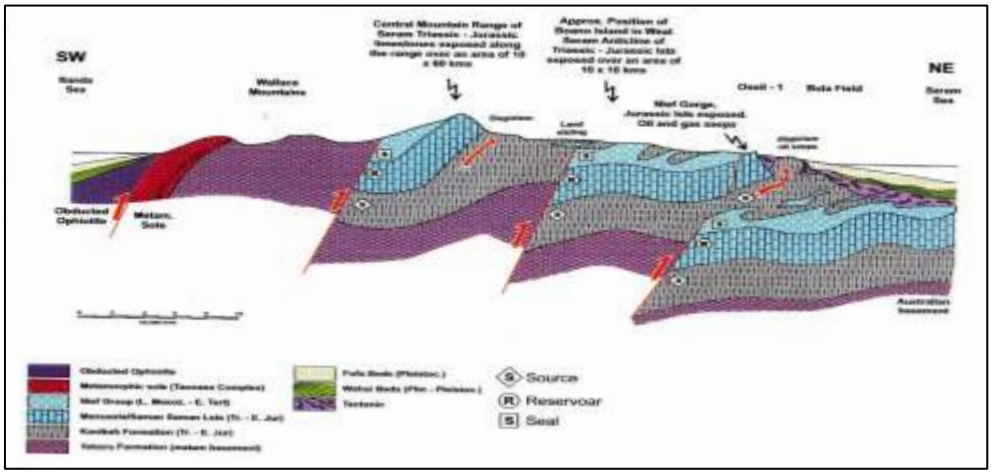

Figure 7. Hydrocarbon play of Seram Basin (Patranusa Data, 2006)

f. In **South Makassar Basin**, 2 formations have the potential as Source Rock, namely: Toraja Formation, Tonasa Formation, 1 formation has the potential as a Reservoir, namely: Tonasa Formation, 1 Seal / Cap Rock namely: Makale (Clay) 1 type of trap in basins namely: Structural. Also found aspects such as Major faults in the basin (Patranusa Data, 2006), Figure 8

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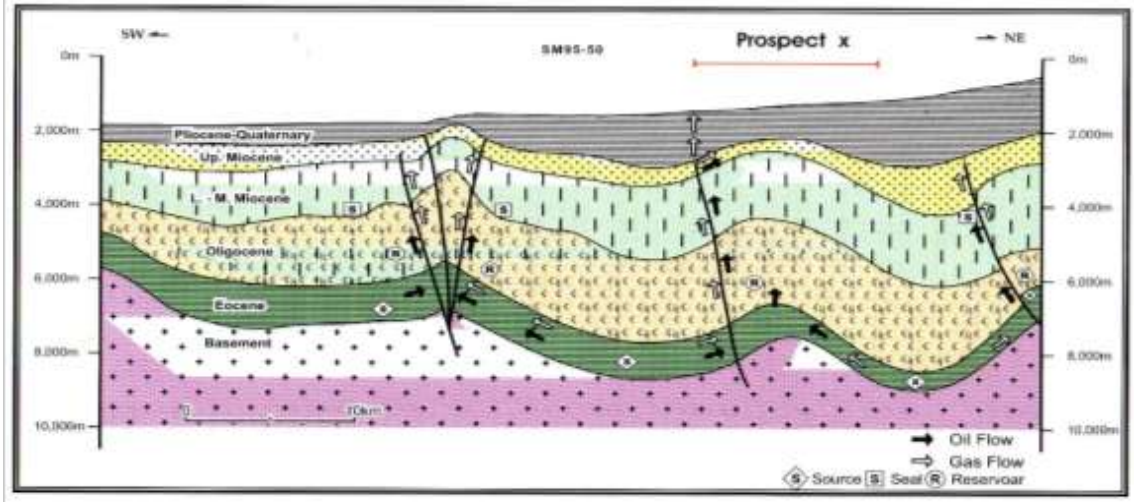

Figure 8. Hydrocarbon Play, Sotuh Makasar Basin (Patranusa Data, 2006)

From the results of the quantity analysis, the geological aspects of the South Makasar Basin are categorized as basins with Moderate Risk, as summarized in Table 2 & Table 3.

