Bypassed Shallow Gas Intervals and the Challenge to Develop the Potential in Mature Oil and Gas Fields of Malacca Strait, Central Sumatra Basin*

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Abstract

The Malacca Strait Production Sharing Contract (PSC) has been producing oil since 1984 and gas over the past decade, making the fields categorized as brownfield. Major reservoirs for the oil and gas fields in the Central Sumatra Basin, and Malacca Strait area in particular (Figure 1), are sandstone intervals from the Early Miocene Sihapas Group and the Early Oligocene Lower Pematang Formation. The shale-dominated Petani and Telisa formations act as regional seals across the Basin. Both formations were deposited in two different tectonic phases (Figure 2). The marine Telisa Formation was deposited in a post-rift sagging phase from Early to Middle Miocene that marked the end of the transgressive sequence of the Sihapas Group. Tectonic inversion followed the regression sequence in the basin, resulting in deposition of the fluvio-deltaic Petani Formation. Both formations are relatively shallow in depth and have indications of gas accumulations as encountered by wells in the area.

Regardless exploration wells, significant shallow gas indications from the Petani and Telisa formations were encountered from existing development wells, which were producing oil but temporarily shut-in due to high water cut. These wells are distributed within major fields in the block; the Lalang, Mengkapan, Selatan, Melibur, Kurau and Kuat fields, but significant gas was encountered in the first three fields (Figure 1). The oil production began in 1984 from the Lalang Field, followed by the Mengkapan and Melibur fields two years later. The play for these fields is the Sihapas Formation High Relief Structure. The Kurau and Selatan fields have been producing oil from the Sihapas Formation Low Relief Structure Play since 1988 and 1989, respectively. Kuat Field, which started producing oil and gas in 1997, is regarded as part of the Pematang Deep Play. These fields have a recovery factor of more than 30% which is on the verge of ultimate recoverable reserves, except for the Kuat Field.

This study utilizes limited wireline logs data supported by mudlogs (total gas reading and chromatography), 3D seismic data, and production data. Integration of the data assisted correlation, interpretation and analyses to define the potential of gas accumulation in the Petani and Telisa formations, and to determine the best area for initial development.

Field Characteristics

Each field has a different data response to the potential shallow gas occurrence. In the Lalang Field, gas peaks within the Telisa Formation reached 387 units, with 105 units of background gas (BG) (3.5 times BG), which correlated with the sandstone intrabeds, from wells near the crest of the structure. The trap is a 3-way dip closure interpreted by 3D seismic, but no bright amplitude as DHI for common gas accumulation. On the other hand, bright amplitude is slightly visible in the Mengkapan Field that occurs near the crest of the 4-way dip anticlines. The highest gas peak recorded in the Mengkapan Field is 203 units with 53 units of background gas (4 times from BG) from the Petani Formation. Twenty kilometers to the southeast of the Mengkapan Field, a potential shallow gas accumulation is identified in the Selatan Field, with the highest gas peak of 686 units with 140 unit of background gas (5 times BG). This is located in a 4-way dip closure with a seismic character similar to the Lalang Field.

The high shallow gas indications in the Petani and Telisa formations are identified from total gas reading data, with peaks 3 to 5 times background gas. These indications occur where the closure exists, which explains the lack of shallow gas indications in the Kurau and Kuat fields. These intervals are also correlated with thin sandstone intercalations within shale-dominated lithology, where these shallow gas zones occur between the depths of 1750 to 2750 feet subsea (Figure 3).

The ratio of gas chromatographic to total gas indicates that the composition has 98% methane (C1) and minor contents of ethane (C2) and propane (C3). With the geothermal gradient in the range of 3.2-3.4°F /100 ft, the zone has a current temperature in the range of 144-212°F, which differs in each field. The high shallow gas interval in Lalang Field lies between 158-212°F, which falls into hyperthermophiles, while in Mengkapan Field, the interval lies within 153-194°F which just crosses the thermophiles into hyperthermophiles. The potential shallow gas interval in the Selatan Field lies in the range 144-180°F, which indicates the upper part of the zone lies within the thermophiles and lower half is hyperthermophiles. This temperature range suggests the gas formation process might be coincident with thermogenesis or even predominately thermogenic hydrocarbon generation, rather than microbial origin (Figure 4). Hence, testing is required to determine the gas presence, performance and type.

