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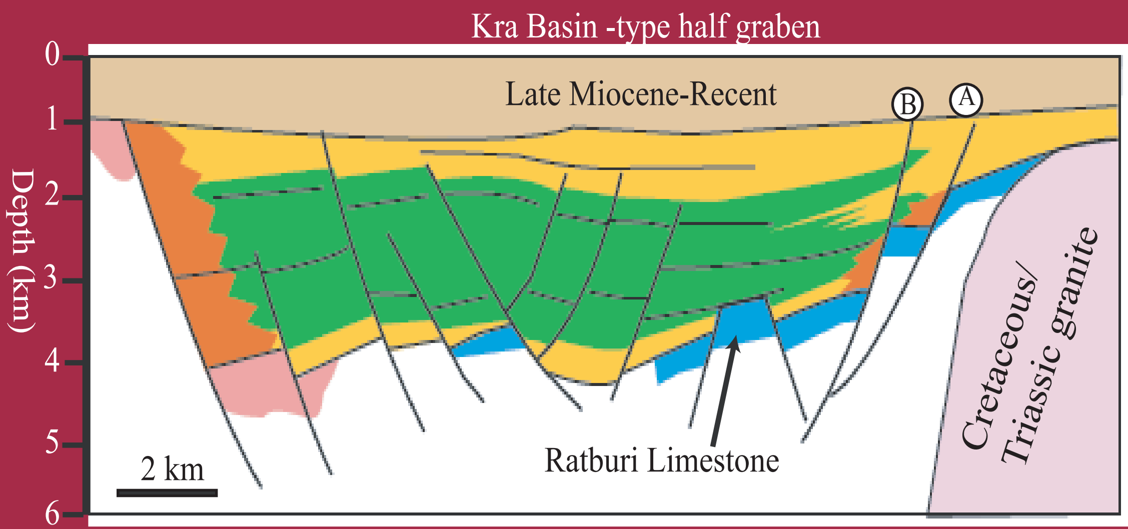

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Cover: A schematic model of the Kra Basin (page 3)

Editorial office:
Department of Geology, Faculty of Science, Chulalongkorn University, Phrayathai Road., Bangkok 10330, THAILAND.
Telephone: 66-2-218-5445, 218-5442-3 Fax: 66-2-218-5464
Website: http://www.geo.sc.chula.ac.th/geonew/Page/BESTjournal.php Editor Email: monkeng@hotmail.com

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.

Associate Professor Visut Pisutha-Arnond, Ph.D.
Head of the Geology Department
August 2010

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The Relationship between Seismic Amplitude, Lithology and Hydrocarbons in Southern RIP Block, Gulf of Thailand

Piyawan Sukitprapanon*

Petroleum Geoscience Program, Department of Geology, Faculty of Science,
Chulalongkorn University, Bangkok 10330, Thailand

*Author email: piyawans_geol@hotmail.com

Abstract

The variation of seismic amplitude with offset in the gas fields of the southern RIP block is the key to detecting gas reservoirs. This research analysed well log data in an attempt to interpret relationship between rock properties and acoustic impedance and to construct AVO models. The objective was to study sand properties and predict potential AVO classification. Well log data from the CB05S, PK11 and PM08 wells suggest that sands in this area are low impedance and can be separated from the shale trend. Hampson-Russell AVO modelling was applied to synthetic seismograms using Aki-Richards equation to study amplitude variations with offset in term of interception and gradient relationship at top sands. The potential AVO responses showed low impedance sands in class III and IV. The angle stack seismic data was used to study seismic amplitude variation with offset in Near versus Mid stack seismic crossplots. Top gas and brine sand picks are negative amplitude in Near and Mid stacks (quadrant III) but cannot separate gas from wet sands. Base sands are quadrant I. This top sand crossplot was employed to detect sands in stacked seismic volumes and is useful tool for displaying lateral extent of sand body. Analysis failed to link seismic amplitude observations to AVO modelling because of the combined effects of seismic related issues, fault plane interference and pore fluid type uncertainty of sand. Seismic data have limited vertical resolution in this thin-bedded sand environment and seismic processing operations during stack affect accurate AVO analysis.

