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Oil-oil correlation of the South Sumatra Basin reservoirs

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The research sets about describing the different oil types in the South Sumatra Basin and relating the hydrocarbon to source rocks. Four different groups of oil have been identified; the character of the oils suggests both lacustrine and terrestrial input to the source rocks. Type 1 oils have marine/lacustrine influenced (low pristane/phytane), Type 2 are terrestrially derived (high pristane/phytane ratio), Type 3 are also lacustrine (oils with bimodal distribution of n-alkanes) and Type 4 are biodegraded oils. These oils are distributed randomly in the South Sumatra Basin and are believed to be sourced from the terrestrial TalangAkar and lacustrine Lemat/Lahat formations.

Key words: South Sumatra, lacustrine, terrestrial, pristane, phytane.

INTRODUCTION

South Sumatra Basin, located in the southern part of the Sumatra Island is a foreland (back arc) basin. It comprises of a series of NNW-SSE trending syn-rift basins with post-rift sequence. The basin is boarded to the south by the Lampung province, to the west by Bengkulu province, to the north by Jambi and to the east coast by the islands of Bangka and Belitung (Figure 1). The basin was formed during east-west extension which took place during pre-tertiary and early tertiary times (Daly et al., 1987). South Sumatra Basin is an important hydrocarbon province in Indonesia. The high geothermal gradient in the South Sumatra Basin is due to the crustal thinning and this is generally a suitable condition for hydrocarbon generation. In the early days of petroleum exploration, South Sumatra Basin received a great attention due to a number of oil seeps that were seen in the area. Courteny et al. (1990) reported that the oil was reported in the South Sumatra Basin near MuaraEnim, to the east of Karangradja. Multiple hydrocarbon source and reservoir systems have been reported in this Basin.

Geology and stratigraphy

The geology and tectonic evolution of the basin have been described by Adiwidjaja and de Coster (1973), de Coster (1974), Pulunggono et al. (1992), Darman and Sidi (2000) and Barber et al. (2005). The geology of South Sumatra is dominated by the Holocene-Pleistocene and Pliocene-Miocene sediments, pre-Tertiary Volcanic and intrusive igneous as well as metamorphic rocks (Figure 2). Stratigraphically, four

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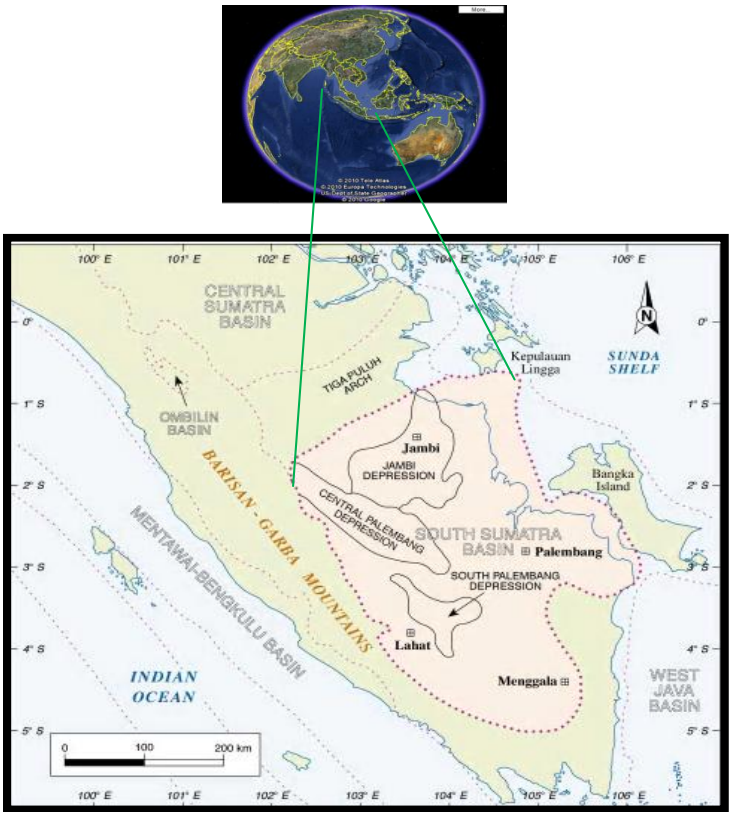