As an analog to those gas occurrences, shallow gas in the Melibur Field is currently being produced and sold for local electricity. The gas lies within the sandstone of the Upper Sihapas Formation, trapped by a major anticlinal structure formed by inversion of the basin. The gas contains heavier hydrocarbons up to pentane, but no isotope carbon analysis as of yet. Another analog is Bentu PSC, which has the same Central Sumatra Basin with Malacca Strait PSC. The PSC is already producing biogenic gas from the equivalent formations with depths around 1000-2000 feet subsea. Identified initially as potential shallow hazardous gas intervals in drilling, where the peak gas is 3 to 4 times BG, then it was tested to determine the economic rate and it successfully produced the gas. The gas has more than 98% CH_4, with low sulphur and CO_2 content. Carbon isotope analysis indicated $\delta 13C$ CH_4 value of -62 to -66‰ that concluded the origin of the gas to be biogenic. The gas bearing reservoir is in 7-25 foot thick sandstone layers trapped along a NW-SE anticlinal system related to a reverse fault (Yuwono et. al., 2012). Seismic data clearly exhibits bright amplitude as DHI.

Conclusions

Since the best shallow gas zone areas within the Malacca Strait PSC currently lies in mature oil fields still in production, oil wells should be converted to gas as was implemented successfully in the Melibur Field. To obtain the desired gas, the Malacca Strait PSC is planning to test the potential intervals in the Lalang, Mengkapan and Selatan fields. The difference in data response and availability in each field determines the confidence level and strategy to develop this shallow gas potential. The first priority is the Mengkapan Field where the gas potential is supported by well and seismic data.

Several wells have been identified to be converted to gas due to their current status of high water cut and being shut-in. The next priority is the Lalang and Selatan fields which are only supported by total gas data. The gas could be used for gas plant consumption to facilitate its own power supply which can reduce the operation costs significantly, as the use of HSD will be minimized. If the test is successful and the gas rate is high, the market for gas is also available in the surrounding Malacca Strait area. It can be sold to the National Electricity Company (PLN) or private companies for their power supply, either in Riau Isles or in the mainland of Sumatra.

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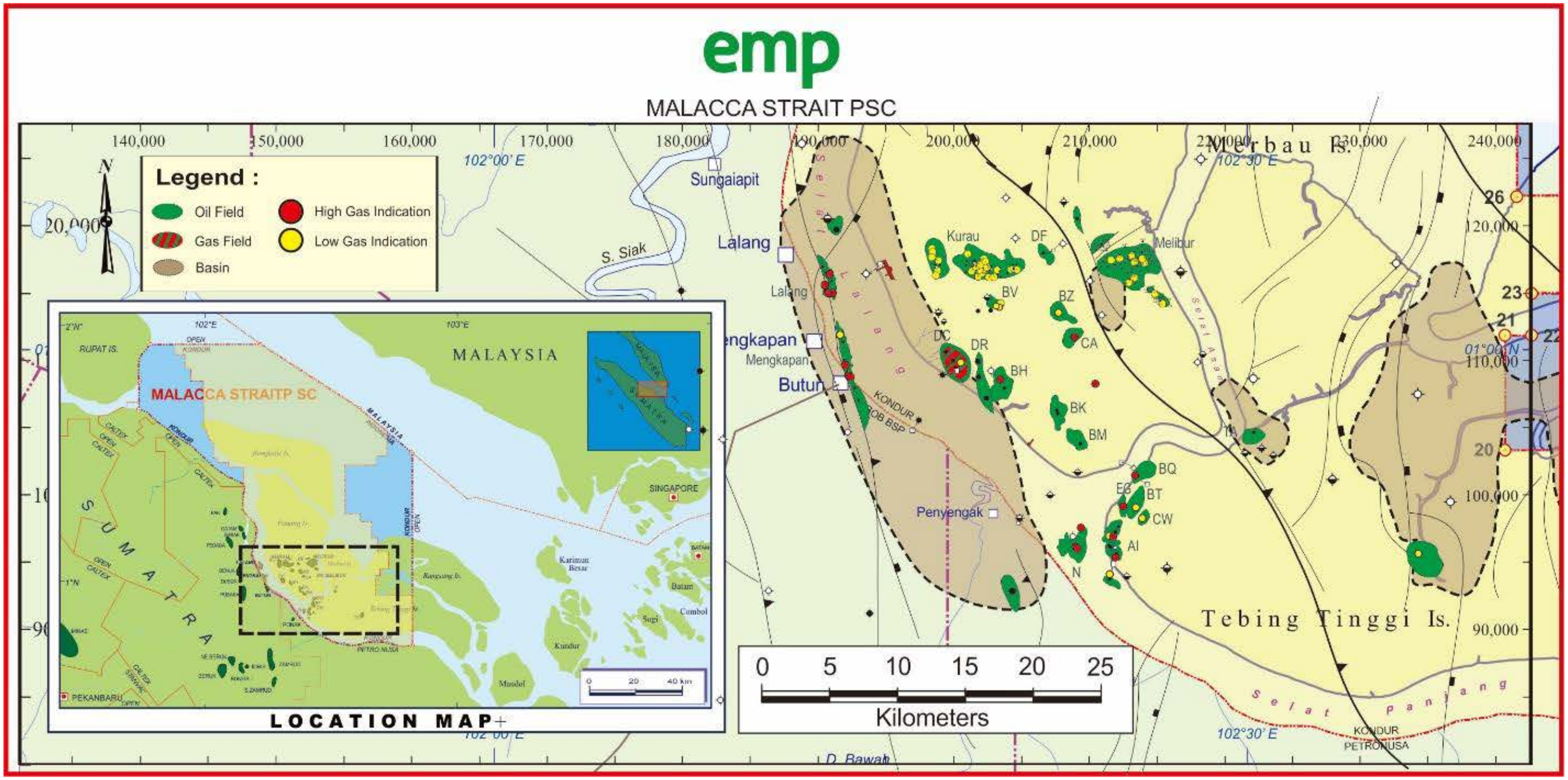

