Science & Technology Development Journal – Engineering and Technology, 4(SI3):SI177-SI183

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Research Article

Applying seismic attributes on finding the petroleum potential of stratigraphic traps in upper oligocene "C", blocks 09-1,09-2/09, center of Cuu Long Basin

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ABSTRACT

The article focuses on applying conventional seismic structural interpretation and seismic attributes in conjunction with supportive surrounding well logs to qualitatively find out any indication of sand stratigraphically trapped in Oligocene ``C'' sediment, the center part of Cuu Long basin where the studied area, a mono-cline structure, has been considered as one of the main depo-center which has a dominant potential of source rocks rather than reservoirs. The conventional attributes show an elongate abnormal zone developing North-South in the studied area. Detailed interpretation and surface attributes application at reservoir scale showing a clearer image of the sand and shale distribution qualitatively, two main sand bodies have been captured from the impedance surface attributes and shale distributions are also roughly generated. Within this paper, the authors only expect to predict the distribution of the sand bodies in Oligocene ``C'' sediment that could open new opportunities of attracting more exploration effort on stratigraphic traps then discoveries in exist in the slope of Oligocene ``C'' sequences at the blocks 09-1,09-2/09 center part of Cuu Long basin. Despite recent years, more hydrocarbon accumulations have increasingly been discovered in the target, but to reveal the full potential of stratigraphic traps, further studies need to be carried out to quantitatively evaluate the oil and gas potential of these stratigraphic/ combination traps. However, many uncertainties related to the petroleum system need to be analyzed to minimize the risk before turned into other further costly exploration activities. And at least the study could narrow down the studied area and attract more attention to exploration efforts in the future. Further quantitative interpretation efforts on the hydrocarbon detection, sealing capacity of these traps need to be invested in order to increase the success probability of the targets for the proper exploration and/or appraisal plan of stratigraphic traps in the future.

Key words: stratigraphic trap, sand bodies, seismic attributes, oil and gas potential

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History

- Received: 02/6/2021
- Accepted: 14/9/2021
- Published: 05/11/2021

DOI : 10.32508/stdjet.v4i3.853

INTRODUCTION

Following the Cuu Long basin (CLB) source rock potential calculation, 3.3 billion tons of oil equivalence has been emitted [1]. Meanwhile, the hydrocarbon initial in place (HCIIP) estimated, in conventional plays such as pre-Tertiary fractured basement highs and Cenozoic structural traps, about 2.1 billion tons of oil equivalence, contains 64% of the total.The remaining HCIIP (1.2 billion ton of oil equivalence) has been bearing in other types of collectors [2].

As the exploration & production in conventional plays in CLB has been getting mature over a few decades, the remaining targets of the same type do not have sufficient reserves for development and production. Exploration activities in CLB, therefore, are shifting towards more complicating types of plays such as stratigraphic traps and combination traps.

Most of the stratigraphic traps are related to lithology & facies change through the marginal slope. The most challenging elements of the plays are reservoir (distribution & quality) and sealing capacity. In order to overcome such difficulties seismic attribute analysis in accompanied with well logs interpretation is necessary.

Besides the mature of traditional targets, several discoveries in stratigraphic/combination traps have been found, some of them recently are producing encouraging up the geoscientist in exploring such unconventional plays. And it now has been considered as secondary targets of exploration activities. In a company with that, the demand for different risk assessments needs to be paid more attention.

Upper Oligocene "C" sediment in the studied area is in one of the deepest areas of the basin which was interpreted to merely deposited shale and another small

Cite this article : Tran X V, Nguyen B K, Truong T Q, Nguyen K X, Nguyen T, Vu T. **Applying seismic attributes on finding the petroleum potential of stratigraphic traps in upper oligocene "C", blocks 09-1,09-2/09, center of Cuu Long Basin**. *Sci. Tech. Dev. J. – Engineering and Technology;* 4(SI3):SI177-SI183.

& fine-grain sediment in low energy depositional environment. The petroleum potential, therefore, was rich in source rock and poor in reservoir rock[3], consequently the effort of exploration activities and research was low too.

Structure of Oligocene "C" is a mono-cline, during the fluctuation of sea water level changes, the lithofacies should be changed accordingly, the pinchout and/or other stratigraphic plays could have chances to be formed. Basing on that, this article is targeting to reservoir distribution qualitatively from mainly seismic data due to no well was drilled through such plays in the area before.

