

Source Rock Geochemical Study in the Southwestern Java, A Potential Hydrocarbon Basin in Indonesia*

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Abstract

An extensive geochemical study, including pyrolysis, vitrinite reflectance determination, gas chromatography (GC), gas chromatography – mass spectrometry (GC-MS), and carbon isotope of outcrop samples from the southwest Java basins was conducted in order to examine the horizontal and vertical distribution of organic matter and regional maturity levels. This information is used in a subsequent basin modelling exercise to identify the most prospective basin(s) in the Java Island.

Fourteen selected outcrop samples, whose locations are scattered in the study area, collected during the first stage of the study in 1997. During the second stage of the study (2007-2008), twenty-three outcrop samples were collected in-line with measuring-section program near Sukabumi City in the West Java Province. All the samples have been analysed geochemically to assess their richness, maturity, source of organic matter, and depositional environment. The best quality source beds analysed are two Miocene outcrops (Cimandiri and Nyalindung Formations), seven Oligocene outcrops (Batuasih Formation), and two Eocene samples (Bayah Formation) characterized by good (gas and oil prone) TOC (total organic carbon). The Miocene and Oligocene sediments are immature to marginally mature and are unlikely to be efficient sources of gas unless buried deeply within the basin. The Eocene Bayah Formation coals are excellent and have significant oil and gas potential and are locally mature. Within the area, no oil seepage has yet been discovered.

Modelling using BasinMod™ 2D reveals that maturity is actually no problem within the area. Therefore, in order to declare that the petroleum system in the area is working, rich source rocks should be found.

Introduction

Basins found in Java Island have been well known as oil and gas producers, particularly the Northeast Java and Northwest Java Basins. These basins have specific geological structures and histories (e.g., Baumann et al., 1973). Exploration and production activities, therefore, are

enormous in these basins. However, in the southern areas of these basins, ironically, exploration activities are very quiet. This study has been done in the southern part of West Java Province in order to give a better understanding about the potential of the area ([Figure 1](#)) and hopefully will be able to attract petroleum companies to the area.

Stratigraphy

Samples studied were mainly collected from two areas: namely, Ciletuh and Gunung Walat ([Figure 1](#)). Stratigraphic column of each area is given in [Figure 2](#).

Geochemical Results

Most of the sediment samples indicate relatively low TOC (less than 1%) with the exception for two samples collected from Bojonglopang Formation (1.41% TOC) and from Cimandiri Formation (1.76% TOC). The sediments also contain relatively low hydrogen indices (HIs are less than 150), suggesting that the organic materials are Type III (gas prone) ([Figure 3](#)). Maturity assessments used in this study are pyrolysis Tmax, vitrinite reflectance, and spore colour. It appears that there are some discrepancies among the maturity parameters; however, in general they show that the samples are immature to marginally mature ([Figure 4](#)). Based on kerogen analyses, two sediment samples from Bojonglopang and Cimandiri formations contained good gas-prone indicators and are the best quality source rock analysed in this study.

Of the fourteen sediment samples, seven of them were analysed for their biomarker distribution. The biomarker studies confirm the results obtained from the kerogen studies that the sediments were deposited in the nearshore marine having anoxic to oxic environment with relatively high contribution of higher plant materials ([Figure 5](#)).

Geochemical Modelling

Since the only available data for geophysical modelling are gravity, thus these data have been used to reconstruct the geology of the area. For this study, cross sections were used, and the data obtained from the geophysical modelling were used in the geochemical modelling ([Figures 6 and 7](#)).

Summary

- In the Section 1 ([Figure 6](#)), maturity of 0.5% Ro was reached at around 1600 m, maturity of 0.7% Ro at approximately 2200 m, and for Ro 1% (peak of oil generation) at about 3000 m. Oil generation is interpreted to have started 28 million years ago.
- In the Section 2, maturity of 0.5% Ro occurred at a depth of approximately 1300 m, 0.7% Ro at 2000 m, and 1% Ro at 2600 m. Oil generation may have started 30 million years ago.

- In Section 3 ([Figure 7](#)), Ro of 0.5% is present at an approximate depth of 1500 m, 0.7% Ro at 2200 m, and 1% Ro at 2900 m. Oil generation may have begun 20 million years ago.