Keywords: AVO analysis, Angle stacks, Synthetic gathers

1. Introduction

Seismic and well log data in the Southern RIP block, Gulf of Thailand was used for this study. The main objective of this research was to study the relationship between seismic amplitudes and AVO observations and the physical rock properties and reservoir characteristics of the pay sands in the area.

2. Methods

The well log data, petrophysical rock properties of three exploration wells and angle stack seismic data was used in this study.

From well log data, crossplots of rock properties and acoustic impedance (AI) with petrophysical properties as a colour attribute were used to study the association of rock properties, rock physics and AI. Next, the synthetic gathers generated by Aki-Richards equation using Hampson-Russell software were utilized to predict AVO classification (Castagna *et al*., 1998) at top sand.

From 3D stack seismic, seismic amplitudes of individual sands in Near and Mid stack seismic datasets were used to study AVO response by using Near versus Mid stack amplitude crossplots. AVO responses in these crossplots were applied to detect potential sands in seismic volume.

3. Results

3.1 Relationship of rock properties and rock physics using well log data

Lithology trends were displayed in rock physical properties (V_p, V_s, ρ, V_p/V_s and σ) versus AI crossplots with clay volume as a colour attribute. Sands have lower density, V_p/V_s and σ than shale. Individually, V_p and V_s cannot distinguish rock type but plotted against AI sand can be discriminated from shale. (Figure 1).

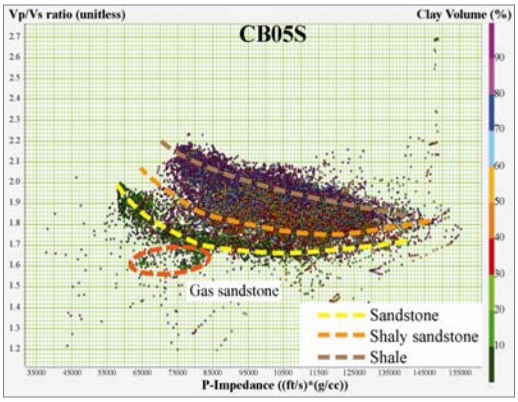

Figure 1. Crossplot of AI versus V_p /V_s colored by clay volume from the CB05S well showing separation of three lithology trends.

In the same way, crossplots were made using porosity as a colour attribute. These showed that porosity relates directly to Vp/Vs and σ and reversely to V_p, V_s and ρ.

In similar analysis it was shown that S_w affects V_s, V_p/V_s and ρ. High hydrocarbon content sands show decreasing Vp/Vs and σ and increasing V_s.In general, AI is lower in sand and decreases in high porosity brine and gas sands.

3.2 AVO modeling using well log data

The well log data were used to generate synthetic gathers from 0 to 35 degree angle offset. Top and base sand amplitude of synthetic gathers were employed to get intercept (I) and gradient (G) values for each sand. These two values were used to do crossplots and to classify AVO response. Top and base of gas and brine sands were plotted and showed predominantly class III and IV AVO responses (Figure 2).

Brine sands were classified as soft rock but some show AVO response with low hydrocarbon content. AVO responses represent low impedance sands.

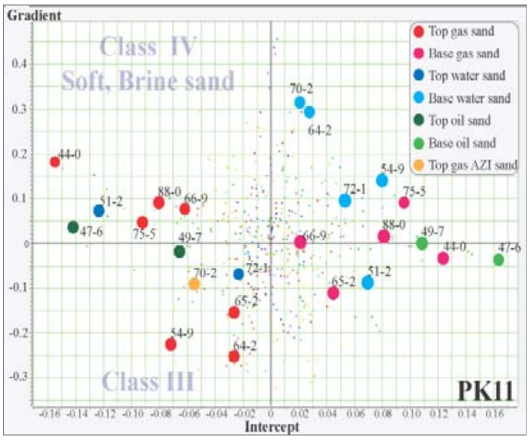

Figure 2. Summary of intercept versus gradient crossplot of sands in the PK11 well.

