Different Types of Organic-Rich Geological Markers in the Sub-Surface in the North Pailin Field, Pattani Basin, Gulf of Thailand

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Abstract

Different types of organic-rich sediments in the Sequence 3(Middle Miocene) stratigraphy in the Pailin field, Pattani basin, Gulf of Thailand are currently used as markers, are not differentiated, and are assumed to be laterally extensive. The integration of existing seismic data, conventional core, palynology and petrography from the South Pailin field was compiled and interpreted then compared with wireline log properties from 115 wells in the North Pailin field to better define wireline logs character in that part of Pailin field in terms of better recognition of organic-rich markers. Three types of previously undifferentiated organic-rich sediment markers are; A) Non-marine coals, the typical petrophysical signature shows low density (<2 g/cc), high transit times (340-380 msec/M) and moderate gamma ray values (130-160 API) with low uranium contents. B) Mangrove coaly shales, the typical petrophysical properties show very high gamma ray values (200-300 API) with high uranium content, low to moderate density (2-2.3 g/cc) and high transit times (350-370 msec/M). C) Transgressive marine shales, the average petrophysical properties of this marine shale show low resistivities (<2 Ohm-m) and high density (2.4-2.6 g/cc). Mapping of the distribution of the trangressive marine shale defines its consistent development in an overall transgressive setting and that it was deposited as a widespread unit. But, mapping shows the distribution of the non-marine coals and mangrove coaly shales are differently developed and distributed, compared to the trangressive marine shales. The overall degree of correlation is poorer. Notably, seismic amplitude mapping is unreliable with exception of a tie back to non-marine coal marker-3 or K-marker which corresponds to a major change in depositional association and acoustic properties.

Keywords: Trangressive marine shale, Non-marine coal, Mangrove coaly shale

1. Introduction

Different types of organic-rich sediments in the Pailin field are currently used as markers, are not differentiated, and are assumed to be laterally extensive. Most of the seismic markers typically exhibit consistent character over relatively small areas, and give only local correlations, except for the K-marker.

The integration of existing seis-

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mic data, conventional core, palynology and petrography will improve our understanding of organic-rich sediments within the region of Pailin field, where the markers occur within a depositional framework and their likely distribution.

Typically, only wireline data is used to define markers in wells and tied to seismic correlation surfaces without reference to real rock data. So, it is interesting to integrate real rock data and wireline logs data to better understand similarity and dissimilarity of organic-rich sediments in terms of their geological meaning, their distribution and their usefulness as markers.

2. Database and methodology

Data made available on Pailin-1 well, Pailin-2 well, Pailin-6 well, Pailin-7 well, Pailin-8 well, Pailin-11 well, Pailin-14 well, and Pailin-16 by Unocal Thailand Ltd. included core descriptions, core laboratory data, core photographs, thin section descriptions from organic-entraining mudstones at different depths in the Pailin-2 and Pailin-6 wells, data from the palynological study in the low resistivity shales from Pailin-1 and Pailin-2 wells. Also studier are wireline log datasets, namely; gamma ray, spectral gamma ray, resistivity, neutron, density, and sonic logs, which are used to link rock-based observations to the 115 wells wireline logs in the North Pailin field (Figure 1).

Then, correlation panels and maps plotting identical organic-rich sediment patterns, based wireline character across various depositional environments are constructed and interpreted.

3. Organic-rich sediment classification

3.1 Trangressive marine shale

Quantitative biostratigraphic analysis was done in the Pailin-1 well, while low resistivity shale units were sampled by sidewall coring at 0.6m intervals across three
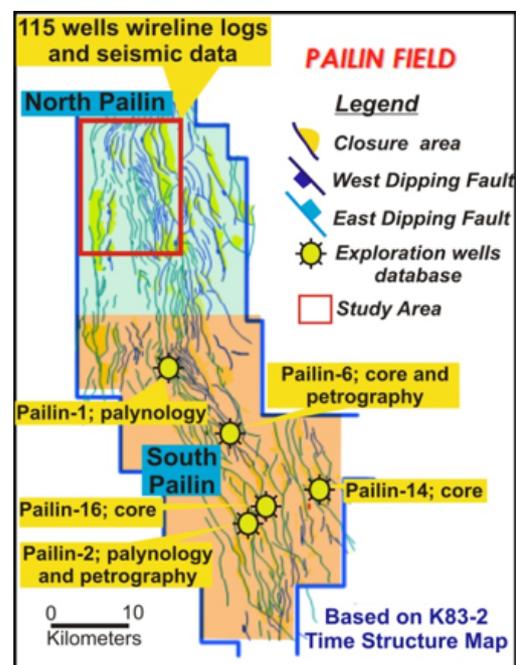
Figure 1 Study location and geological detail from the South Pailin applied to the North Pailin

intervals from Sequence 3. The quantitative palynological data through one "transgressive/regressive unit" show the lower part of the cycle represents the initial transgression of rising water levels across a deltaplain. The upper part of the cycle is characterized by the highest percentage of marine dinoflagellates and fluoramorphinite are the most reliable indicators for maximum

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transgression. Therefore, at and immediately above the maximum transgression surface within the low resistivity shale unit, the organic-rich horizon that occurs there could be a good event to use as marker.

