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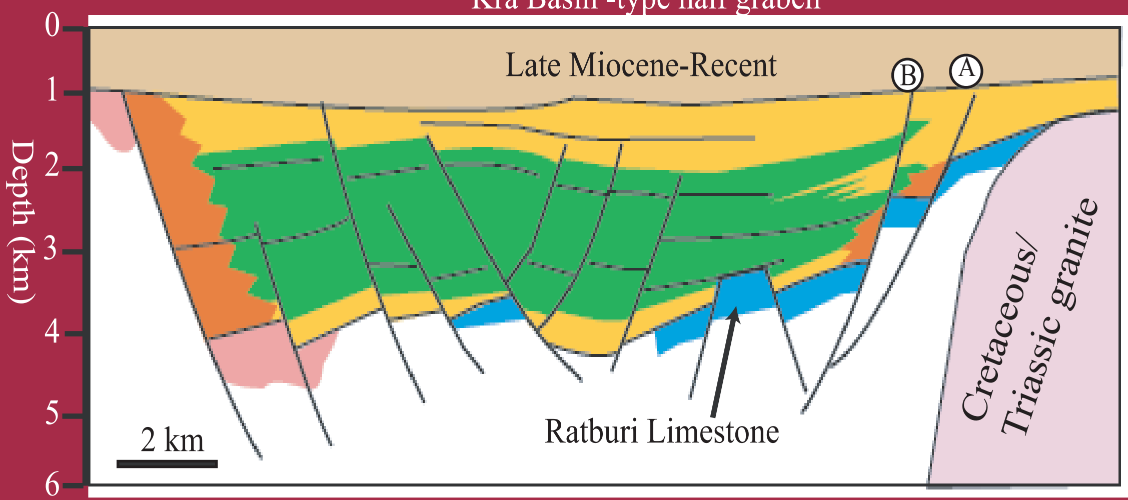

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Cover: A schematic model of the Kra Basin (page 3)

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Preface

The Bulletin of Earth Sciences of Thailand (BEST) has established itself as an international academic journal of the Geology Department, Chulalongkorn University (CU) since the year 2008. This Number 2 issue of Volume 3 is devoted specifically to the publications contributed by the International Petroleum Geoscience M.Sc. Program of the Geology Department, Faculty of Science, CU for the academic year 2009/2010. Certainly this Bulletin has attained more and more international recognition, not to mention the citation of publications in previous volumes, as can be seen from the contributions of 17 research papers by international students of the M.Sc. program. This program is an intensive one year curriculum that has been taught in the Geology Department of CU in the academic year 2009/2010 for the first year. These scientific papers were extracted from the students' independent studies which are compulsory for each individual student in the program. Because of the confidentiality reason of a number of contributions, the requirement of the Chulalongkorn Graduate School as well as time constraints of the program, only short scientific articles were able to release publicly and publish in this Bulletin.

Lastly, on behalf of the Department of Geology, CU, I would like to acknowledge the Department of Mineral Fuels, Ministry of Energy, Chevron Thailand Exploration and Production, Ltd, and the PTT Exploration and Production Public Co., Ltd., for providing full support for the Petroleum Geoscience Program and the publication cost of this issue. Sincere appreciation also goes to guest editors; Professors Joseph J. Lambiase, Ph.D., John K. Warren, Ph.D., and Philip Rowell, Ph.D., the full-time expat staff, for their contributions in editing all those papers. Deeply thanks also go to Associate Professor Montri Choowong, Ph.D., the current editor-in-chief, and the editorial board members of the BEST who complete this issue in a very short time. The administrative works contributed by Ms. Suphannee Vachirathienchai, Ms. Anamika Junsom and Mr. Thossaphol Ditsomboon are also acknowledged.