Table 2. Summary of Geological Characteristics of the Basins

REGION	BASIN	PETROLEUM SYSTEM					
		SOURCE ROCK	RESERVOIR	SEAL	TRAP	FAULT	FOLD
West Indonesia	North West Java	Banuwati Formation Jatibarang/Talang Akar Formation Eocene Formation Parigi Formation Cisubuh Formation, (PERTAMINA-BEICIP, 1992), (Petroleum System of Northwest Java Province, USGS, 2000)	Talang Akar Formation Baturaja Formation Cibulakan Formation Main Formation Parigi Formation (Patranusa Data, 2006)	Cisubuh (Shale/Claystone) Upper Cibulakan (Mudstone) Baturaja (Shale) Talangakar (Shale), (PERTAMINA-BEICIP, 1992) (Petroleum System of Northwest Java Province, USGS, 2000)	Structural Anticlinal Fault Stratigraphic (Patranusa Data, 2006)	5 Major Fault (Patranusa Data, 2006)	4 Major Anticline (Patranusa Data, 2006)
	Pati	"CD" Formation Kujung Formation Unit II (Patranusa Data, 2006)	"CD" Formation Kujung Formation Unit III Kujung Formation Unit I "OK" Formation (Patranusa Data, 2006)	"GL" (Shale) Lower "OK" (Shale) Kujung Unit II (Shale) "CD" (Shale) (Patranusa Data, 2006)	Structural Stratigraphic Mix (Patranusa Data, 2006)	1 Major Fault (Hydrocardom Play of Pati Basin (Patranusa Data, 2006))	None
	Ujungkulon	Batuasih Formation (Regional Stratigraohy of West Java (Martodjojo, 2003))	Bayah Formation Rajamandala Formation (Regional Stratigraohy of West Java (Martodjojo, 2003))	Upper Batuasih (Shale) (Regional Stratigraohy of West Java (Martodjojo, 2003))	Structural (Yulianto et al., 2007)	8 Major Fault (PERTAMINA-BEICIP, 1992), (Yulianto et al., 2007)	None
East Indonesia	Salawati	Sirga Formation Klasafet Formation Klasaman Formation, (Patranusa Data, 2006) (Satyana, 2009)	Faumai Formation Kais Formation, (Patranusa Data, 2006) (Satyana, 2009)	Kais (Clay/Marl), (Patranusa Data, 2006), (Satyana, 2009)	Structural (Satyana, 2009), (Patranusa Data, 2006)	12 Major Fault (Patranusa Data, 2006), > 10 normal faults (Satyana, et al., 2009), (Patranusa Data, 2006)	None
	Seram	Kanikeh Formation Manusela Formation Saman Saman Formation Nief Beds (Patranusa Data, 2006)	Fufa Formation, Kanikeh Formation, Manusela Formation (Patranusa Data, 2006)	Kanikeh (Clay) (Patranusa Data, 2006)	Structural (Patranusa Data, 2006)	4 Major Fault (Hydrcarbon Play of Seram Basin, Patranusa Data, 2006)	None
	South Makasar	Toraja Formation Tonasa Formation (Patranusa Data, 2006)	Tonasa Formation (Patranusa Data, 2006)	Makale (Clay) (Patranusa Data, 2006)	Structural (Patranusa Data, 2006)	5 Major Fault (Hydrcarbon Play of Seram Basin, Patranusa Data, 2006)	None

Table 3. Basin Classification Based on the Quantity of Geological Factors

REGION	BASIN	PETROLEUM SYSTEM						WEIGHT OF ASSESSMENT	RISK CATEGORY
		SOURCE ROCK	RESERVOIR	SEAL	TRAP	FAULT	FOLD		
West Indonesia	North West Java	5	5	4	4	5	4	27	Very Low Risk
	Pati	2	4	4	3	1	0	14	Low Risk
	Ujungkulon	1	2	1	1	8	0	13	Low Risk
East Indonesia	Salawati	3	2	1	3	12	3	24	Very Low Risk
	Seram	4	3	1	1	4	0	13	Low Risk
	South Makasar	2	1	1	1	5	0	10	Moderate Risk

The results of the analysis are greatly influenced by the Petroleum System and the available data from each basin. Finally, it will affect the results obtained in determining the geological risk.

By using basin risk category in Table 3, a map of categorized risk level was produced. The map of risk level category in the six basins in the western and eastern regions of Indonesia is shown on Figure 9.

Figure 9. Map of risk level category in the six basins in the western and eastern regions of Indonesia (Base map IAGI, 1985)

CONCLUSIONS

The studied six basins show the total weight of geological factors, respectively as follows: North West Java Basin 27, Pati Basin 14, Ujung Kulon Basin 13, Salawati Basin 24, Seram Basin 13, and South Makasar Basin 10. The weighted geological factors classify the basins into the following category:

a. Very Low Risk for North West Java Basin
b. Low Risk for Pati Basin
c. Low Risk for Ujungkulon Basin
d. Very Low Risk for Salawati Basin
e. Low Risk for Seram Basin
f. Moderate Risk for South Makasar Basin.

RECOMMENDATIONS

This study is focused only for 6 of about 60 sedimentary basin in Indonesia. The same method should be applied for whole sedimentary basin. So that the sedimentary basin map will be easier to read with its own geological riks category.

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