Second Stage Geochemical Sampling

During the second stage of this study (2007-2008), twenty-three outcrop samples were collected. These samples were specifically collected from an area around Sukabumi. All samples belong to the Eocene Batuasih Formation. The sediment samples indicate fair to good organic carbon content (TOC: 0.49 – 1.72%). Most of the samples contain Type III kerogen (HI: 70 – 149).

The isotope analysis indicates that the Ciletuh Formation extract displays identical $^{13}\text{C}_{\text{sats}}$ to one Bayah Formation sample, and is relatively light at -28.1‰, consistent with a significant terrestrial plant input. The very mature Bayah Formation extract displays heavier $^{13}\text{C}_{\text{sats}}$ (-26.9‰) than the two less mature extracts which correlate well with Indonesian Palaeogene coals and yield relatively light values of -28.1‰ and -28.6‰, respectively. This is likely to be due to the advanced maturity of the former sample. The Rajamandala, Cimandiri, and Nyalindung samples all yielded very similar $^{13}\text{C}_{\text{sats}}$ ratios of -26.9‰, -27.2‰, and -27.4‰, respectively, comparable to the majority of marine extracts from the North and South Central Java basins, and correlating well with East Java basin oils ([Figure 8](#)).

Conclusions and the Next Exploration Stage

It appears that maturity is not a problem in the area, particularly in the deeper positions. The main problem that has not been clear is source richness due to the lack of information based on well samples. If the thick sediments in the area were rich of organic carbon, then petroleum system in the area is “really working!”

The next stage of the work will focus on Bayah Formation which comprises fluvio-deltaic black shales, sandstones and conglomerates, seams of allochthonous coal and tuff beds. Thickness of this formation is around 1500 m or more. According to Martodjojo (1989) to the north of the study area, a more marine facies is found with clays, marls, quartz sandstones and foraminiferal limestones. It remains unknown if this formation is a good source rock in the Southwest Java Basin.

Acknowledgements

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References Cited

Baumann, P., de Genevraye, P., Samuel, L., Mudjito, and Sajekti, S., 1973, Contribution to the geological knowledge of southwest Java: Proceedings Indonesian Petroleum Association 2nd Annual Convention, p. 105-108.

Darman, H., and Sidi, F.H., eds., 2000, An outline of the geology of Indonesia; Indonesian Association of Geologists, 192 p.

Huang, W-Y., and Meinschein, W.G., 1979, Sterols as ecological indicators: *Geochim. Cosmochim. Acta*, v. 43, p. 739-745, (1979).

Martodjojo S., 1989, Stratigraphic and tectonic behaviour of the back-arc basin in West Java, Indonesia: *Proceedings 6th Regional Conference of GEOSEA VI*, p. 229-244.