Figure 1. Location map of the South Sumatra Basin (After Petroconsultants, 1996).

phases of tectono-stratigraphic evolution are recognised. The basin contains pre-tertiary rocks that occur as isolated inliers that are overlain by a thick sequence of tertiary to recent sediments and volcanic. These are; Early Syn-rift (Eocene to Early Oligocene), Late Syn-rift (Late Oligocene to Early Miocene), Early Post-rift (Early to Middle Miocene) and Late post-rift (Middle Miocene to Quaternary) (Figure 3).

MATERIALS AND METHODS

Literature review was undertaken to understand the geologic and tectonic setting of the basin. The basic elements of petroleum system (source, reservoirs, seals and traps) ware identified. The data sets that form the basis of this research include the gas chromatograms from different wells and Oil distribution maps. Oils were chromatographically grouped on the basis of gas chromatograph (GC). The pristane/phytane ratio and the distribution of the n-alkanes were used to grouped the oils and understand their maturity as well as environment of deposition. These oils were then related to source rocks (Table 1).

Oil families and distribution

On the basis of pristane/phytane ratio, four main types of oils have been recognised. These are type 1, 2, 3 and 4 (Figure 4). These are:

Type 1: They are oil with low pristane/phytane ratio. They originated from algal kerogen (Type I) deposited in a lacustrine environment.
Type 2: These are oils that have high pristane/phytane ratio. They are oils originated from terrigenous kerogen (Type III). They are deposited in terrestrial environment (mainly fluvial deltaic) with minor algal organic matter influence.
Type 3: These are oils that have bimodal distribution of the n-alkanes and they have low pristane/phytane ratio. The oils are lacustrine derived and waxy in nature.
Type 4: These are oils that have undergone various degree of biodegradation.

Moreover, South Sumatra oils can also be subdivided on the basis of their maturity, pristine/phytane rations and environmental influences into five families (Figure 5). There is various level of maturity in these oil types. There are normal (mature), light oils (more mature) and/or heavy (waxy oils less mature) (Figure 6). The oil families' characteristics are summarised below:

Family 'A'

Type A oils have high pristane/phytane ratio. They are considered to be light oils with moderately waxy oil properties. Family 'A' oils include Tanjung Laban, Ramba, Rawa, Keri, Tenga etc.

Family 'B'