MATERIALS

The studied area is limited vertically within upper Oligocene "C" sediments and laterally among blocks: 15-2/05, 16-1, 09-1 & 09-2/09 (Figure 1).

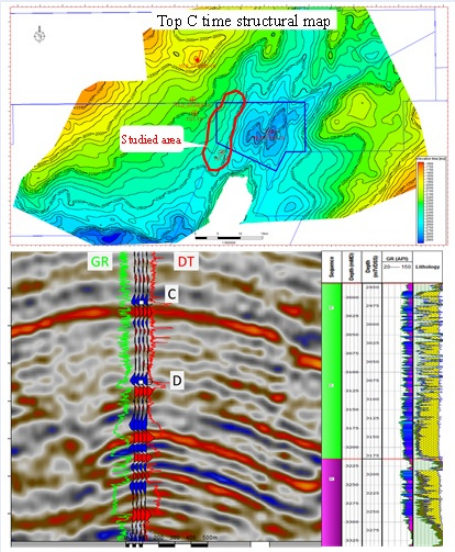

Figure 1: Studied area & materials

Only seismic data exists as digital data in the area, the study has to use 01 adjacent well data (well A) to geologically guide on seismic research (Figure 1). Other regional geologic information is also referred to, specially CLB stratigraphic column (Figure 2).

METHODOLOGY

Conventional seismic structural interpretation in conjunction with seismic attributes has been applied to reveal the sand distribution in the area.

General structural information

A seismic section from West to East cross TGT field and Hai Cau structure showing a mono-cline trend,

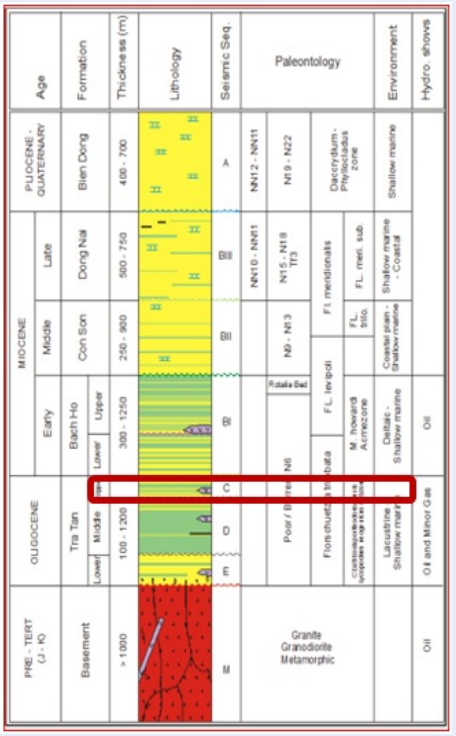

Figure 2: General stratigraphic column CLB

tilting gradually from continent to paralic and deep water. Top C structural and time thickness maps also support the depo-center is deepening to the East. Onlap terminations have been observed which initially shows the indication of sediment source predicted is from West to East. Seismic reflection internal structure (amplitude & continuity) gradually changes from dim amplitude and low continuity in the western side to brighter and higher one in the eastern side (Figure 3).

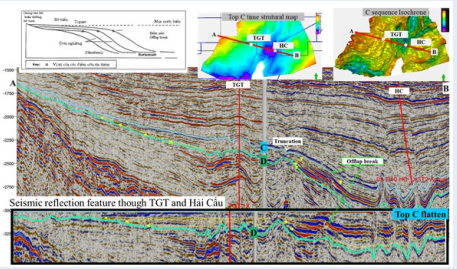

Figure 3: A sequence set of Oligocene "C" on the seismic section crosses the center part of CLB.

Sand definition on seismic

One basic and very important step of structural seismic interpretation is correlated seismic data to well data. The meaning of that is integrating geologic information from well log into seismic data, by that the non-reservoirs & reservoirs could be defined on seismic evens. The petrophysical interpretation has been done in order to define whether sand and shale on log data (Figure 4).

