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Identifying Fluid Contacts In Stratigraphic Trap Through Seismic Forward Modeling; A Case Study

PK chaudhuri, NK Khatri**, V RangaChari***

GEPOIC ,ONGC, , Dehradun, India

Summary

Mehsana tectonic block located in the western Indian state of Gujarat is a fairly well explored, productive block of North Cambay Basin. Exploitation in Mehsana block has attained a mature stage. Large sized pools are in Kalol Formation occurring at shallower depths in structural plays and operate under water drive while small sized pools are concentrated at deeper depths in Mehsana and Mandhali Members of Kadi Formation controlled by strati-structural entrapment operating under depletion drive. The problems in these reservoirs are of contrasting nature.

Introduction

It has been endeavor of industry to minimize the drilling of dry holes. As drilling in offshore is much costly affairs, it becomes all the way more necessary to make use of Direct Hydrocarbon Indicator (DHI) tools to minimize the failures. Customizing seismic and other geophysical data for studying them as DHI is minor fraction of drilling cost and helps in delineation and development of fields. The present work is in this direction covering the producing interval within Pliocene age.

In present scenario, it is a strtigraphic trap given by channel system. Seismic Stratigraphic forward modeling has been done to understand the waveform generated by multilayered depth sections populated with seismic parameters viz. compress ional velocity and density and which has been an interpretational aid for mapping the contacts. No. of multilayered depth sections were created by changing the number of layers, their thickness and separations.

Dip of the layers were calculated from corresponding time seismic section and used while creating the depth section. The fluid contacts were inserted as horizontal interface within sand layers. Two basic models for thin layer case viz. one with hypothetical vertical contact and other with horizontal contact were generated and subjected to image ray tracing to generate the migrated time seismic section. The seismic responses generated by these two models were utilized to understand the response generated from hydro dynamically connected sand layers, thereby having single value contact.

Methodology

No. of multilayered depth sections were created by changing the no. of layers, their thickness and separation.

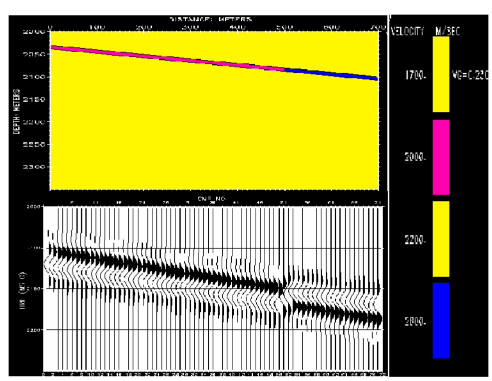

Figure1: Single layered sand model with hypothetical vertical contacts having ~3^0 of dips (of the existing dips in the area).

Dip of the layers were calculated from corresponding time seismic section and used while creating the depth section. The single value fluid contact is inserted as horizontal interface within all sand layers as sands are considered hydro dynamically connected. The layers were populated with typical values of the Vp, density for shale, gas and water sands in the interval under study. Two basic models for single thin sand layer case viz. one with hypothetical vertical contact, other with horizontal contact were generated and subjected to image ray tracing to generate the migrated time seismic section.

The reflectivity generated so was convolved with zero phase Ricker wave of 30Hz frequency. The individual sand thickness was limited to λ/4. The inferences/understanding from study of response from these models were made use while interpreting them from reservoir of two or more layers having less than λ/4 thickness including separating shale and also for more than λ/4 thickness.

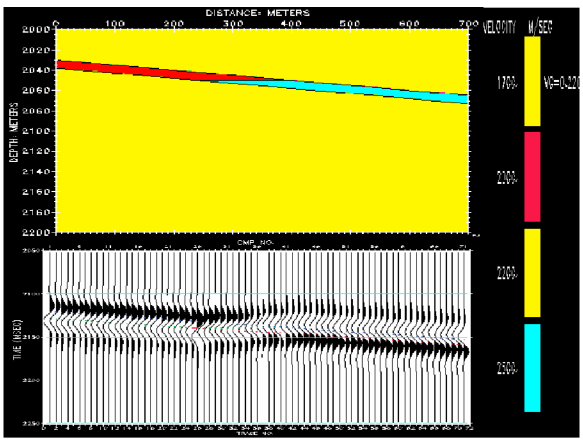

Figure2: Single layered sand model with horizontal fluid contact having ~3^0 of dips.