Family 'B' oils are lacustrine derived oils. Chromatograms of this oil

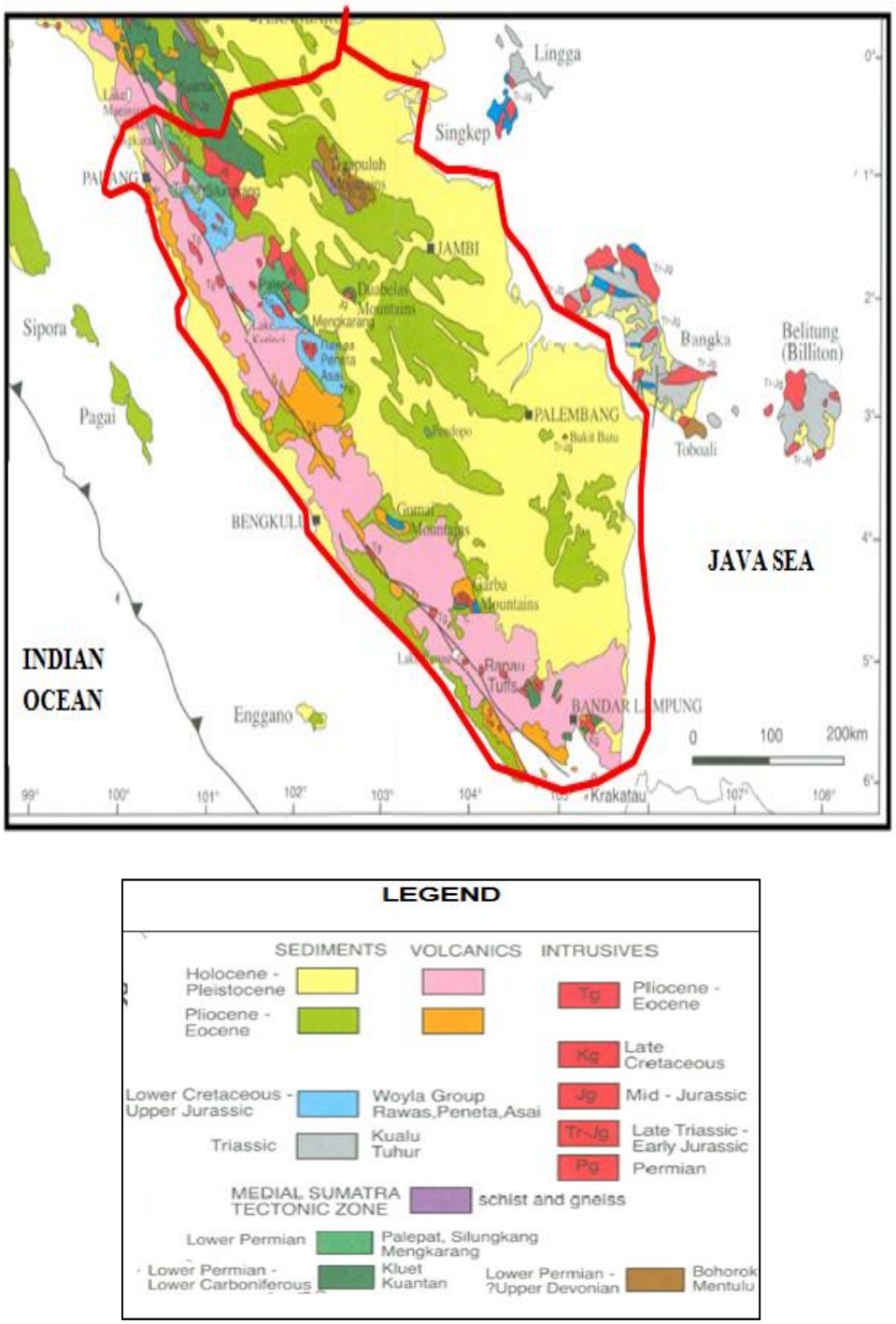

Figure 2. Simplified Geological Map of the South Sumatra Basin (modified from Barber et al., 2005).

type show strong waxy components and bimodal distribution of n-alkanes. They have low pristane/ phytane ratio. The development of the isoprinoidpristane is eratic in this family. The pristine/phytane ratio value reached 12.8 in the Bentayan-1 but only 1.8 in the Bentayan-13 crude (Armstrong, 1992). The oils are waxy with onset of oil generation in the 0.6 to 0.7%Ro (Armstrong, 1992). These oils include Bentayan-13 oil, Bertak-1 etc.

Family 'D1'

These oil categories have normal distribution of n-alkanes and are limited to marine source. Pristane/phytane ratio is low and these oil expelled oil at 0.70 to 0.90%Ro that is, normal maturity (Armstrong, 1992). Examples include East Rebonjaro-1 oil, Hari-1 oil and Plajawan-1 oil.