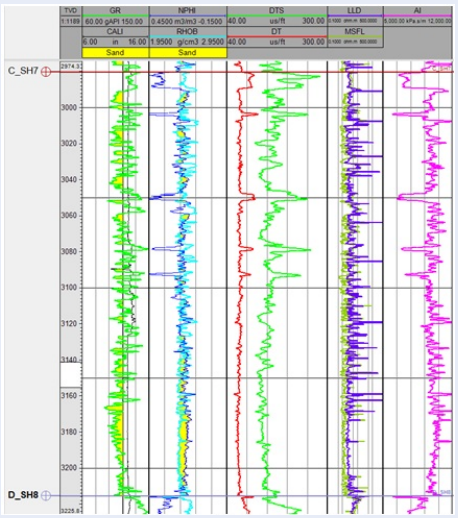

Figure 4: Sand & shale definition on log data

Then seismic well tie process has been applied, showing a good match between well log synthetic and actual seismic data. Top of shale layer (non-reservoir) responds as a trough (negative amplitude) and top of sand layer (reservoir) responds as a peak (positive amplitude) (Figure 5).

The correlation in the impedance domain, where the seismic is more geologic friendly than in the reflectivity domain (Figure 6)[4]. The relative acoustic impedance attribute was used to converting seismic into the impedance domain (Figure 7). Top sand is defined as zero-crossing from negative to positive (zero-crossing S) and bottom sand is zero-crossing from positive to negative (zero-crossing Z).

Surgical mapping

Top and base of sand defined at well location then interpreted spreading to the whole seismic impedance cube. Three pairs of top and base of sand have been captured within Oligocene "C" sequence, they are top base sand01, 02, and 03. Three shale layers also mapped, they are top shale01 -top sand01 (shale01); base sand01- top sand02 (shale02); base sand02-top sand03 (shale03) (Figure 8).

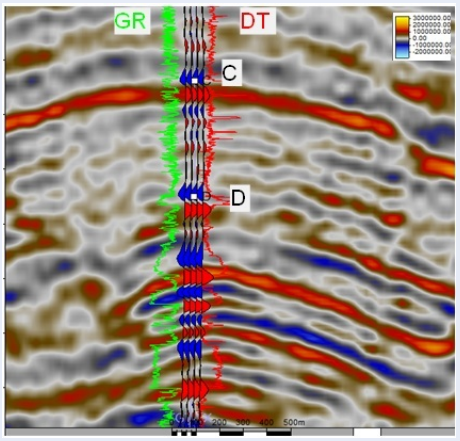

Figure 5: Synthetic & seismic correlation, a good match has been captured. Top shale responses as a negative amplitude (blue), meanwhile top sand as in positive (red).

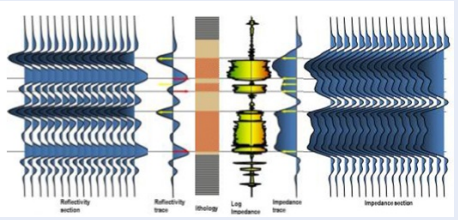

Figure 6: Seismic forwarding model. Reflectivity section derived from the convolution of wavelet with reflectivity series (left). Impedance section is the result of convolution of wavelet with impedance log (right). The seismic impedance obviously looks more geologic than reflectivity.

Seismic attributes

Several conventional seismic attributes were applied, such as spectral decomposition, RMS amplitude, instantaneous amplitude/reflection strength/envelop. They are all the recommended attributes to detect litho-fluid spots qualitatively (Figures 9, 10, 11 and 12).

Surface seismic attributes applied are average negative amplitude for prediction of sand distribution and average positive amplitude for shale distribution on the lithology elastic impedance cube (Chi angle = 170^o)[4]. The window limited from top to bottom of each layer (sand or shale) is illustrated respectively in Figures 13 and 14.

RESULTS AND DISCUSSIONS

The good matching between log data (synthetic seismogram) and seismic data giving high confidence of

