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Deepwater Channels and their Intricacies

C.Samajdar*, P.K.Nath**
Oil & Natural Gas Corporation Ltd A&AA Basin, Jorhat, Assam Email : scs_cal1@yahoo.com

Summary

Nowadays channels, specially, the deepwater channels become more and more attractive targets for exploration worldwide as major discoveries have been made in deepwater channel sands in recent times. In this paper different deepwater channel variability has been analyzed with seismic signature and log motif. Seismic amplitude variability along with integration of different logs has been used to delineate the interesting zones. Natural gamma ray spectrometry (NGS) log has been used to know the sand variability and genesis. This study highlights the pitfalls in the interpretation of seismic attributes to help in minimizing the risk of exploration

Introduction

Recent discoveries in deepwater have open up a new era for hydrocarbon exploration. Some of the major discoveries have been in channels and associated morphologies like levees, fans or terminal lobes. With

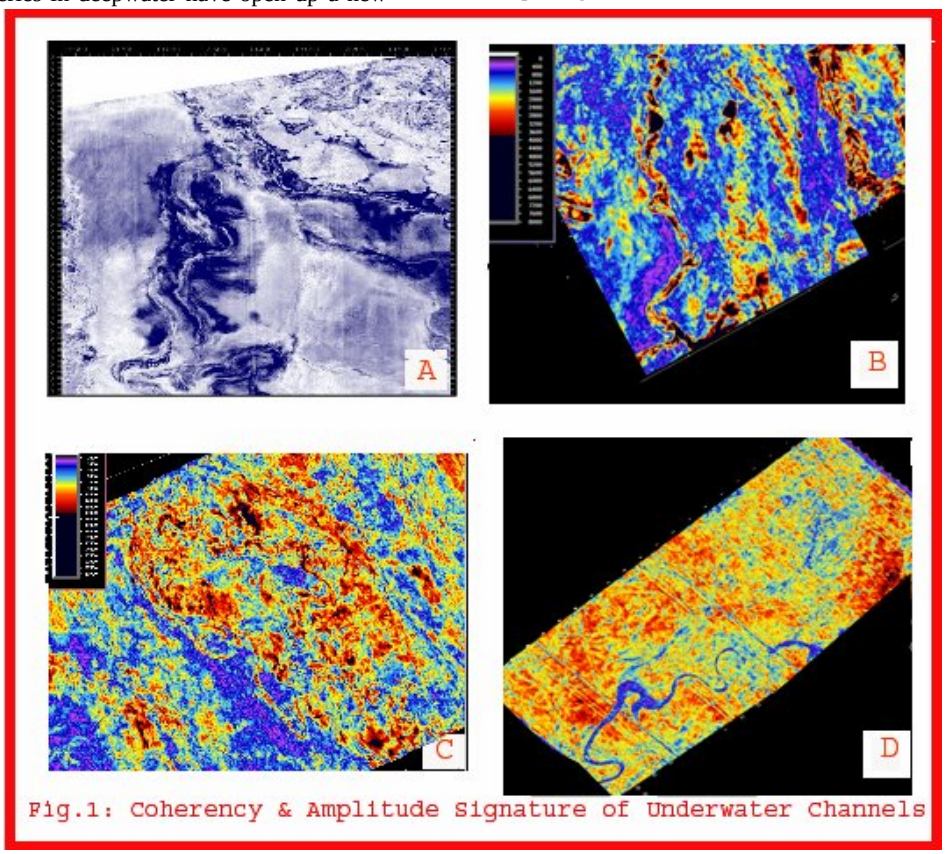

Fig.1: Coherency & Amplitude Signature of Underwater Channels

rapid up gradation of acquisition and processing technologies and reducing cost of offshore 3D acquisition it has now become easier to identify and delineate these channels and reservoir facies within it with high resolution 3D data, in a cost effective way. The importance of channels as conduits for sands to reach the basin floor was not fully appreciated in the past and the possibility of large volume of sand was not recognized to occur downdip of slope system. When large volume of coarser clastic sediments was discovered in deepwater part, the transportation and depositional mechanism were studied. Now it has been found that the deposits arising from gravity controlled mass transport processes are the major components of deepwater clastic system. As described by several authors, the gravity controlled processes are mainly slides, slumps and debris flow deposits arising due to turbidity currents. The processes involved in deposition may not be recognized on the seismic data, but the depositional morphologies are often expressed nicely in 3D seismic data. The variability of the deepwater channels in their lithology and fluid content has surprised the interpreter on many occasions. Some of the cases are described in this paper which relates the seismic expression to sub-surface geological features.