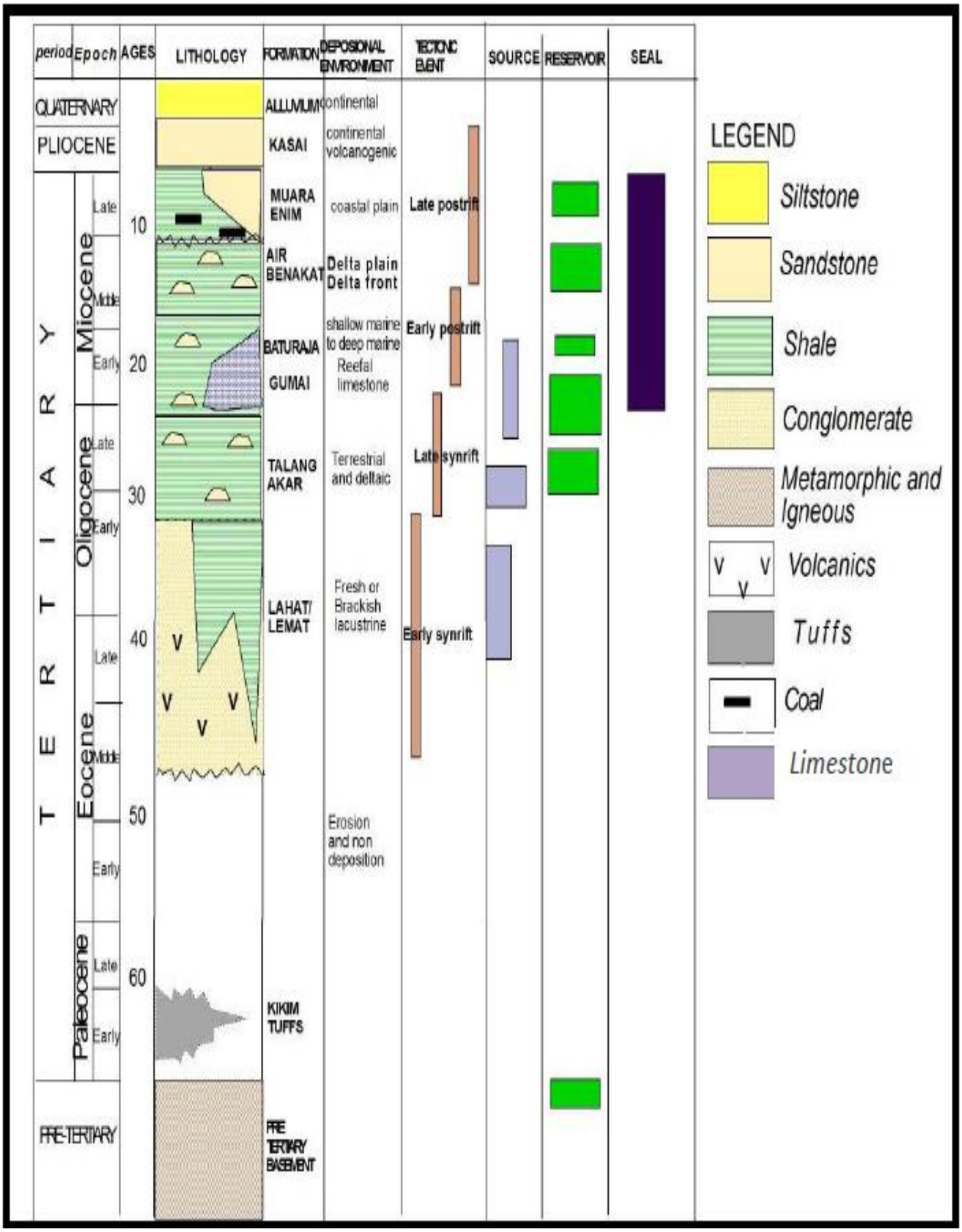

Figure 3. Generalized stratigraphy of the South Sumatra Basin (Redrawn after de Coster, 1974; Sudarmono et al., 1997; Hutchison, 1996; Petroconsultants 1996; Sosrowidjojo et al., 1994).