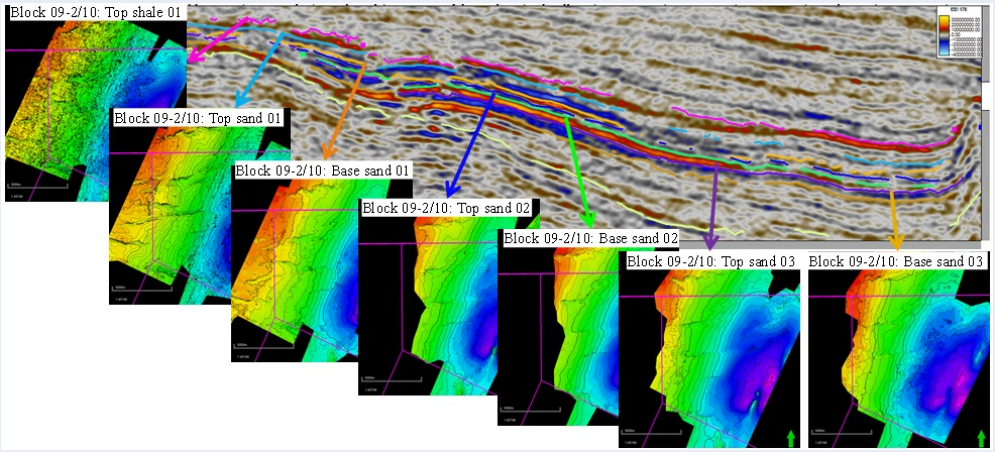

Figure 8: Seven structural maps are interpreted to detail the dominant sand and shale intervals of which 03 shale layers and 03 sand layers intercalated. They are then used to generate seismic attributes in order to detect the distribution of sand

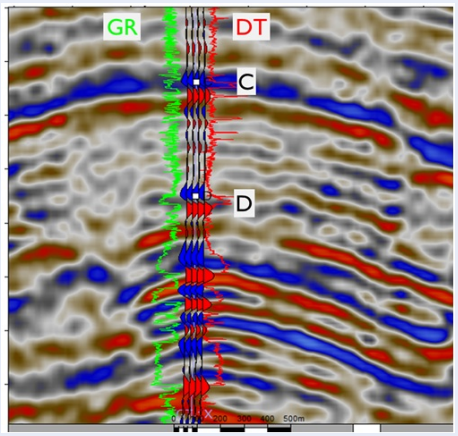

Figure 7: Synthetic & seismic correlation in impedance domain, overlay with GR & DT logs. Top and bottom of layer now respond at zero-crossing (S or Z) of the even.

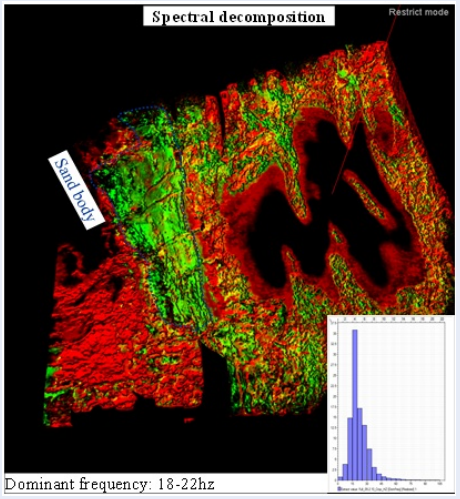

Figure 9: Spectral decomposition nominates the frequency range of 18-22hz[5]. An abnormal amplitude trend easily observed which elongate extends to the strike of the mono-cline.

sand/shale definition on seismic data.

From the structural maps, it is obvious that the studied area lies on the margin slope with no indication of structural closure. There are several faulting activities cut through the "C" sequence seen on both vertical sections and maps (Figure 8).

Conventional attributes show an elongate abnormal zone developing North South in the studied area, especialy in blocks 09-1, 09-2/09 (Figures 9, 10, 11 and 12). A detailed interpretation and surface attributes application at reservoir scale showing a clearer image of the sand and sand distribution qualitatively. There are two main sand bodies have been captured from the impedance surface attributes (Figure 13). Shale distributions are also roughly generated (Figure 14). Quantitative effort need to put on to improve the result confidence.

The abnormal seismic amplitude trends, which are predicted as sand bodies, initially reveal one of five elements in the petroleum system, which is one reservoir present. Qualitatively, there is a high potential of sand at studied area. However, many uncertainties related to the petroleum system need to be analyzed to minimize the risk before turned into other

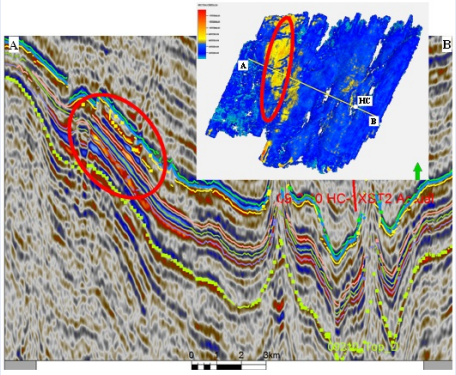

Figure 10: Average positive amplitude[6] surface attribute from top "C" to base "C". An abnormal amplitude trend is also recognized.