Figure 1. Location map of Malacca Strait PSC, with structural framework, basin configuration of the block, and oil and gas fields distribution within the block and adjacent area, including oil and gas field distribution with gas indication level in development wells.

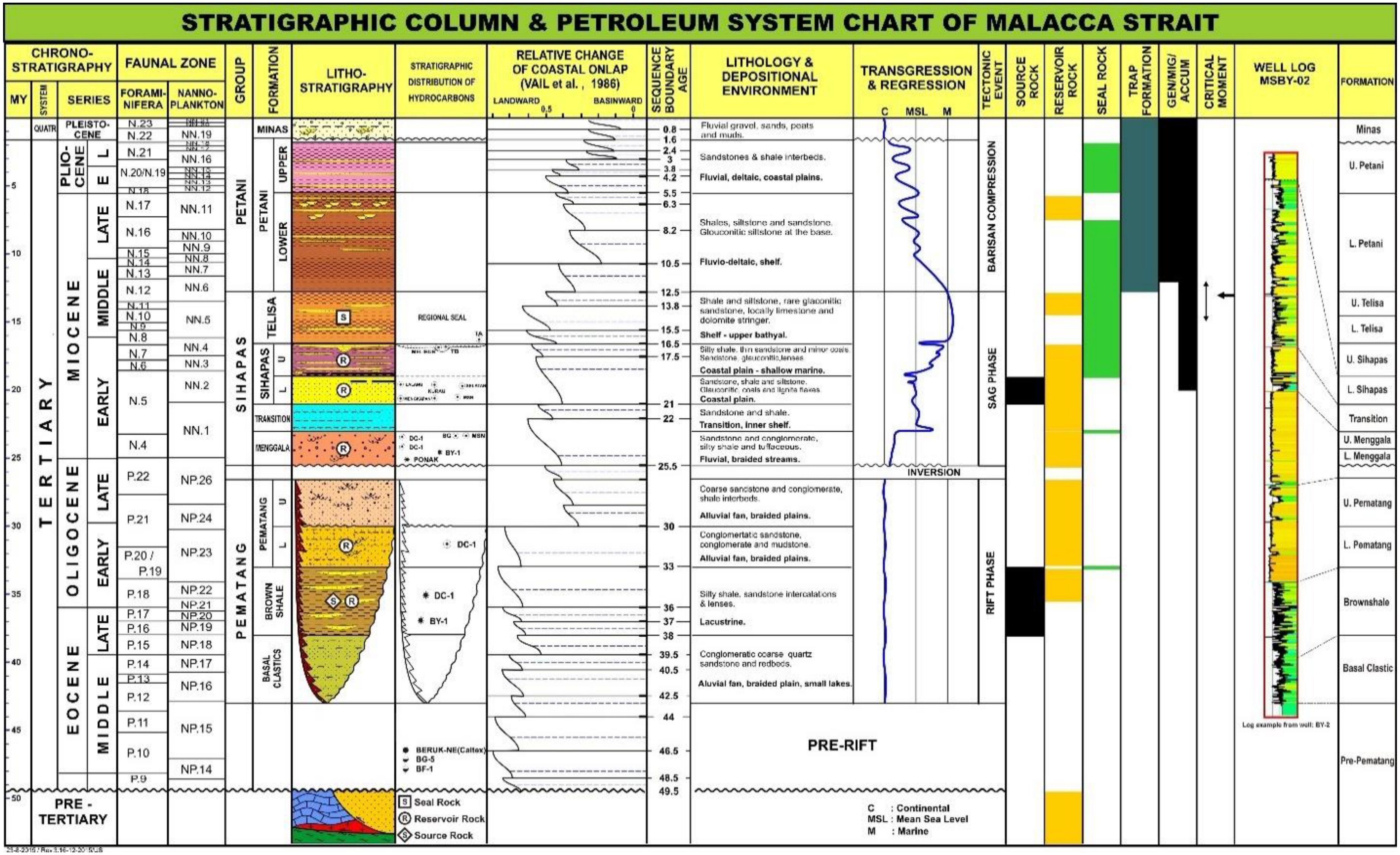