Four of the sidewall cores from Pailin-06 and four of the sidewall cores from Pailin-02 well are from "low-resistivity shales" intervals were samples from the Sequence 3. Those are claystones and calcareous claystone that contain abundant pyrite and small calcareous foraminifera. Therefore, these rocks are similar and consistent with the palynology study in Pailin-1 well, and indicate restricted, marine-influenced facies, indicative of a large estuary or bay (Leffingwell, 1990; Trevena 1990a).

The average petrophysical properties of marine shale shows low resistivity, less than 2 ohm-m, high density (2.4-2.6 g/cc), moderate transit time (310-330 msec/M), moderate to high gamma ray value (170-250 API), and moderate neutron value (30 dec).

3.2 Non-marine coal

In Pailin-6 well, 82m of core was recovered from lowermost Sequence 3. The cored interval at 2,433 m-2,441 m recovered a 0.3m thick coal bed. It is both overlain and underlain by laminated clayey siltstone. The coal is interpreted to represent a lake-margin or bay-margin swamp (Trevena, 1994). Pailin-14 well 76 m cores were recovered in two cores from lower Sequence 3. The cored interval at 2,627 m-2,637 m shows that mudstone overlies coal or coaly mudstone, and probably represents a coastal

plain swamp as it contains likely marine foraminifera at 2,629.9 m, which indicates a likely marine influence in this area. Therefore, I interpret the organic-rich beds from Pailin-6 and Pailin-14 wells as conventional coal beds deposited on land near to a shoreline environment. That this unit is a thin coal is undeniable as it was recovered in cores from two wells and so can be related directly to its wireline character in Pailin Field.

The typical petrophysical properties for non-marine coal show low density values less than 2 g/cc, high transit time (340-380 msec/M), moderate gamma ray values (130-160 API) with low uranium content in the spectral log, high neutron values (40 dec), and variable resistivity (4-6 ohm-m). The inherent low uranium content of this type of organic-rich sediments supports an interpretation that this conventional coal was deposited in an area that had little or no marine influenced. So, I interpret this coal unit as freshwater swamp facies.

3.3 Mangrove coaly shale

Pailin-16 cores totaling 63.6 m were collected from Upper Sequence 2. The cored interval from 3,395 m-3,405 m recovered a variable 2 m thick coaly clayey siltstone to silty claystone, which was interpreted as a possible coastal swamp (Trevena, 1995). Therefore, this intersection of the coaly shale facies should provide reliable rock-based data that can be used to characterize coaly shale intervals in wireline logs.

The Pailin-2 well study provides some potentially useful biostratigraph-

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ic information gleaned from well ditch cuttings samples. Ballog (1992) defined five palynological "events" that document environment settings from coastal mangrove/back mangrove to fluvial, and possibly lacustrine, environments (Mountford, 1992). Therefore, these cutting analysis are similar and consistent with above Pailin-16 core study which indicates coastal swamp environment.
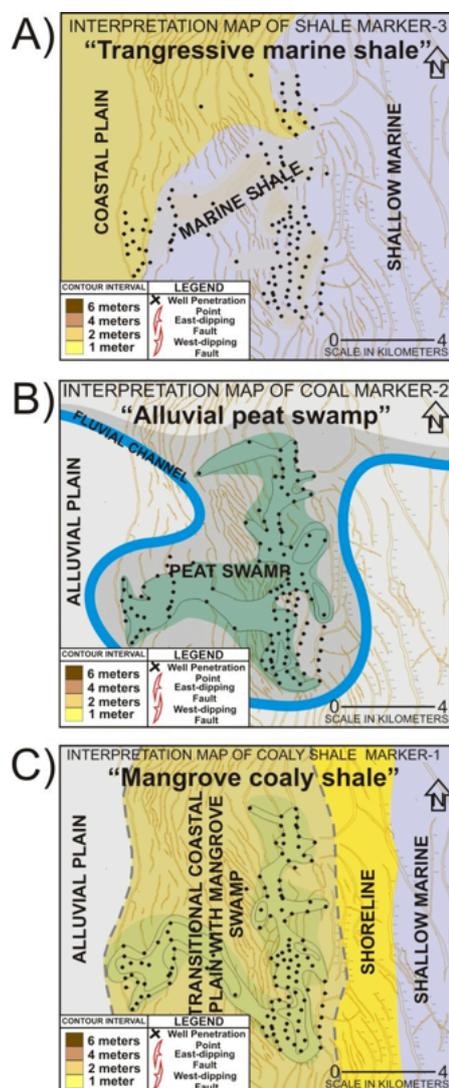
The average petrophysical properties of mangrove coaly shale shows very high gamma ray values (200-300 API) with high uranium content, low to moderate density (2-2.3 g/cc), high transit time (350-370 msec/M), high neutron values (40 dec), and variable resistivity (3-5 ohm-m). The typical high uranium content supports the idea that this coaly shale unit was deposited under the influence of marine waters in the continental-shallow marine transition zone. The concentration of uranium in seawater is 3 parts per billion (Emsley, 2001). And, as mangrove forests grow in brackish waters (Choy, 1994), I interpret this coaly shale unit as a mangrove coastal swamp facies which was filled by seawater.