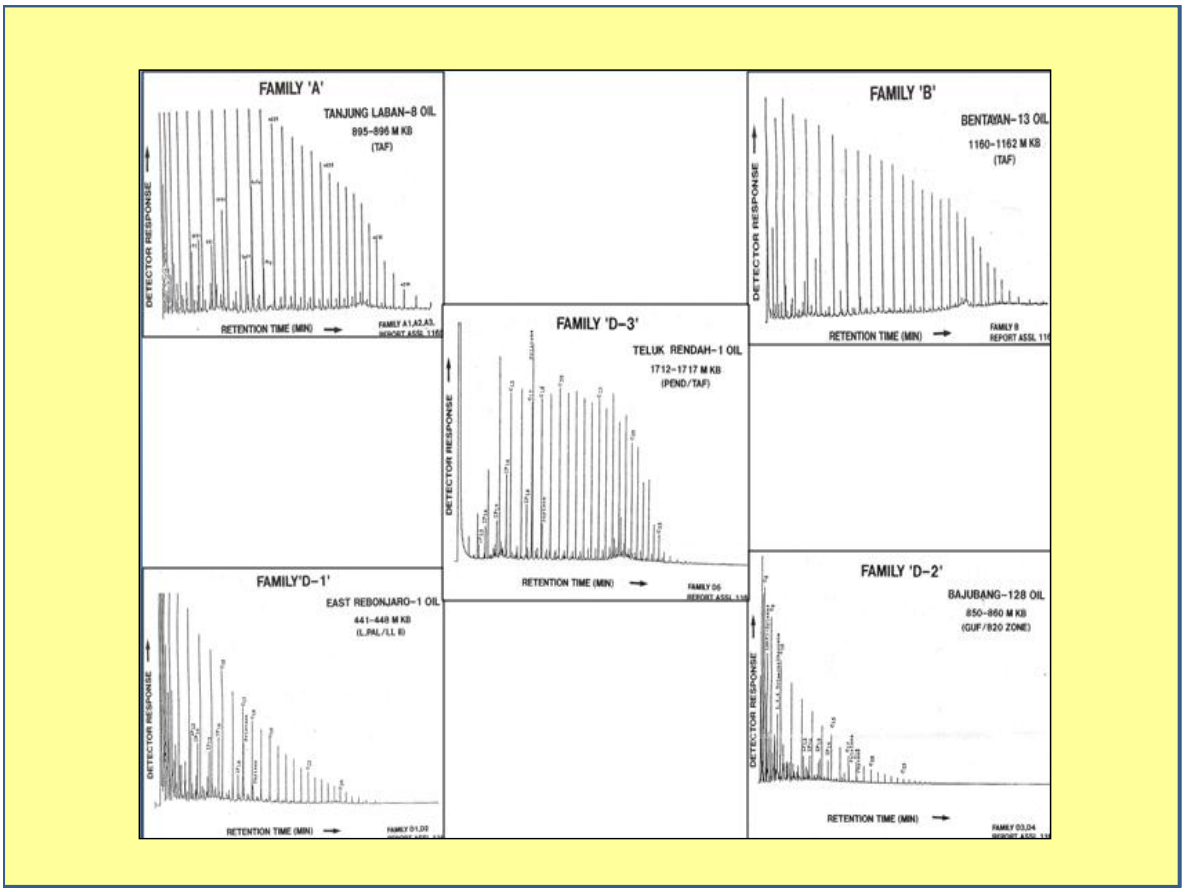

Figure 4. Oil Families of the South Sumatra Basin.

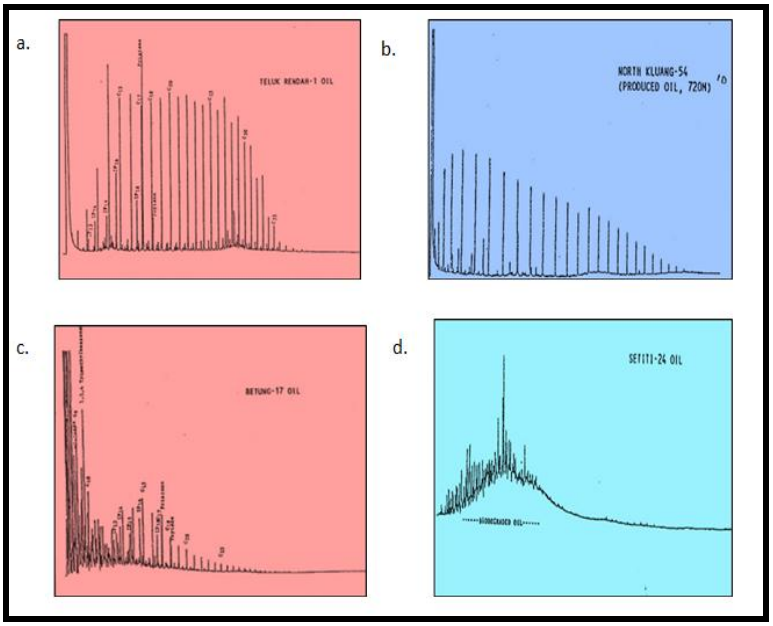

Figure 5. Showing different oil maturity. (a) Teluk Rendah-1 oil (Heavy oil, less (early) matured, (b) North Kluang-54 (produced oil) (Normal oil) (c) The Betung-17 oil (Light oil that is, more mature) (d) Setiti-24 oil (Biodegraded oil).

