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Gas Habitat of the East Java Basin, Indonesia : Meets the Future Demand

Awang H. Satyana[*)]
Elan Biantoro[*)]
Achmad Luthfi[*)]

EXTENDED ABSTRACT

The East Java Basin, Indonesia (Figure 1), 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; yet, the basin is still very attractive for exploration. Big to giant oil and gas accumulation are still discovered today in this basin. The gas discoveries are ready to be developed to overcome shortfall of gas from existing fields. However, due to gas demand in the region will increase very fast in the next three years, the available gas supply could not fulfill the demand even combined with some new gas discoveries and development. Without any increasing exploration and production activities, a shortfall of gas in the East Java will happen for a long time. The study indicated that the East Java Basin is very rich in gas accumulation. This potential should be worked out to solve future gas shortfall problem.

The East Java Basin has recorded an active geodynamic history. The basin developed from an oceanic basin in front of the Late Cretaceous subduction zone to presently a backarc basin behind the volcanic arc. The basin was segmented into a number of horsts and grabens that facilitated the deposition of the Paleogene synrift and postrift sediments (Ngimbang Formation) as well as the carbonate development (Kujung Formation) (Figure 2). Inversion history starting in the Neogene has posted significant changes in the geology of the basin. Siliciclastic sediments were deposited (Tuban-Tawun-Ngrayong-Wonocolo Formations). The rising southern volcanic arc has made the East Java Basin to be an asymmetric backarc basin. Plio-Pleistocene volcano-clastic sediments dominated the southern basin. Southern downwarping area due to volcanic uplift created Pliocene basin's depocenter into which Mundu sediments were deposited. The basin's Neogene history has become more complicated by the activities of a major wrench fault zone called the Rembang-Madura-Kangean Fault which transversally deformed the basin in the central part. Compressive east-west trending structural elements resulted from southern subduction dominate the present structural styles mainly in onshore basin.

The basin's dynamic tectonics, structure, and stratigraphy influence the petroleum system. Hydrocarbons have been discovered from the Eocene to the Pleistocene sandstones, carbonates, and volcano-clastics. The mature sources are available from the pre-Eocene to the early Miocene shales and coals. The traps are various from the classic four-way anticlines through reefal build-ups to deepwater stratigraphic plays.

[*)] Implementing Body for Upstream Oil and Gas Business, Jakarta, Indonesia

A total of 33 gas data have been compiled for this study derived from gas seeps, gas fields and gas discovery wells. Three types of natural gases showing a clear correlation between genetic types of gases and the age of the reservoirs from which they are produced can be distinguished in the East Java Basin : (1) thermogenic gases which commonly are associated with oil and are produced predominantly from Eocene to Early Miocene reservoirs, (2) bacterial/ biogenic gases which are found predominantly in Pliocene reservoirs, and (3) mixed gases which are reservoired in the middle Miocene to Pleistocene sediments. Four trends of gas occurrences have been identified (Figure 3).

Thermogenic gas accumulations are distributed across the basin from west to east and north to south forming the two trends : (1) Cepu-Kangean High and (2) North Madura Platform. The Mudi-Sukowati-Banyu Urip-Kedung Tuban-Rembang gases form the Cepu High and the gases are accumulated within the Oligo-Miocene Kujung carbonates. Suci gas is also within this trend and the gas is reservoired within the Ngimbang carbonate. The Pagerungan and West Kangean Fields constitutes the eastern Kangean High trend. The gases occur in the Eocene pre-Ngimbang and Ngimbang sands. The North Madura Platform trend contains the KE 5, KE 23, KE 13, KE 38, KE 39, KE 40, Bukit Tua, Jenggolo, and Payang fields at the East Java Sea to the north of the Madura Island and the gases are reservoired within the Kujung and Rancak carbonates. The thermogenic gas fields occur both as non-associated and associated gas. They 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. Gases from the Cepu High are characterized by high CO_2 gas content due to thermal degradation of the carbonate reservoirs. Condensates are generally produced from the fields. Produced condensates have API 40-50°, sulfur content of 0.1 %, and $\delta^{13}C$ whole oil of –25.8 ‰. Some condensates are produced due to fractionation by gas striping. Geochemistry and geologic evaluation concluded that the gases were sourced by middle Eocene Ngimbang to early Miocene Lower Tuban shales/coals.