4. Correlation and mapping

The distribution maps of the various organic-rich sedimentary markers were created based on wireline log correlations using the define property sets. Mapping of the distribution of the trangressive marine shale defines its consistent development in an overall transgressive setting and that it was deposited as a widespread unit. Mapping shows the distribution of the
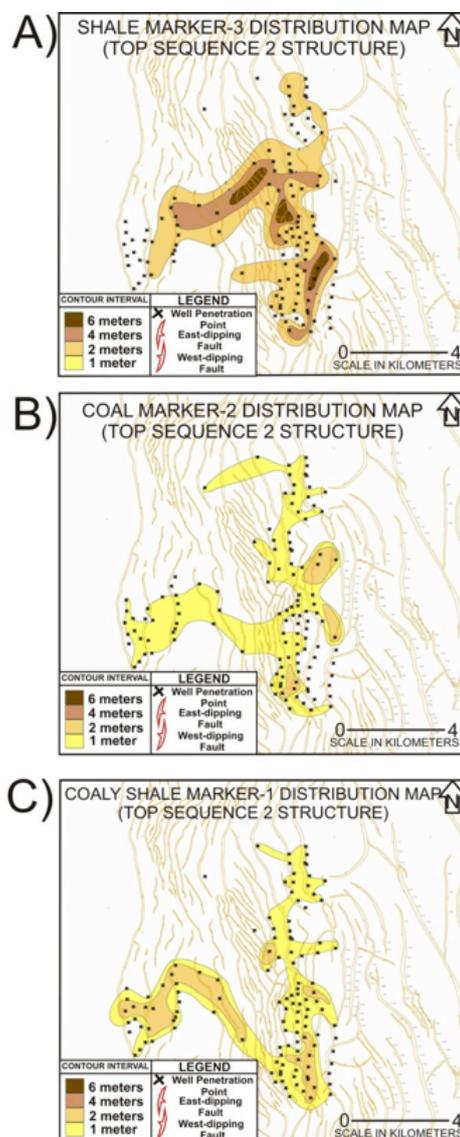
Figure 2 Distribution maps based on real data of A) Trangressive marine shale marker-3 B) Non-marine coal marker-2 and C) Mangrove coaly shale marker-1

non-marine coals and mangrove coaly shales are differently developed and distributed, compared to the trangressive marine shales. The overall degree of correlation is poorer (Figure 2).

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Figure 3 Interpretation maps of A) Trangressive marine shale B) Alluvial peat swamp and C) Mangrove coaly shale

5. Integration and Implication

The distribution of marine shale units may have implications with respect to: regional source facies distribution, widespread shales topseals, and reservoir facies with respect to the depositional cycles of the transgressive and regressive patterns in the associated marine shale units. The distribution of coal and coaly shale units may have implications with respect to: gas prone sediment distribution. Notably, seismic amplitude mapping is unreliable with exception of a tie back to coal marker-3 or the K-marker which corresponds to a major change in depositional association and acoustic properties. It is likely that small-scale delta front sand sheets and large fluvial reservoirs may have developed in intervals associated with coal development. Therefore, this study has improved our understanding of the distribution of trangressive marine shales, non-marine coals and mangrove coaly shales and using this new subdivision of organic-rich markers will facilitate the better prediction of source distributions and reservoir layering in future development planning (Figure 3).

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