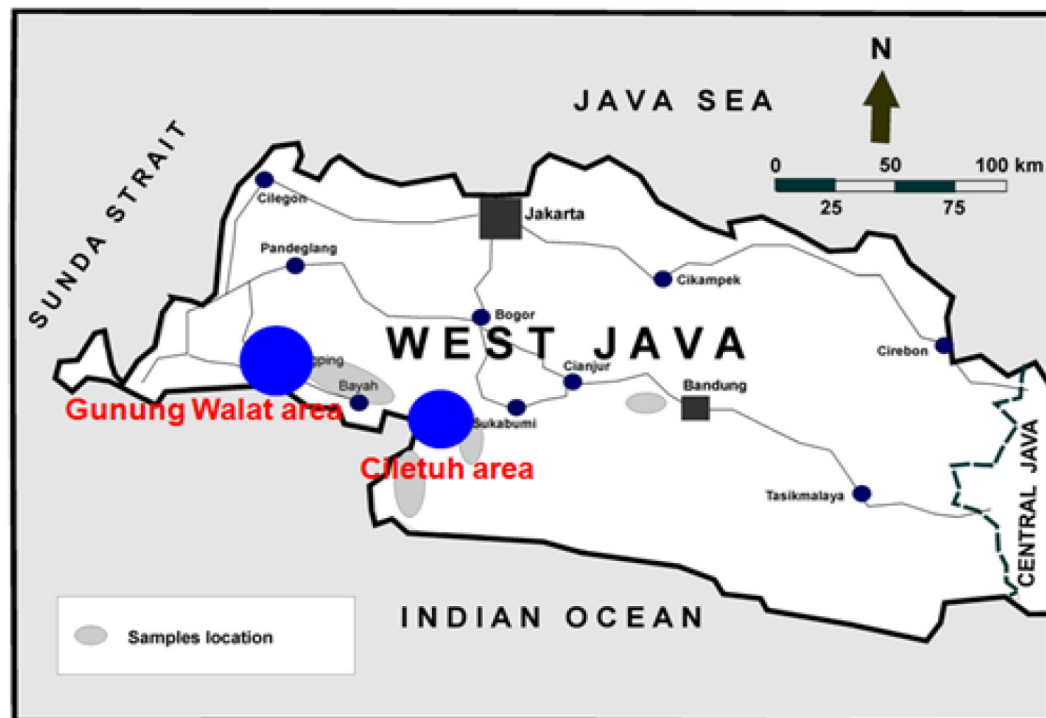


Figure 1. Regional index map (upper) and location map of the study area (lower).

AGE		FORMATION	ROCK UNT	THICK (m)	LITHO LOGY	DESCRIPTION	DEPOSITIONAL ENVIRONMENT	
QUARTER	RESEN		Colovium			Loose material, boulder size	Upland	
	HOLOSEN		Breccia Units	50 m		Monomitic breccia and andesite fragment with glass-buff matrix	Upland	
TERTIARY	MIOCENE	RAJAMANDALA	Limestone Units	>200 m		Reef limestone, reef, coral rich and Lapidary limestone, but in lower part most clastic limestone	Shallow Marine	
								EARLY
	OLIGOCENE		MIDDLE					
				EARLY				
					BATU ASIH	Main Units		
	Eocene		BAYAH	Sandstone with conglomerate intercalation			500 m	
				Sandstone with coal intercalation	370 m		Medium to coarse quartz sandstone, conglomeratic with shelly and all later blocky intercalation	
				MIDDLE-LATE	Sandstone with day-stone intercalation	>900 m		Fine to coarse quartz sandstone with partial laminated claystone and carbonaceous limestone intercalation, locally bioturbated

AGE	FORMATION	ROCK UNIT	DESCRIPTION	DEPOSITIONAL ENVIRONMENT
RECENT		Alluvial	Loose material in fine sand to boulder size	Upland
BAYAH FORMATION EARLY EOCENE	BAYAH FORMATION	Sandstone Claystone	Quartz-sandstone with thin claystone and carbon intercalation	Upland
		Conglomerate sandstone	Interbedded quartz sandstone and Bayah conglomerate with fragment from Ciletuh Formation	Transition
		Breccia	Interbedded megabreccia, graywacke and quartz sandstone	Lower Bayah
CILETUH FORMATION MIDDLE EOCENE	CILETUH FORMATION	Sandstone Claystone	Sandstone with black-claystone intercalation, contains oolite with variation size of siliceous rock, basalt, graywacke, breccia, and Nummulite-conglomerate	Outer Hantik-Upper Bayah
		Basalt	Group of ultramafic, mafic, and metamorphic rock thrust in accretion zone	Accretion Zone
		Schist		

Figure 2. General stratigraphy of Gunung Walat area (top) and Ciletuh area (bottom), West Java Province, Indonesia (Darman and Sidi, 2000)