Biogenic or bacterial gases are distributed in two trends : (1) Surabaya-Madura Strait Trend consist of Wunut, Oyong, Maleo, MDA, Terang-Sirasun-Batur-Kubu, and (2) Muriah-Bawean Trend consist of Kepodang Field. The reservoirs of biogenic gas are from middle Miocene Tawun to early Pliocene Mundu sands and carbonates. 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 ‰. Mixing between thermogenic and biogenic gases is observed in those two belts (Oyong, Wunut, Kepodang fields). Mixed gas occurred by depth-selective accumulation with shallow biogenic and deep thermogenic origin. Biogenic gas sources are the middle Miocene to Plio-Pleistocene shales and coals of the Tawun to Mundu formations.

Thermogenic and biogenic gas prospects and leads have been identified in those four trends. The structures have similar plays with those of existing fields and discoveries within the trends, therefore the petroleum systems of these remaining structures are proven. Future gas potential of the East Java Basin lies in these four trends. As much as 25 TCF thermogenic gas, 3 TCF biogenic gas, and 18 TCF mixed gas have been expected.

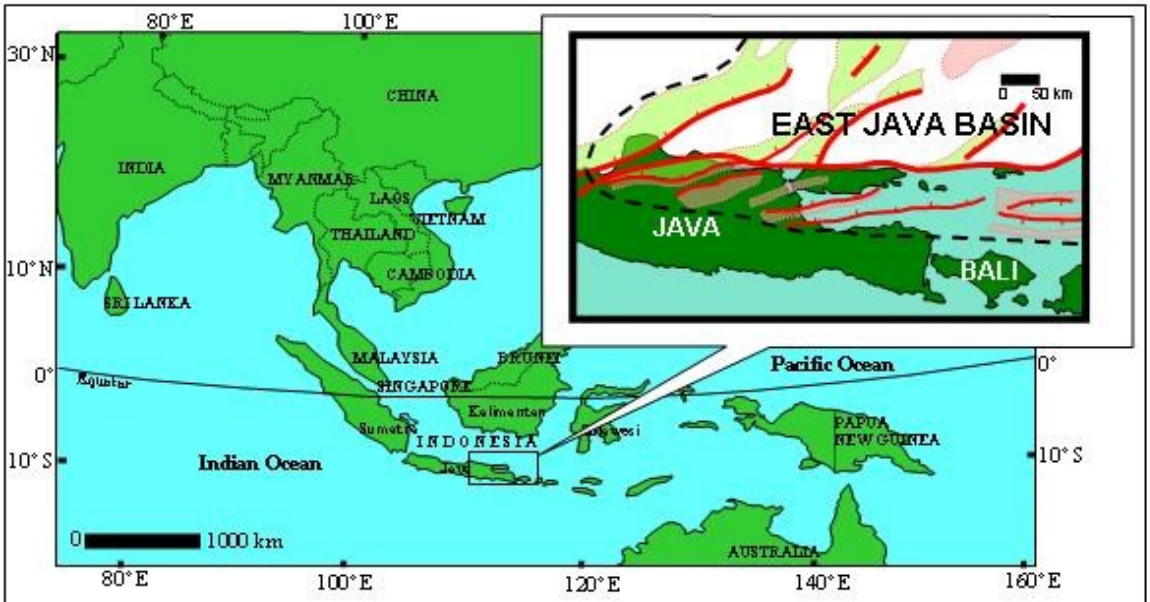

Figure 1. East Java Basin Location Map

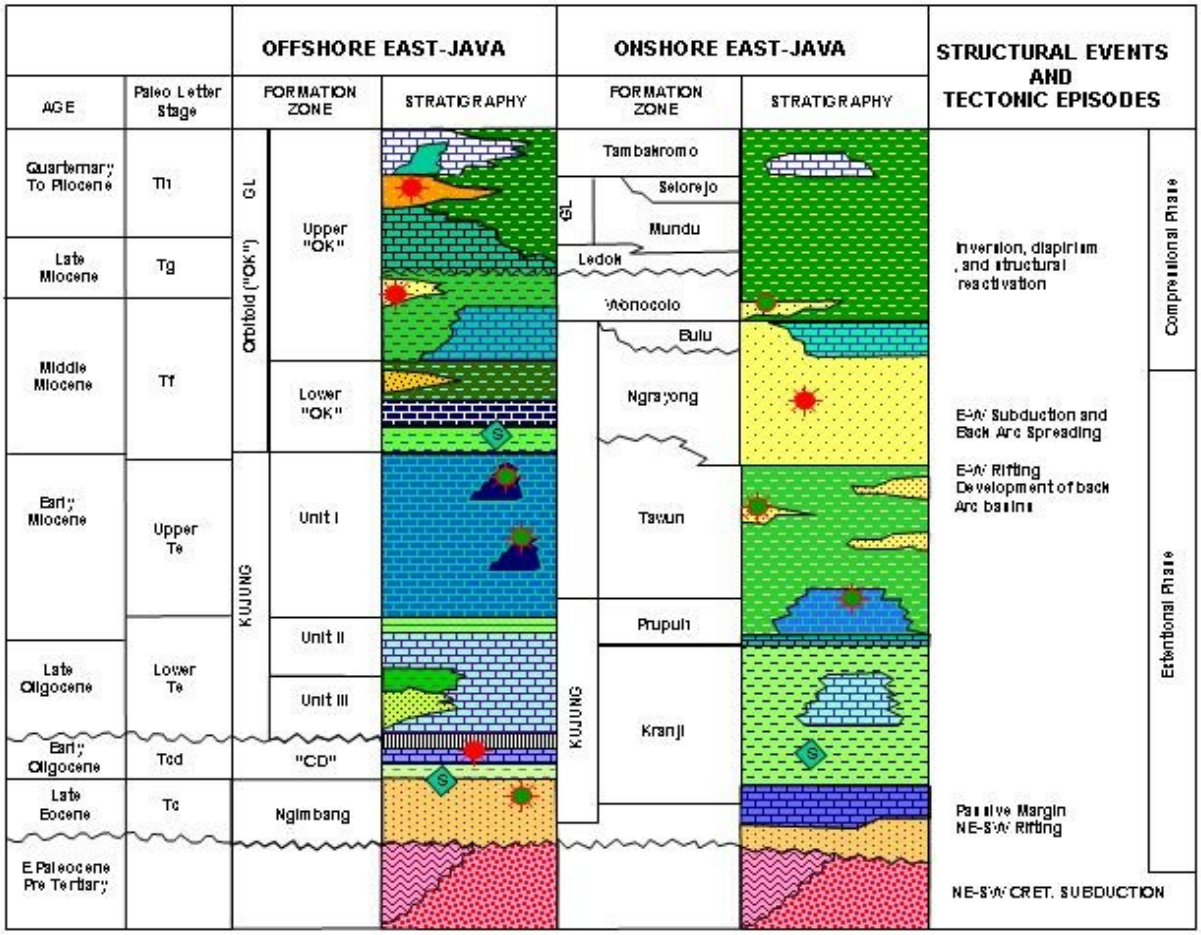

Figure 2. Generalized Tectonic Episodes and Stratigraphy

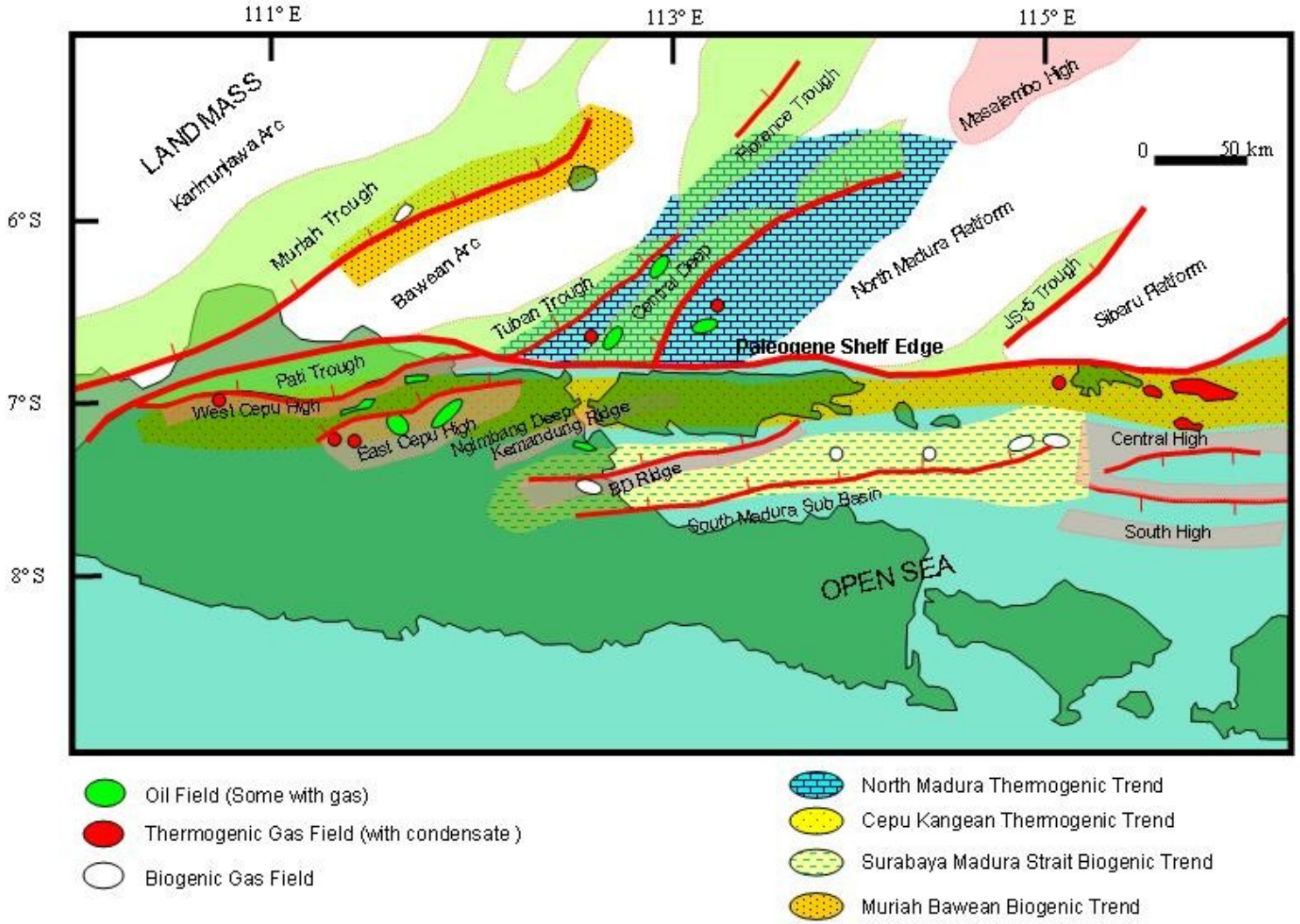

Figure 3. Trends of East Java Gas Habitat