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Controls on Reservoir Quality in a Depositional Framework of Formation 2, South Bongkot Area, North Malay Basin, Gulf of Thailand

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Abstract

Greater Bongkot South (GBS) is part of Greater Bongkot Field (GBF), which is situated in the northern Malay Basin. The subsurface geology of GBF comprises a thick interval (6 km of Oligo-Miocene siliciclastic sediments) deposited in fluvial, delta plain to delta front environments of FM2. This study is focused on cored units in FM2 in the GBS area and to find that most potential reservoir sands in the Bongkot south area show significant evidence of tidal influence. Previous work argued that sands in whole Bongkot area accumulated in what were more fluvial-dominant settings. There is significant subsurface uncertainty in reservoir quality prediction due to variations in depositional environment in the GBS area. The outcome of this study is an improved understanding of factors controlling depositional environment, potential reservoir facies and reservoir quality. This was achieved by relogging relevant cores and integrating this new understanding with existing core data, core images, wireline logs, thin sections and other previous reports. In the FM2 sediments under study, the Tidal sand flat (TSF) facies contains the most significant and widespread grouping of potential reservoir sands. Internally in this grouping, porosity-permeability is variable due to differing proportions of laminated clay versus structural and dispersed clay. When this unit is defined by its gamma signature, there is strong overlap with other significant facies sets, ranging from consistently excellent reservoir sands of Tidal channel (TC) facies, at the upper end of the poroperm value range, to less economically-significant thin sands in the tidal flat (TF) and lower shoreface (LSF) facies associations, which mostly occupy the lower end of the poroperm range. The FMI log is a valuable subsurface wireline tool that, given the nature of sediments in the GBS area, could be used to quantitatively differentiate laminated clay from structural and dispersed clay, work so far has shown clay content is mostly controlled by depositional environment. An FMI log would be much more reliable than a Gamma ray log when defining electrofacies in log suites run in the dominantly muddy FM2 environments present in the GBS area.

Keywords: Bongkot field, Formation 2, Tidal environment, Tidal channel, Tidal sand flat

1. Introduction

The Bongkot Field is situated in the northern Malay Basin, Gulf of Thailand (figure 1) and comprises north, main and south Bongkot (GBS). The subsurface geology of Bongkot field comprises a thick interval (6 km of Oligo-Miocene siliciclastic sediments) deposited in fluvial, delta plain to delta front environments of FM2.

2. Methods

Six conventional core data from well in GBS area was used in combination with a reassessment of the core detail (via relogging) to interpret depositional environment. Gamma ray logs were used for lithology identification and to better tie inferred sand patterns to core intervals. Well plug data (porosity and permeability from laboratory core plug measurement) were used to identify potential reservoir interval

3. Results

A reassessment was done on conventional core from FM2 (which has 5 units, 2A, 2B, 2C, 2D and 2E from bottom to top) In this revised interpretation most sandier units show evidence of a tidal influence as in; Tidal channel, Tidal flat, Tidal sand flat, Tidal mud flat facies associations and they are interbedded with muddy lacustrine shale and Marine shale facies as well as with mixed tidal and wave influenced areas in the Lower shoreface and Marine shale faceis. Overall, the core from the 6 studied wells are interpreted as accumulating in a transitional depositional setting that centred on the upper tidal plain, coastal shoreline to shallow marine shelf systems.

The reclassification in this study uses a modification of Dott's (1964) classification. This gamma-aware classification shows the main rock types as; Lithic arenite, Sublithic arenite, Subarkosic arenite, and those samples with higher clay contents as; Lithic wacke - Arkosic wacke, Lithic wacke. The results better tie to environments with high clay contents (such as tidal-dominated settings).

The poroperm plot in figure 2 shows the range of reservoir potentials in the various lithofacies from all cored wells. Only the TC facies associations show a tightly clustered grouping of values that place it in the excellent potential reservoir class. The poorer reservoir quality of the Sandy lacustrine facies (2C unit), and the clay-rich end of the Tidal sand flat (2A unit) spectrum is thought to be due a combination of mechanical compaction and diagenetic alteration/ cementation. Overall, the variable reservoir quality within the Tidal sand flat facies (e.g. Unit 2E, 2D, 2C) and the sandy lower shoreface –lower shoreface (unit 2E) is due mainly to variations in laminar clay content which dominates over the levels of structural and dispersed clay in these wells. In contrast, the excellent reservoir quality in the Tidal channel facies (Unit 2E) is because the clay is present in this setting mostly as structural clay with much lower amounts of laminar and dispersed clay. Hence, its pore throats are mostly open and capable of transmitting fluids, so explaining its excellent levels of porosity and permeability.