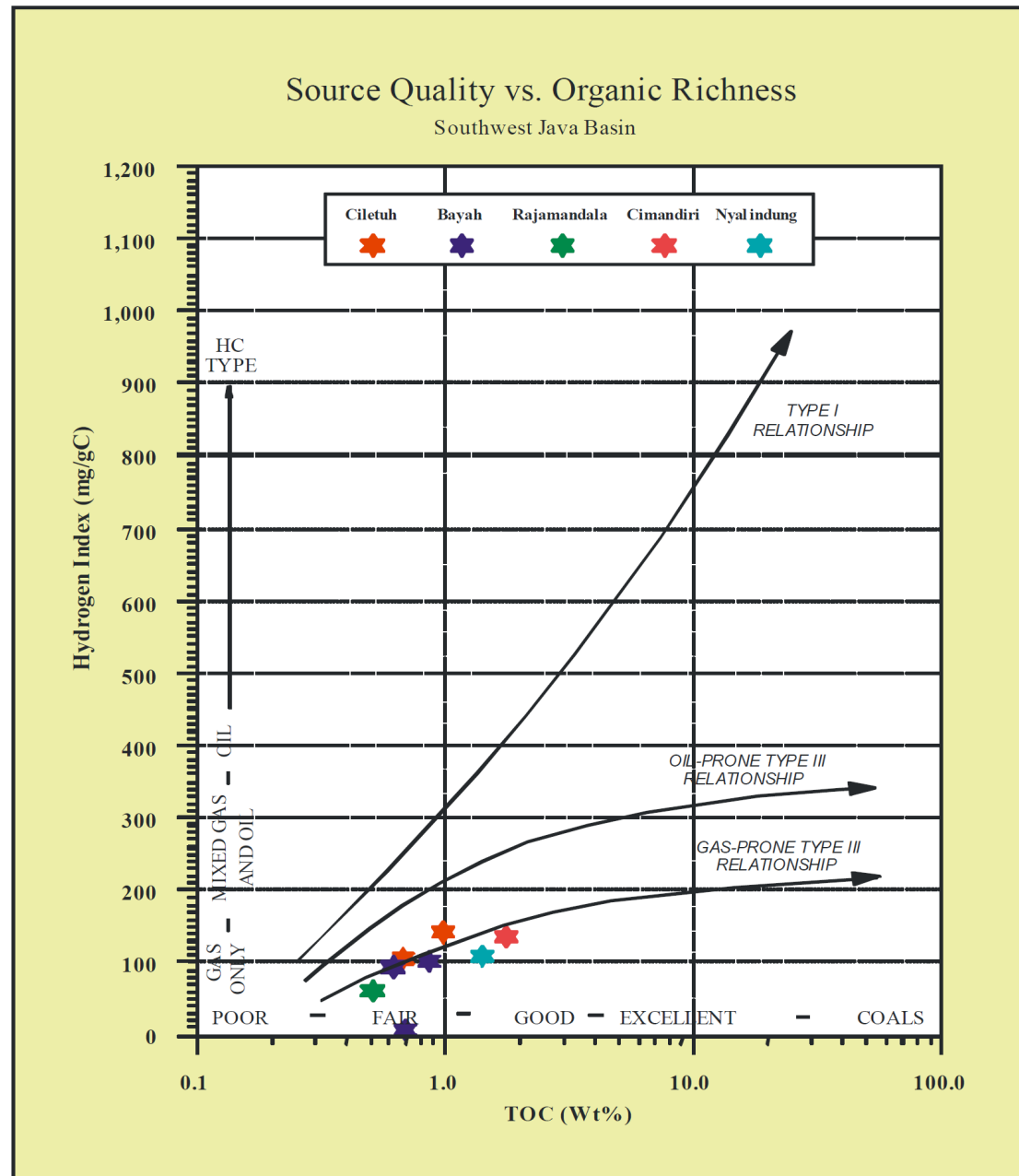


Figure 3. Crossplot between HI and TOC showing that most of the samples belong to Type III kerogen with relatively poor organic carbon.