Figure 2. Stratigraphic column and petroleum system chart of Malacca Strait PSC (Bengkalis Subbasin).

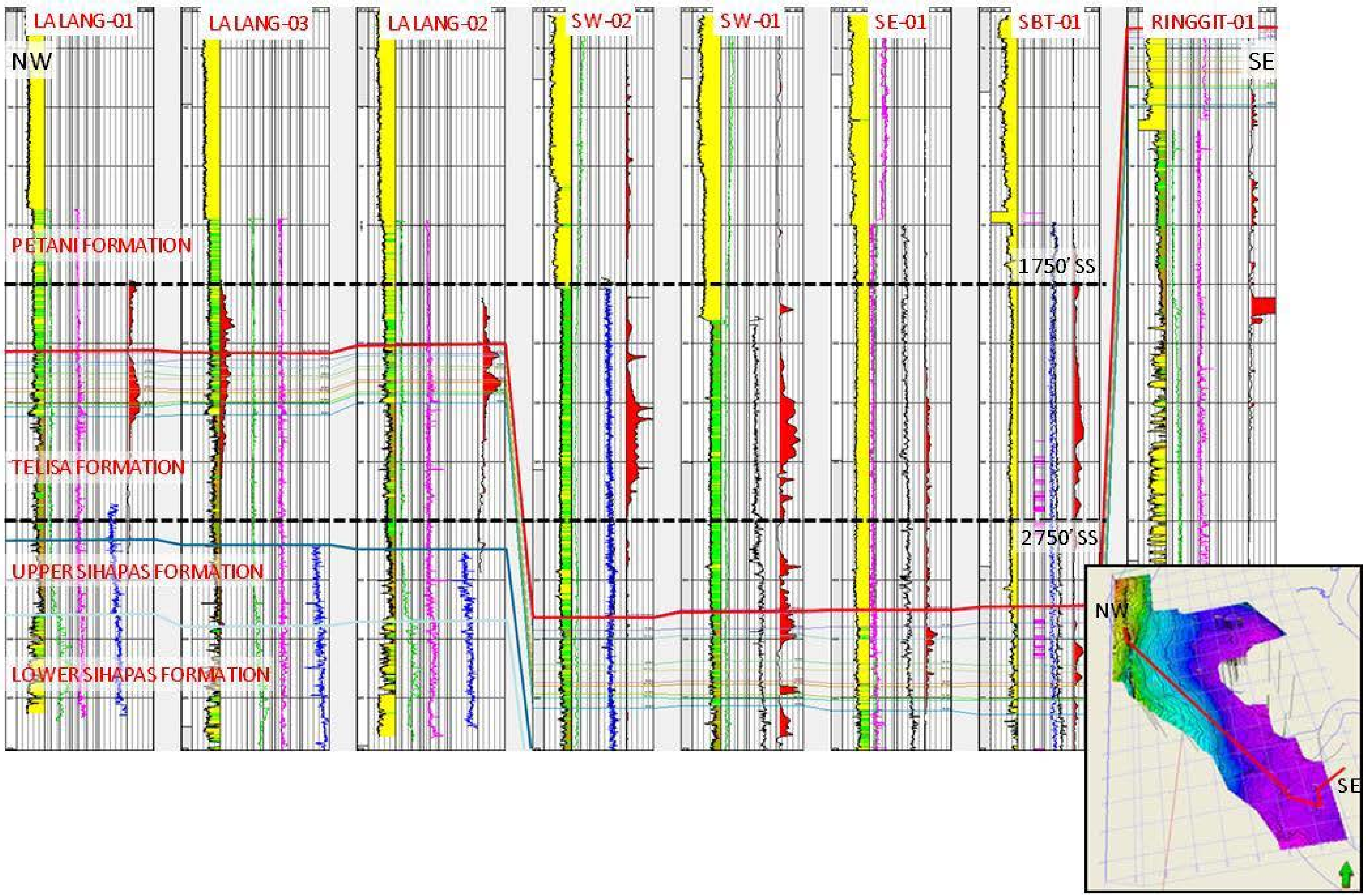

Figure 3. Well correlation within the Petani and Telisa formations from Lalang-Mengkapan Field in the northeast to TB Field in the east across Selatan Field.