The redefinition of exiting potential reservoir intervals shows that there is a diffuse grouping of sand-dominant clayey intervals that is indicated by gamma ray log values being not too low and not to high, yet these same intervals contain units of moderate to good reservoir quality. As a depositional association, the better reservoir quality units in this diffuse grouping are largely made up of the Tidal sand flat facies. But this is a grouping that has a variable volume of structural clay, dispersed clay and laminar clay. Using the gamma ray log to define it is difficult; its API range of values strongly overlaps with other depositional settings with much lower reservoir potential (e.g. tidal flat, lower shoreface, etc).

4. Discussions

This study shows that most sand distributions in the GBS area are related to tidal reworking, probably across a floodplain or tidal plain, in a possibly overall deltaic setting, and across the transitional zone to shallow marine setting.

Muds tend to be commonplace within a tidal environment and this is seen in the classification of sediments in the study area that uses the "clay-aware" sandstone classification scheme of Dott (1964).

The revised classification creates a set of "clay-aware" subdivision that is better related to API values of the sediments.

The most widespread potential reservoir in FM2 in the study area is probably the Tidal sand flat facies. It can be recognized in core from all the units from 2E -2A (except 2B). In terms of reservoir potential in this unit, the study of the various cores shows that the main concern is its variable content of mostly laminar clay, which can lead to poor vertical continuity. Another problem is that the more clay-rich intervals in the TSF can appear quite similar in quality to the sandy lower shoreface –lower shoreface sand as in Unit 2E. Without core to separate the two settings (based on associations of indicator sedimentary structures), it is impossible to breakout the two styles using their API values.

In conventional wireline log suites (as collected in the studied wells) the, gamma ray log is most important lithology indicator. But, in the dominantly muddy environment (tidal environment) of the GBS area, it is difficult to use it to reliably define facies and so have an indirect indicator of reservoir quality. In such a muddy setting, the FMI log is a valuable log, it greatly improves the reliability of a remote-sensed sedimentological interpretation, as it can identify laminar clay down to the centimeter scale. It cannot identify dispersed clay and structural clay, but it can identify distribution of clay layers and redistribution via burrowing (Prosser *et al.*, 1999). Tidal channel and tidal sand flat associations can be recognized and differentiated as facies using the FMI log. At this stage of our geological understanding, the most important advantage of running an FMI log is to help reliably differentiate within a number of facies those sandier intervals with reservoir potential.

5. Conclusion

(a) The core-based reinterpretation of depositional settings in the GBS area shows they accumulated under a stronger tidal influence than previous recognized. It is likely that the sands in the GBS area were deposited in a more marineward position where tidal influence was more important compared to the updip fluvial-dominated sands of the GBN area.

(b) The revised classification creates a set of “clay-aware” subdivisions that are better related to API values of the sediments and so better outline mud-dominant environment (which are commonplace in tidal settings).

(c) Main factor controlling reservoir quality is clay distribution. Tidal sand flat is most widespread facies association with reservoir potential but its high variation in porosity and permeability can be a problem and is due to development of zones with more depositional clay.

(d) In variable but muddy environments, it is difficult to use the gamma ray tool because a number of depositional associations should a range of poroperm values (log reads broad variations in radiogenic clay content).

(e) FMI log can identify laminar clay beds and other sedimentary structure down to the sub-centimeter scale, but cannot identify dispersed clay and structural clay. Its use is recommended in future wells.

6. Acknowledgements

The author would like to thank the PTTEP Company and staff for the fully support the data. PTTEP staff especially Denkey Thatchachawalit, Kanjana Krisadasima, Jintasak Na ubol and Patchada Chatsakulkanachan who have provided valuable support and illuminating technical discussion. Thanks also to my thesis supervisor, Professor John K. Warren.