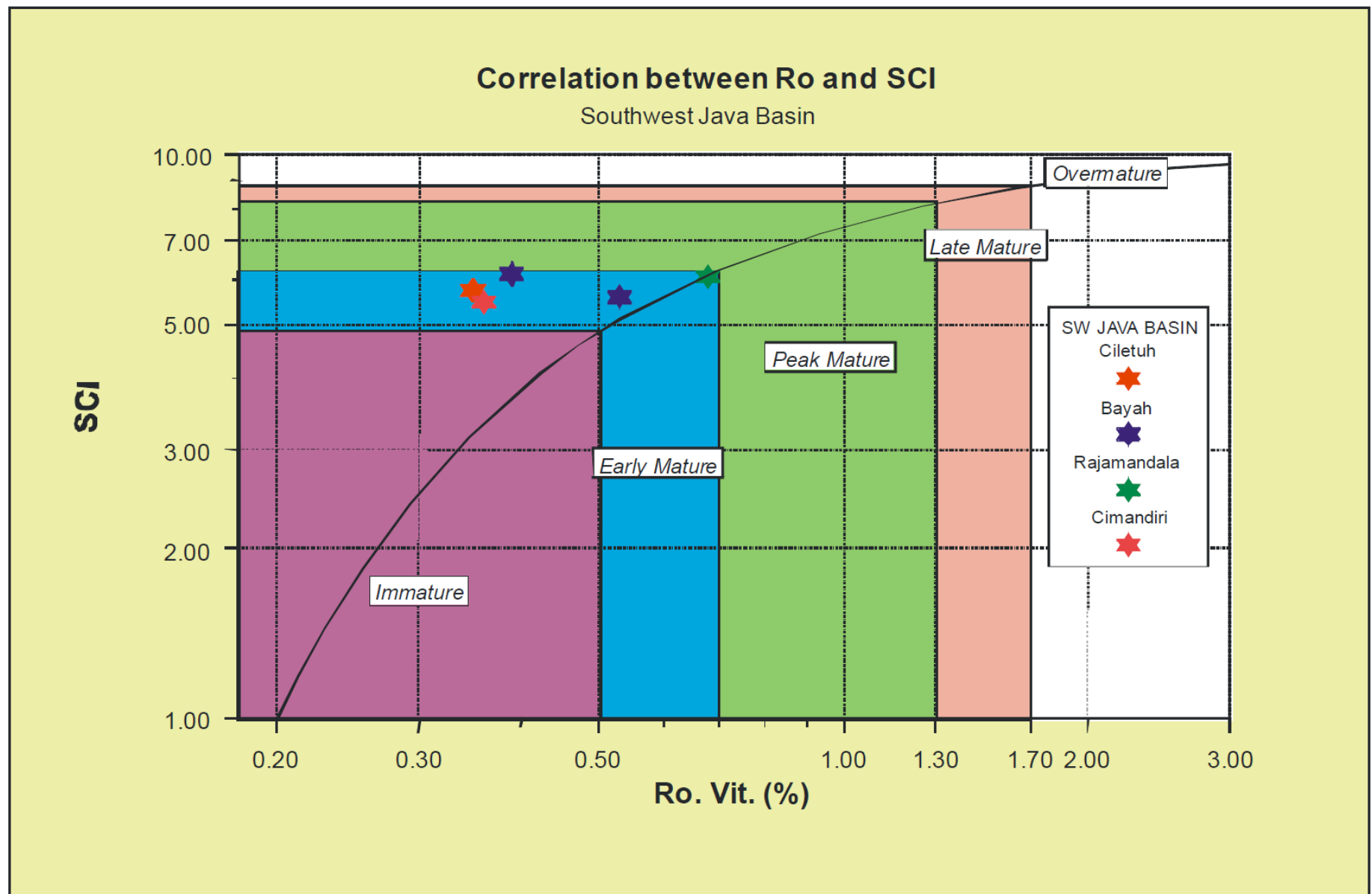


Figure 4. Crossplot between vitrinite reflectance (Ro) and spore colour index (SCI), indicating that the samples analysed are in early mature stage.