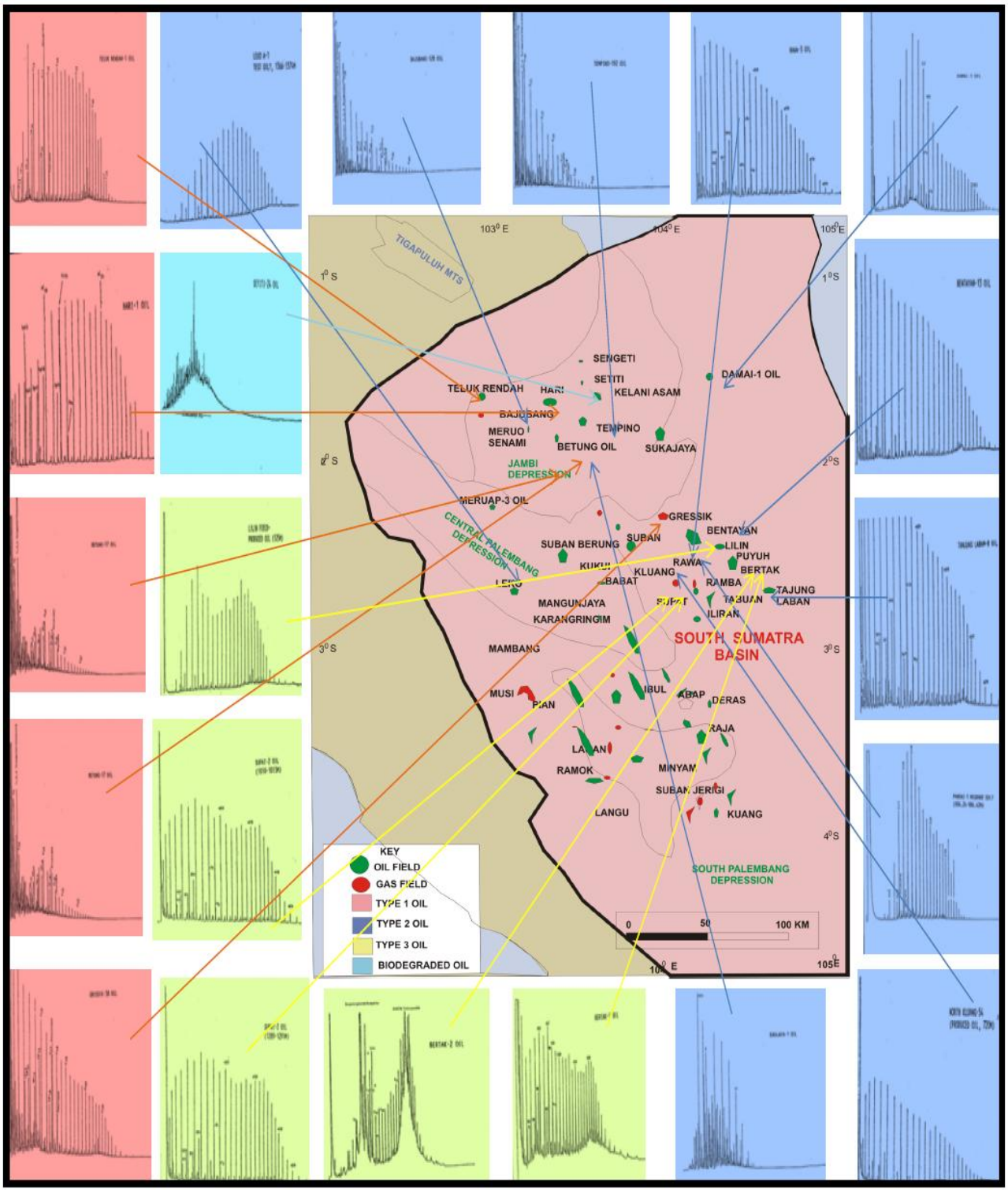

Figure 6. An oil map of the South Sumatra Basin showing the distribution of the various oil types.