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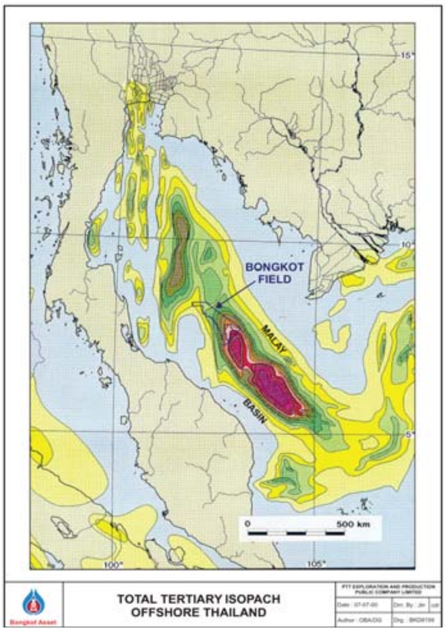
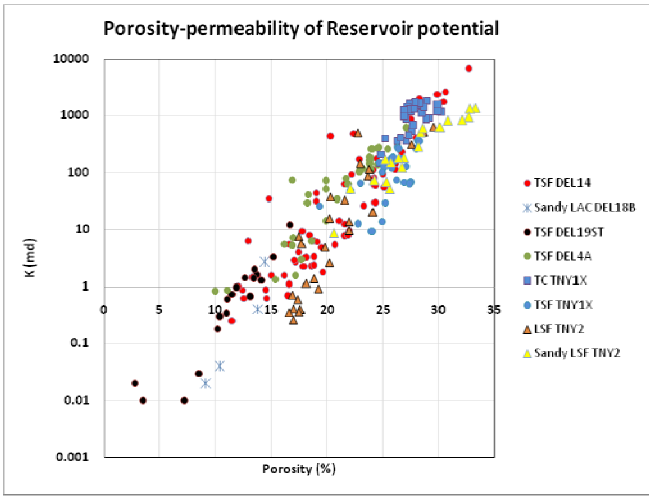


Figure 1. Location map of the study area, which lies in the northern part of the Tertiary North Malay Basin.



Figures 2. Porosity and permeability plot showing reservoir potential of all facies.

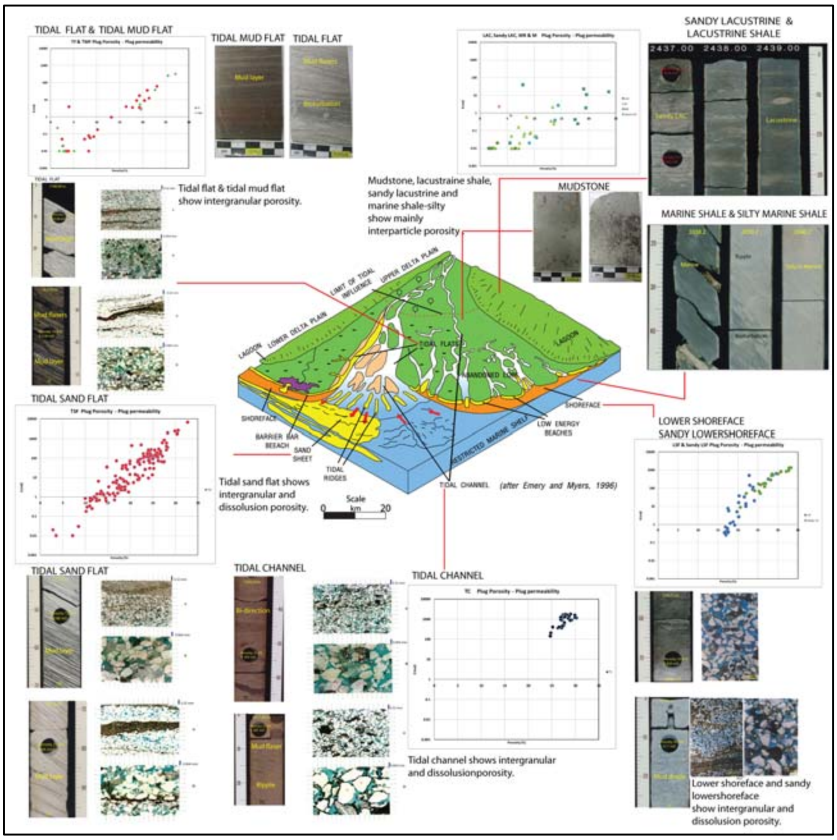


Figure 3. Summary of depositional environment related to rock property data, showing poroperm plots, representative core photos tied to facies with typical clay distributions shown in with thin section photomicrographs (after Emery and Myers, 1996). North and main Bongkot is the fluvio-deltaic environment related to facies such as distributary channel, splays, deltaic bar, all facies can tie to upper delta plain (above dash-red line limit of tidal influence). For the depositional of Bongkot area is deltaic system, the North and main Bongkot is upper delta plain- less influence of tidal, fluvial dominant and GBS is lower delta plain – tidal dominant influence, which relate to different reservoir quality based on clay distribution and depositional environment.