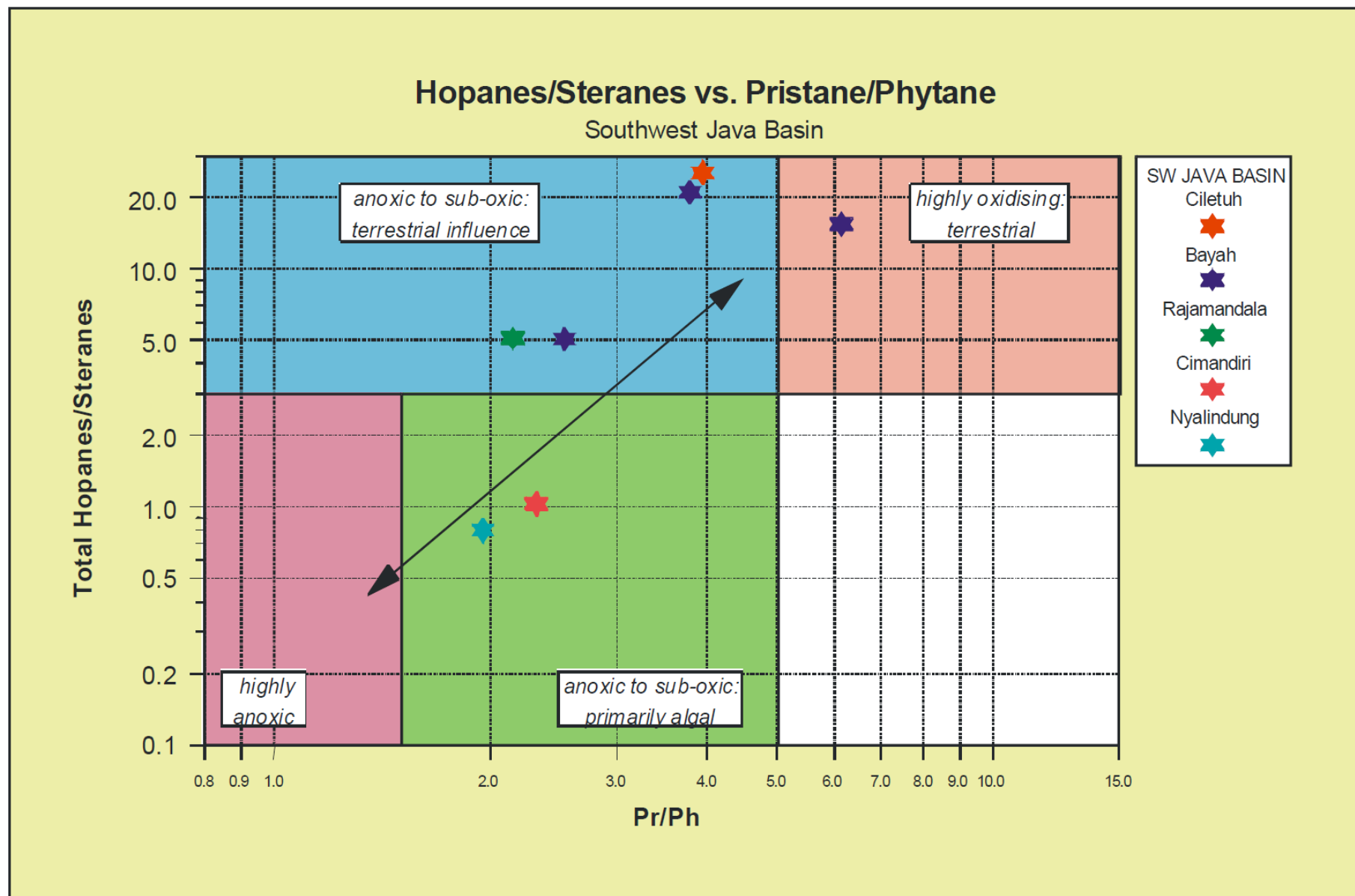
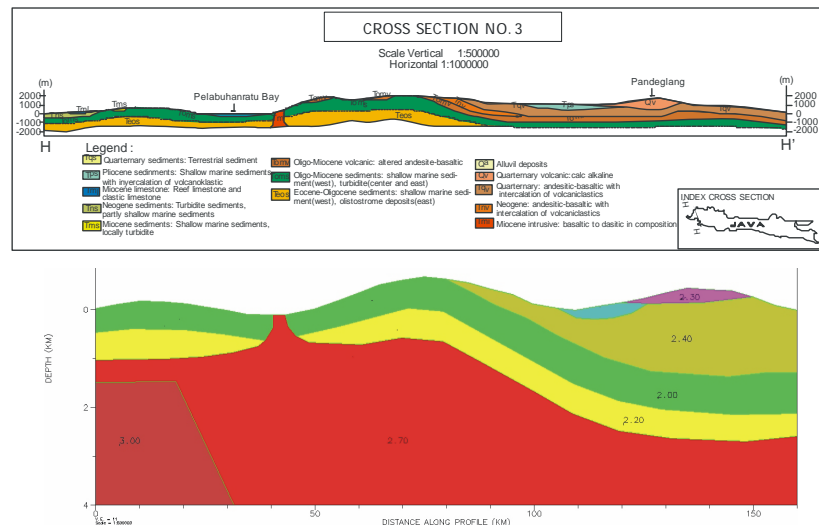
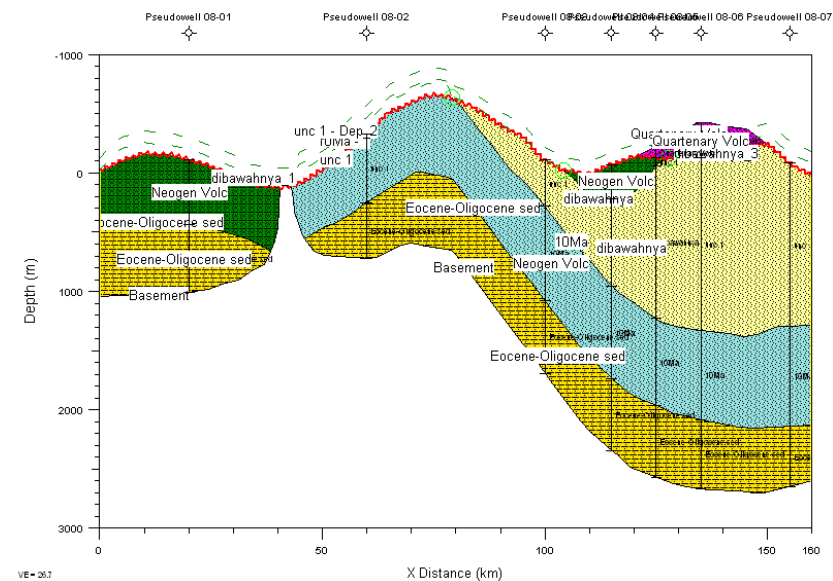