Family 'D2'

Family 'D2' oils are light oils with low pristane/phytane ratio. Some of these crude are however biodegraded. Examples of this oil type are Bajubang-128 oil and Leko oil.

Family 'D3'

These are low pristane/phytane ratio and low maturity oils. They have high oleanane biomarkers content which indicates input from Late Cretaceous and tertiary flowering plants. The pristane/phytane

Table 1. Bulk properties/GC produced oils.

Well/field	Formation	% Wax	% HC	Pr/Ph ratio	Max. N-alkanes
Teluk Rendah-1	TalangAkar	20.8	73.9	5.96	C20
Dayung-1	Air Benakat	0.87	79.2	-	-
Betung-17	Gumai	2.51	89.7	2.36	C9*
Setiti-24	Air Benakat	0.16	93.5	-	-
Tempino-48	Gumai	2.05	89.2	2.65	C15
Bajubang-128	Gumai	1.62	93.8	2.71	C9*
Kenali Asam-195	Gumai	3.48	98.4	2.88	C15
Kenali Asam-9	Air Benakat	1.14	85.7	-	C9*
Tempino-192	Gumai	3.70	24.0	3.00	C14
N. Kluang-54	Batu Raja	-	-	4.11	-

*Based on whole oil trace, - missing data.

ratio indicates a high oxidation depositional environment. Examples of oils under this family include Teluk Rendah-1 oil.

RESULTS AND DISCUSSION

The study confirmed two main source rocks in the South Sumatra Basin, the TalangAkar and the Lemat/Lahat Formation. The extent of these two source rocks vary from well to well. The TalangAkar Formation is believed to be terrestrially (lower deltaic) derived. It contained oil and gas Type I, II and III kerogene (Suseno et al., 1992). The Lemat/Lahat is a lacustrine source rock associated with oil and gas prone Type I, and II kerogene as well as gas prone Type III kerogene. This depends on the well location in the basin (Suseno et al., 1992). The source rocks are early mature to oil window. The TalangAkar and Lemat/Lahat source rocks are good to very good with TOC vales 1.5 to 4 (1.5-4 (in the Kluang oil field). The Talang Akar accounts for more than 75% of the cumulative oil production in South Sumatra (Tamtomo et al., 1997).

South Sumatran oils are derived from source rocks of Tertiary age. These source rocks were deposited in lacustrine to marine and terrestrial environment. The majority of oils in the South Sumatra Basin are believed to be lacustrine or terrigenous (terrestrial). Oil type analysis indicates that more than one type of oil is present and these oils are associated with the TalangAkar and Lemat/Lahat formations. The major oil and gas fields are the Ramba, Kuang, LimauTimur, Tempino, TalangAkar-Pendopo, Raja Ibul and Beringim. The various bulk properties/GC of the produced oils in the South Sumatra Basin are summarized in Table 1. The oil types and their characteristics also confirmed the maturity of the source rocks.

Early migration of oil and late migration of gas have been reported in the South Sumatra Basin. The possible traps form in the Eocene, Oligocene and Pliocene times. The traps predate the hydrocarbon expulsion from the source rocks and this promotes hydrocarbon accumulations. The leaky nature of the seals results in hydrocarbon migration into reservoirs especially in the Oligo-Miocene reservoirs (Clure, 2005). The distribution of n-alkanes confirmed that most oils in the South Sumatra Basin are normal (mature) to light (more mature) with few heavy/waxy (less mature) oils. The oils can therefore said to be correlated to the sources.

Conclusion

It has been established that the South Sumatra Basin contains oil and gas rich source rocks that are at early mature to oil window. Oil and gas has been generated from these sources in the Oligocene time through to the present time. The character of oils in the basin suggests both lacustrine and terrestrial input to the source rocks. Presence of oil wells already shows that the South Sumatra Basin is a hydrocarbon generative basin.

Conflict of Interest

The authors have not declared any conflict of interest.

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