3.3 AVO attribute analysis using 3D seismic data

Top gas and brine sands were picked individually in Near (5-22 degree) and Mid (18-35 degree) stack seismic volumes. Top sands match with trough seismic amplitude. Top sand amplitudes were plotted in Near versus Mid stack amplitude crossplots. Gas and brine sands plotted in Quadrant III which is negative amplitude on both Near and Mid stack seismic data, but they show a scattered trend in these crossplots. However, most gas and wet sands show decrease in amplitude with offset. These crossplots cannot separate gas and wet sand but potential sands are characterized with the top sand in Quadrant III and the base sand of opposite amplitude located in Quadrant I. The characterization of sand amplitudes in this way was applied to seismic volumes (Figure 3a) to point out extent of sands in seismic section (Figure 3b).

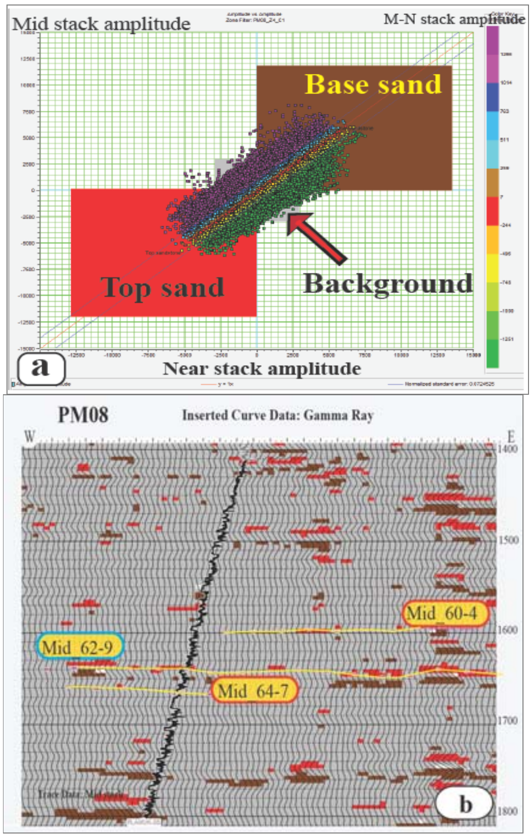

Figure 3. (a) Characterization of top and base sand amplitudes in Near versus Mid stack crossplot. (b) Top sand picks in the PM08 well. Top and base sands coloured red and brown, respectively.

4. Discussions

Seismic reflection amplitudes are influenced by the contrast of AI at rock layer interfaces. As well, seismic amplitudes vary with incident angle and this attribute is used to study AVO characteristics

The well log data crossplots show lithology discrimination in ρ, Vp/Vs and σ. Individually Vp and Vs cannot differentiate lithology trends but plotted with AI can show low impedance sand trends because this trend is affected from ρ in the AI equation. High porosity sands show low Vp, Vs, density and AI and high Vp/Vs and σ. Gas sands show low Vs, Vp/Vs and σ and low AI. From these results, high porosity sand overlain by shale shows high negative seismic amplitude because of AI differential. Gas and brine sands have AI overlap.

The result of the synthetic gathers constructed along well paths show AVO responses in the class III and IV range in gas and low hydrocarbon content sands, typical of low impedance sands.

The real seismic data shows that the top sands in the Near versus Mid stack crossplots cannot distinguish gas and brine sands but they are still shown as low impedance sands (Quadrant III). Top sand amplitudes generally decrease with offset (class IV) which conflicts with AVO modeling. The real seismic data has a lot of limitations that create errors in seismic amplitude. Analysis showed that vertical tuning thickness is larger than sand thickness in this area which affects seismic amplitude responses.

5. Conclusions

The objective of this study was to observe the relationships between seismic amplitudes and AVO response and the physical rock properties and reservoir characteristics. It concluded that:

(a) Well log data shows sands have low AI and porosity and gas content affects their AI value.

(b) The synthetic gathers show low impedance sands have class III and IV AVO response.

(c) Crossplots of Near and Mid stack seismic data shows seismic amplitudes of sands plot in Quadrant III. Gas and brine sands cannot be separated in these crossplots.

(d) Amplitudes of seismic data have some errors because sand thickness is generally less than critical tuning thickness.

Also, seismic amplitudes are affected by seismic processing.

(e) Seismic amplitudes are also affected by poor fault zone imaging and variation of fluid types in the sand bodies.

6. Acknowledgements

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7. References

Castagna, J. P., Swan, H. S., Foster, D. L., and Peddy, C. A. 1998. Framework for AVO gradient and intercept interpretation. *Geophysics* 63: 948-956.