Waveform formed by the peak generated from top and trough from base of gas sand is peak followed by trough of equal amplitude, and in case of water sands it is vice versa. (in SEG polarity as impedance of gas sand are lesser than the encasing shale and higher in case of water sands)

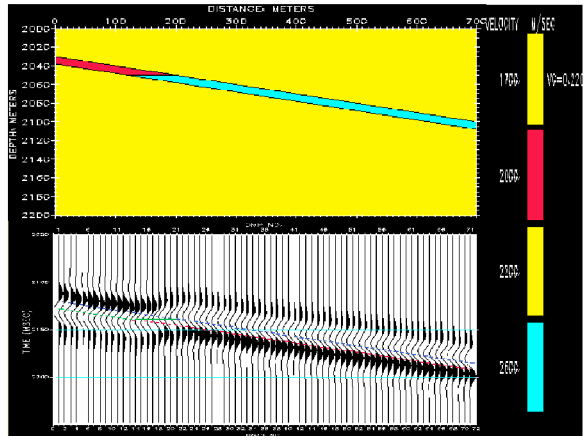

Figure3: Single layered sand Depth model with horizontal fluid contact having ~6^0 of dips (double of the existing dips in the area).

In case of hypothetical vertical contact in single reservoir layer, the waveform generated by gas sand is abruptly reversed for water sand across the vertical contact. However dip of the waveform generated remains the same if change in polarity consideration is made.

In case of single thin sand layer (less than λ/4) with horizontal contact, the waveform generated from gas sand is reversed corresponding to water sand across the horizontal contact. The continuity of dip of the waveform generated by the gas sand is broken by event from fluid contacts and remains horizontal up to the extent of contact and thereafter the dips are restored without any shift but reverse in polarity i.e., the waveform generated by the water sand (figure 2).

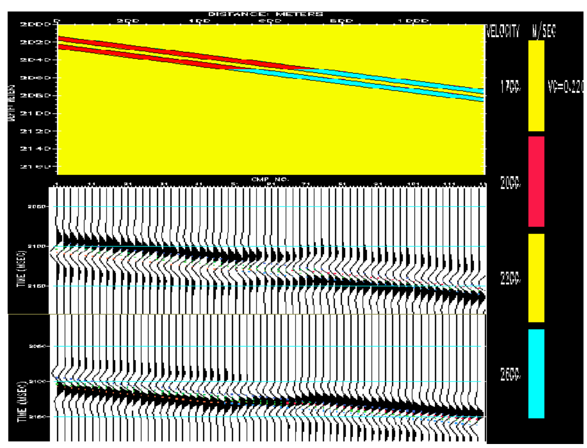

Figure4: hydodynamically connected two layered sand model in depth having ~3^0 of dips with horizontal fluid contact. Total thickness of sand layers including shale inbetween is less than -/4.

In this case of horizontal contact, the transition of response from gas and water sand is taking place over the horizontal fluid contact where an additional event is generated from contact. The study is extended to the other cases.

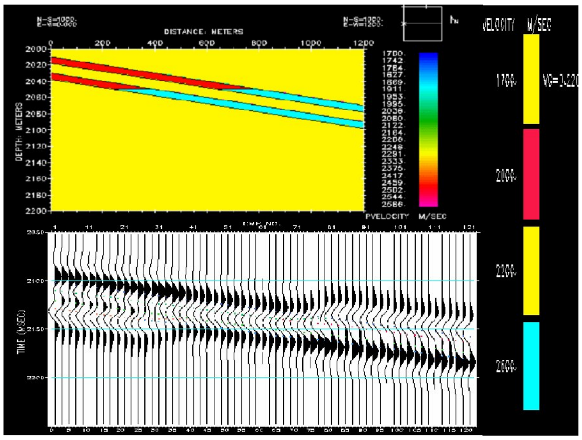

Figure5: hydodynamically connected two layered sand model in depth having ~3^0 of dips with horizontal fluid contact. Total thickness of sand layers including shale inbetween is more than -/4.

In case of sand layer having higher dips (in this case 6^0 i.e. double than existing 3^0 in the interval understudy). Horizontal extent within dipping events is comparatively short but enhanced (figure 3).

Next model consists of two hydro dynamically connected sand layers separated by shale with total thickness of less than λ/4, and therefore having same value of GWC. The waveform generated in this case is same as generated from single sand layer. However amplitude is proportional to the net sand thickness (excluding shale in between). The higher thickness of the combine (including shale in between) has caused more horizontal extent of event from contact (Figure 4).

Next model consists of two hydro dynamically connected layers separated by shale with total thickness of more than λ/4, therefore and having common GWC. Waveform generated in case of gas and water sand is one generated from a single layer of more than λ/4 thickness (as per widess diagram) but are reversed across contact. And therefore waveform is reversed in this case also. Effect of water sands having higher velocity than gas sands is seen lesser time thickness than that of gas sand. However in the extent of contact, the events from upper layer are generated from gas sand, whereas from layer are from water sand and thereby in reverse waveform resulting in waveform different than both gas and water sands and having trough between two peaks (Figure 5).

Conclusions

- Waveform generated from gas and water sands are in reverse polarity.
- Continuity of the dips of seismic events generated by gas sands is broken by fluid contact and remains horizontal upto the extent of the contacts, thereafter dip of sands are restored, but in reverse polarity.
- Study of synthetic seismic response generated for various depth sections helped to interpret contact on seismic data. Seismic forward modeling tool helped to understand the influence of contacts on waveform and also helped to resolve issue resolved with fluid contacts.

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