Figure 5. Crossplot between pristane/phytane ratio and total hopanes/steranes ratio revealing the depositional environment of the source rocks.

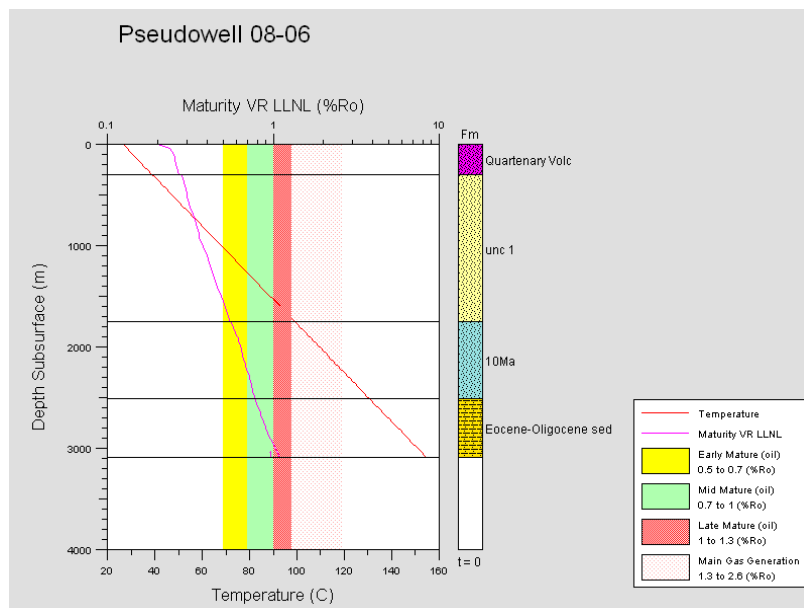
A



B



C



D

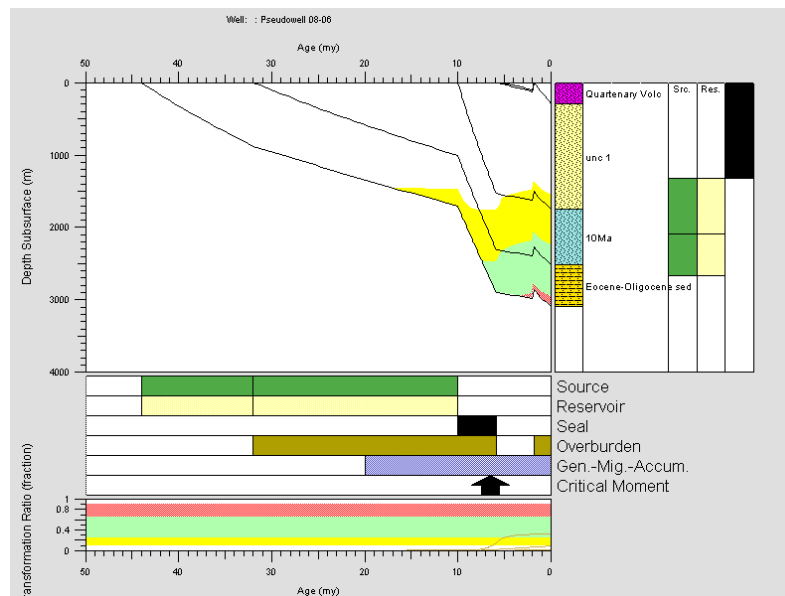


Figure 7. Schematic cross section No. 3 based on geophysical data (A) and cross section indicating position of pseudo-wells (B). Crossplot between depth and maturity for one of the pseudo-wells (C). Petroleum system of the pseudo-well (D).

