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GEOCHEMISTRY AND HABITAT OF OIL AND GAS IN THE EAST JAVA BASIN : REGIONAL EVALUATION AND NEW OBSERVATIONS

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ABSTRACT

A regional oil and gas geochemistry study was conducted recently based on geochemical data from around 100 wells and seeps of the East Java Basin. Geologic setting of the oil and gas occurrences were evaluated to derive their habitats. Most oils were derived from sub-oxic and oxic terrestrial to marginal marine source facies. Offshore oils are more terrestrial than those of onshore. Three genetic types of natural gases are found : thermogenic, biogenic, and mixed gases. The Paleogene Ngimbang, Lower Kujung, and Lower Tuban shales and coals are the sources of the oils and thermogenic gases. Biogenic gases were sourced by the Neogene Tawun to Lidah shales and coals. The study also evaluated the CO_2 gas accumulations and found that significant high CO_2 gas content are associated with thermal degradation of the Paleogene Kujung carbonates. Four trends of habitats are recognized : Ngimbang, Kujung, Ngrayong, and Mundu Trends.

INTRODUCTION

The East Java Basin is one of the earliest basins in Indonesia to start being explored in the late 1800s. The basin has produced oil and gas for 114 years and been explored for 130 years. However, even today, the basin is still very attractive for exploration (Satyana and Darwis, 2001). Big oil and gas discoveries still occur in this basin. These discoveries, fortunately, commensurate with the region's fast growing fuel consumption. Therefore, the basin is currently the "hottest spot" in hydrocarbon exploration in Indonesia (Figure 1).

As a mature basin, geochemical data on oil samples, including data derived from biomarkers and carbon isotope, are abundant. Whereas, geochemical data on gas samples are limited, most gas data are only the molecular composition. Geochemical data on rock samples are quite available mostly from the Eocene to Miocene rocks. This enables an evaluation of oil to source rock correlation.

However, regional and integrated geochemistry study of the East Java Basin has never been published. Available published geochemistry studies were from Russel *et al*. (1976) for selected crude oils and sources in the East Java Sea and from Phillips *et al*. (1991) for the origin of hydrocarbons in the Kangean area, offshore northeast Java Sea. Recent publication on source geochemistry was from Purwanti and Bachtiar (2001) who discussed the Eocene petroleum kitchen in the East Java Basin. There are a number of unpublished geochemistry studies conducted by service companies, one of them which is commonly referred, is a study by Robertson Research in 1986 : East Java and East Java Sea basin area : stratigraphy,

petroleum geochemistry and petroleum geology. As for the East Java's gas geochemistry, there has never been published and unpublished regional studies.

This paper presents a regional oil and gas geochemistry study of the East Java Basin both onshore and offshore. The study was based on abundant published and unpublished data of more than 100 wells and seeps. The objective of the paper is to understand regional geochemistry of oil and gas and to define their habitats. Oil and gas properties, grouping and genetic types, source identification and deposition, mature kitchen, generation and migration versus basin evolution, and areas of accumulations will be addressed. Systematic understanding of the basin's oil and gas geochemistry will more enhance the discoveries within this basin.

SUMMARY AND CONCLUSIONS

- Regional evaluation of the East Java's oil and gas geochemistry within this study is based on 86 oil, 33 gas, and 57 rock samples derived from around 100 wells and seeps distributed in the onshore and offshore areas.

- Oil geochemistry study shows that the East Java's oils are typically moderate-medium API degree (average 37º), low sulfur (0.21 % wt), medium-high pristane to phytane ratio (5.13), medium-high oleanane biomarker content (ratio of oleanane to hopane 0.60), C_{29} sterane dominated, light isotope carbon-13 ratio (saturate -27.1 ‰, aromatic -25.6 ‰), and moderately waxy. These characteristics indicate an oxic to sub-oxic terrestrial to marginal marine source facies of group "D" classification. Subdivision into onshore and offshore oil dataset, shows that the present offshore oils are more terrestrial and present onshore oils are more marine. Based on oleanane content, offshore oils are considered to be sourced by older sources than those of onshore. The offshore oils are grouped as "D_I", the onshore oils are grouped as "D_{II}". The oils were generated from medium maturity of average calculated Ro (derived from methyl phenanthrene index) 0.74 %. These match with the geologic setting of expected sources. Based on the geochemical inversion method, besides the oil to source correlation using GC and GC-MS, the expected sources of oils are middle Eocene Ngimbang, Late Oligocene Lower Kujung, and Early Miocene Lower Tuban shales/coals. Which the best sources are various, depending on local geologic setting.

- Gas geochemistry study shows that based on the gas composition and carbon-13 and deuterium isotopes, the East Java natural gas can be divided into three genetic types : thermogenic associated and non-associated gas, biogenic/bacterial gas, and mixed biogenic-thermogenic gas. Thermogenic gases have wet gas composition of methane 73-94 % and ethane plus 6-27 %, isotopes of carbon-13 methane are -39.8 to -33.84 ‰ and isotopes of deuterium -152 to -145 ‰ indicating a wet thermogenic origin. Biogenic gases have dry gas composition dominated by methane from 99.5 to 99.8 % and ethane plus below 0.5 %, isotopes of carbon-13 methane are more negative (lighter) than -60 ‰. Mixed gas occurred by depth-selective accumulation with shallow biogenic and deep thermogenic origin. Thermogenic gas sources are similar with those of oil sources, i.e. from middle Eocene Ngimbang to early Miocene Lower Tuban shales/coals. Biogenic gas sources are the middle Miocene to Plio-Pleistocene shales and coals of the Tawun, Wonocolo, Mundu, Paciran, and Lidah Formations. Non-hydrocarbon gas of CO_2 is evaluated regionally and found that significant high CO_2 gas content (25-79 %) only occurs in the fields with Kujung-Tuban carbonate reservoirs located at the Cepu High

area. Carbon isotope of CO_2 show ratios of -5.17 to 4.85 ‰ indicating that the origin of CO_2 was from thermal destruction of carbonate rocks (deeper reservoir or source) within the adjacent basinal kitchen at the temperature above 100º C.

- The habitats of East Java's oils and gases are discussed within the framework of tectonics, sedimentary regimes, and the occurrences of oils and gases. The genetic oil and gas types of East Java are the products of major geologic settings. The generation, migration, and accumulation of oil and gas are related to the intense Paleogene and Neogene tectonic and sedimentologic events responsible for the present structural framework of East Java. Different physical and geochemical properties of the oil and gas were determined by the diverse geodynamic histories. Four trend of habitats are recognized : Ngimbang, Kujung, Ngrayong, and Mundu Habitats. Existing and future potentials of East Java's oils and gases are located within these trends.