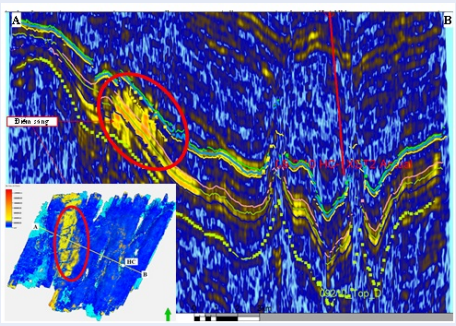

Figure 11: Reflection strength/instantaneous amplitude/ envelop cube and surface attributes to define bright & dim spots. High amplitude is normally related to lithology change or hydrocarbon accumulation[6].

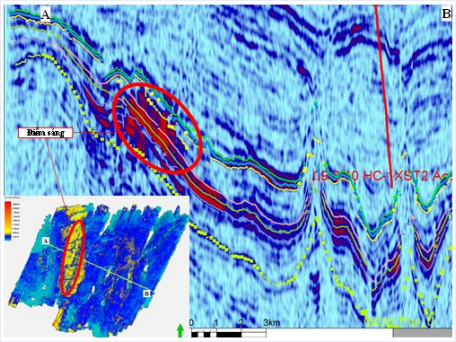

Figure 12: RMS amplitude cube[6] and total amplitude surface attribute of the whole C sequence, an abnormal amplitude trend is also recognized.

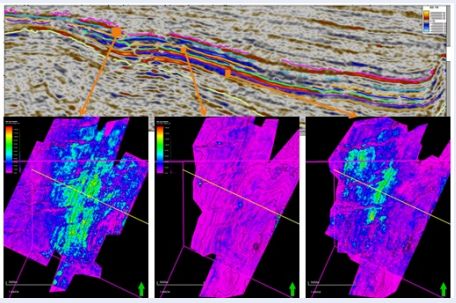

Figure 13: Average amplitude surface attribute showing sand distribution predictions of sand 01, 02 & 03.

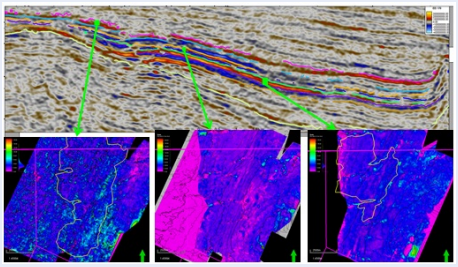

Figure 14: Surface attribute showing shale distribution predictions' shale 01, 02 & 03

further costly exploration activities. And at least the study could narrow down the studied area and attract more attention to exploration effort in the future.

CONCLUSIONS

The statement concluded from the study results as following:

Existing of abnormal seismic amplitudes which are predicted as the sand bodies, lying conformally on the mone-cline structural base of Oligocene "C". The stratigraphic traps then could be considered to exist in the slope of Oligocene "C" sequences at the blocks 09-1, 09-2/09, center of Cuu Long basin.

Further quantitative interpretation efforts on the hydrocarbon detection, sealing capacity of these traps need to be invested in order to increase the certainties of the object for the proper exploration and/or appraisal plan of stratigraphic traps in the future.

ACKNOWLEDGMENT

The authors would like to thank you to PetroVietnam, PetroVietnam Exploration Production Corporation, Hoang Long JOC, VietsovPetro for the support and permission to publish this work. To the technical assistance and comments for this manuscript from

PetroVietnam Domestic Exploration Production Operating Company and Ho Chi Minh City University of Technology are greatly acknowledged and appreciated.

This research is funded by Vietnam National University Ho Chi Minh City (VNU-HCM) under grant number **C2020-20-26.**

CONFLICT INTEREST

I'm the main author of the manuscript publicing the research results: "Applying Seismic Attributes on Finding the Petroleum Potential of Stratigraphic Traps in Upper Oligocene "C", blocks 09-1,09-2/09, Center of Cuu Long Basin". I hereby undertake the following:

• I and my co-authors of this manuscript have permission from the Sponsor and the Project Manager to use and publish the research results.

• All authors named in the article have read the manuscript, agreed to the order of authorship, and agreed to submit the article to the journal STDJET.

• This work does not have any conflicts of interest between the authors in the article and with other authors.