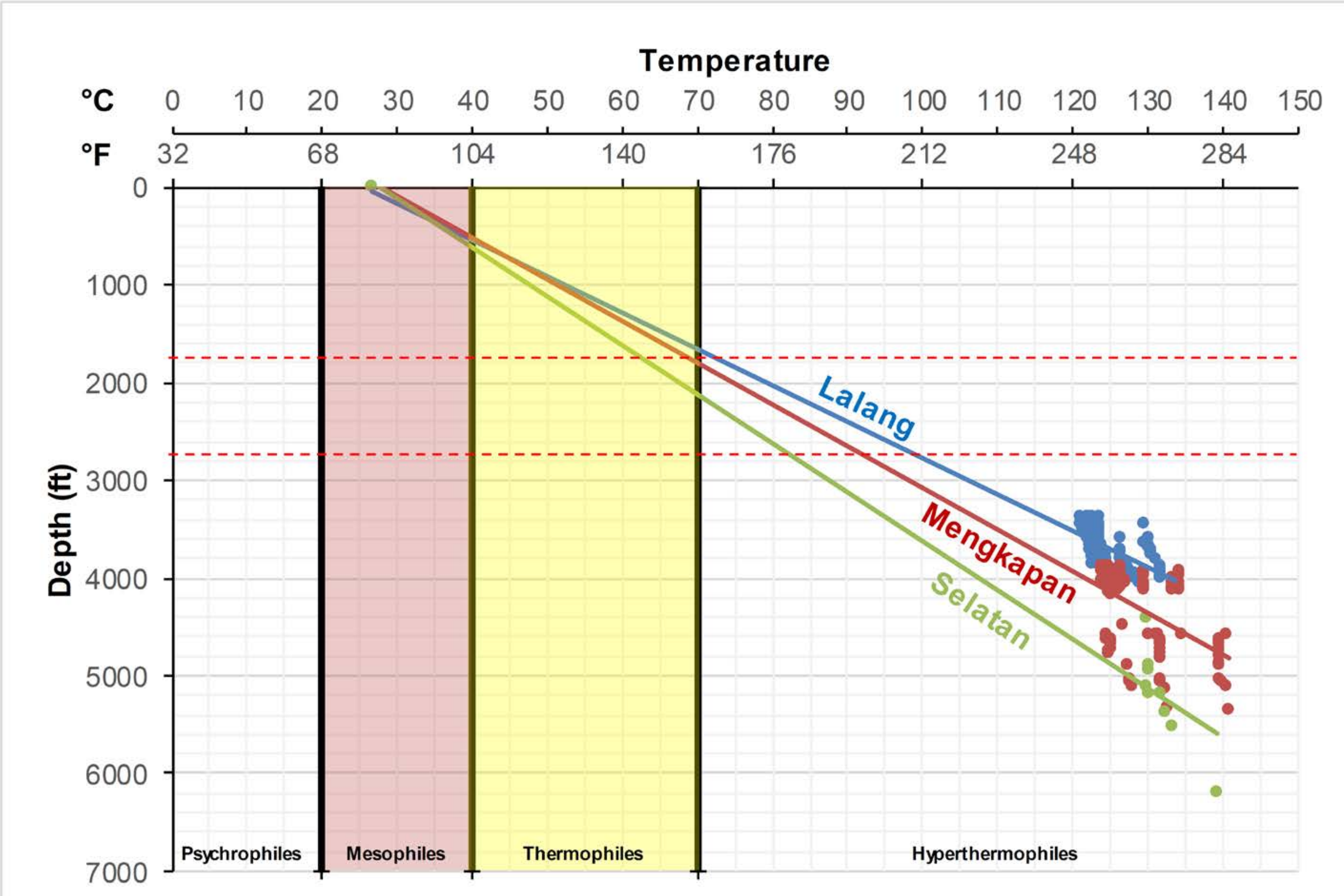

Figure 4. Temperature function as relative methanogen activity in Malacca Strait PSC oil fields.