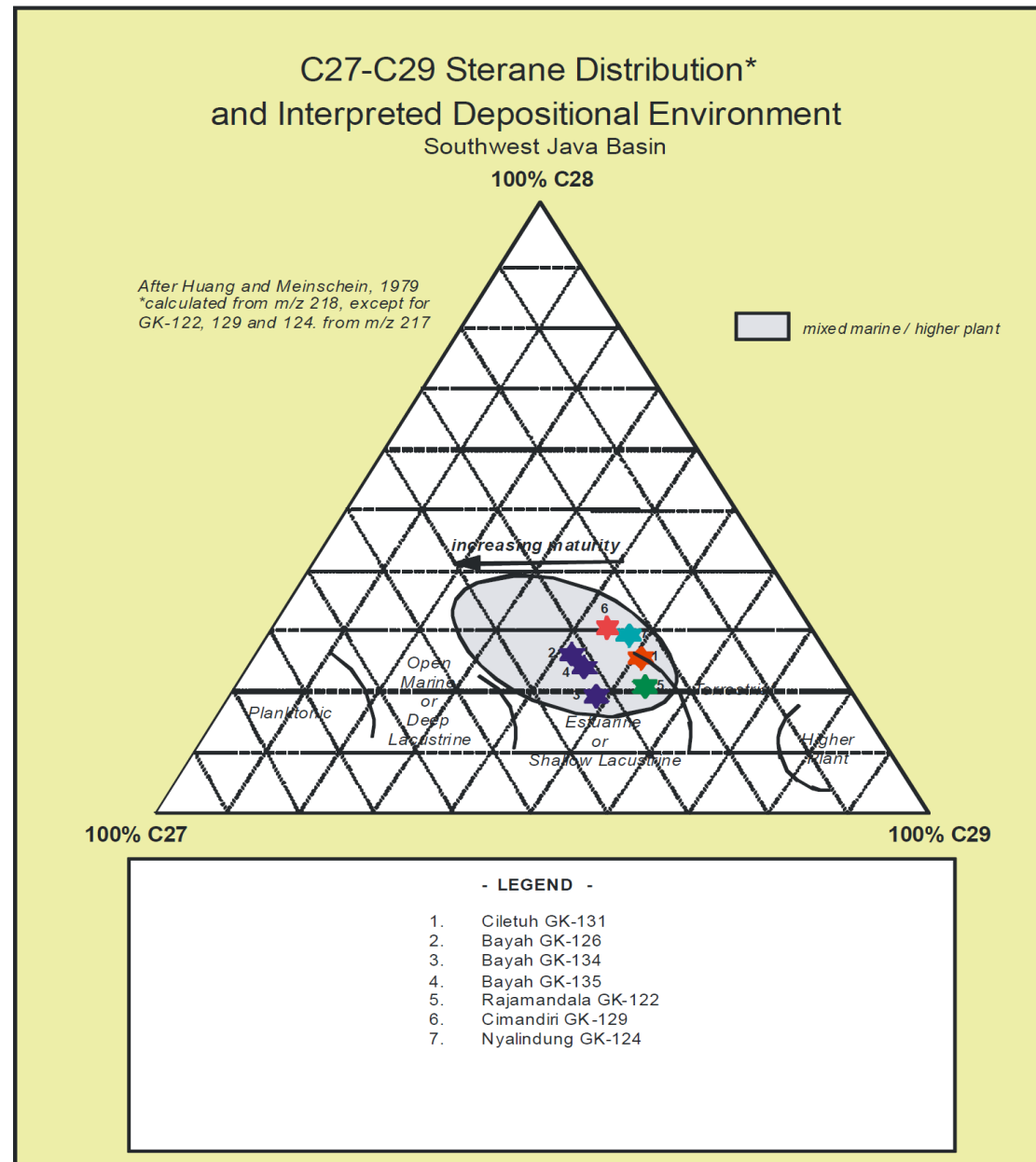


Figure 8. Steranes distribution plotted in Huang and Meinschein's diagram (1979) characterising the depositional environment of the source rocks.