AUTHORS' CONTRIBUTION

• Xuan Tran Van: Lead author of the manuscript, who drafted the paper, designed the study, and performed the basic and statistical analysis.

• Binh Kieu Nguyen: Participates in research design and implementation, interprets data, collects data, and performs fundamental and statistical analysis.

• Thanh Quoc Truong: Involved in the design and implementation Research, analyze, interpret data, collect facts, and perform fundamental and statistical analysis.

• Kha Nguyen Xuan: Contributed to data interpretation and data collection, and checked the article.

• Tuan Nguyen: Involved in the design and implementation Research, analyze, interpret data, collect facts, and perform fundamental and statistical analysis.

• Vu Truong: Participated in editing the manuscript, advising the research process since the work just started.

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Tạp chí Phát triển Khoa học và Công nghệ – Engineering and Technology, 4(SI3):SI177-SI183

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Bài Nghiên cứu

Ứng dụng thuộc tính địa chấn phát hiện tiềm năng dầu khí bẫy địa tầng trong trầm tích Oligoxen "C" lô 09-1, 09-2/09, trung tâm bể Cửu Long

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TÓM TẮT

Bài báo tập trung trình bày ứng dụng kết hợp minh giải địa chất cấu trúc truyền thống và thuộc tính địa chấn với tài liệu địa vật lý giếng khoan nhằm tìm kiếm định lượng biểu hiện bẫy chứa dầu khí dạng địa tầng trong tập "C" trầm tích Oligoxen, trung tâm bể Cửu long, vùng cấu trúc sườn đơn nghiêng, khu vực được cho là đá mẹ chiếm ưu thế hơn là vỉa chứa. Kết quả nghiên cứu thuộc tính truyền thống cho thấy đới dị thường kéo dài phát triển theo hướng Bắc Nam khu vực nghiên cứu. Việc minh giải chi tiết và áp dụng thuộc tính địa chấn bề mặt với cấp độ vỉa chứa đã cho thấy hình ảnh định lượng rõ nét của thân cát và tập sét, cụ thể bằng thuộc tính địa chấn trở kháng bề mặt đã phát hiện hai thân cát và một tập sét. Việc dự báo thành công đặc trưng phân bố của tập cát Oligoxen "C" mở ra triển vọng cho nỗ lực thăm dò với bẫy địa tầng nhằm mở ra cơ hội tăng cường thu hút hoạt động tìm kiếm trong bẫy địa tầng của các phát hiện tại cánh sườn dốc của tập "C" trầm tích Oligoxen lô 09-1, 09-2/09 trung tâm bể Cửu Long. Cho đến nay, mặc dù nhiều tích tụ dầu khí được phát hiện trong đối tượng này, nhưng để thực sự làm sáng tỏ tiềm năng của bẫy địa tầng cần bổ sung nghiên cứu nhằm đánh giá định tính tiềm năng dầu khí trong cả cơ chế bẫy địa tầng và hỗn hợp. Tuy nhiên, nhiều yếu tố không chắc chắn liên quan đến hệ thống dầu khí cần được lý giải để giảm thiểu rủi ro trước khi chuyển sang các hoạt động thăm dò kế tiếp với chi phí tốn kém. Cuối cùng công trình này cho phép thu hẹp phạm vi nghiên cứu và thu hút quan tâm nỗ lực thăm dò trong thời gian tới. Các nỗ lực minh giải định lượng về khả năng phát hiện dầu khí, khả năng chắn của cơ chế bẫy này cần được đầu tư nghiên cứu để tăng xác suất thành công của đối tượng đảm bảo hoạch định thăm dò và thẩm lượng bẫy chứa địa tầng một cách phù hợp.

Từ khoá: Bẫy địa tầng, thân cát, thuộc tính địa chấn, tiềm năng dầu khí

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Lịch sử

- Ngày nhận: 02/6/20201
- Ngày chấp nhận: 14/9/20201
- Ngày đăng: 05/11/20201

DOI : 10.32508/stdjet.v4i3.853

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Trích dẫn bài báo này: Xuân T V, Bình K N, Thanh T Q, Khá N X, Tuấn N, Vũ T. **Ứng dụng thuộc tính địa chấn phát hiện tiềm năng dầu khí bẫy địa tầng trong trầm tích Oligoxen "C" lô 09-1, 09-2/09, trung tâm bể Cửu Long**. *Sci. Tech. Dev. J. - Eng. Tech.;* 4(SI3):SI177-SI183.