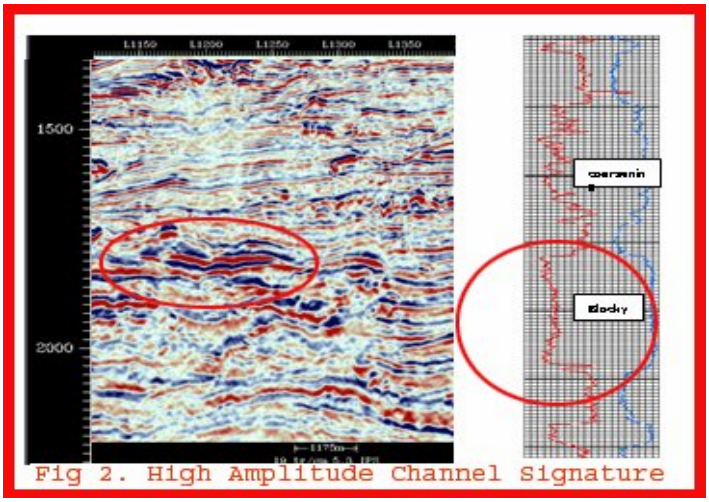

Fig 2. High Amplitude Channel Signature

Analysis and results for different case studies

In this paper 3D seismic amplitude and coherency slices from a pericratonic, passive margin settings have been used for morphological definition of different channel system from shelf to slope in Fig.1.A-D.

Fig.1A-D show four different channel morphologies from Shelf (1A) to deep basinal part(1D) in 3D datasets. Fig. 1A displayed on coherency data whereas Fig. 1B,1C &1D are average absolute amplitude (AAA) horizon maps. Fig1A-D data indicate gradient changes in slope–basinal system, manifested by varied sinuosity of these channels in the basinal part.

On seismic sections, the channels are often recognized by abrupt truncation, discontinuity or by amplitude anomaly of the reflection events. In gamma ray log (GR), channels and its associated features have wide variety of motif (blocky, coarsening or fining upwards etc) depending upon the position of well in channels, fans or splays. Fig2. shows a vertical seismic section with typical high amplitude channel feature and GR log motif of channel sand characterized by its blocky nature.

The variability of these channel sands vis-à-vis reservoir facies delineation are the major risk in deepwater exploration. Channels shown in Fig. 1 are represented by high amplitude events on the seismic sections. Since deepwater is generally shale prone areas, anomalous high amplitude seismic events may generally be considered as sand/hydrocarbon bearing if clastic deposition persists and supported by other studies.

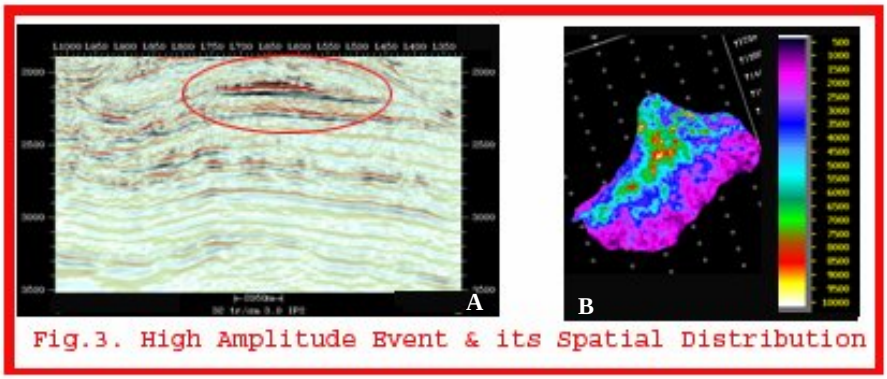

Fig.3. High Amplitude Event & its Spatial Distribution

Case –I – Lithology Assumption

Fig.3A shows a vertical seismic section in which a high amplitude event has been seen. The average absolute amplitude distribution of this event has been shown in Fig3B. The amplitude distribution appears to be a 'fan' like pattern with both sides of the fan bounded by subsequent younger clay filled channel (not shown in vertical section). Probability of deepwater limestone presence was not considered as it was not encountered in the drilled wells in the basin. All other attributes and studies (like AVO and inversion) were also responded positively for a clastic fan deposit.

After drilling, the causative of the high amplitude found to be the presence of deepwater limestone alongwith the reworked limestone grain from older sediments.

So amplitude signature is misleading in this case – most of the other attributes like AVO and inversion are also influenced by amplitude characteristics. If the environment of deposition assumption model (mainly clastic /non-clastic) fails, all amplitude related prediction may also be inconclusive or wrong.

Case –II – Low resistivity sands

It has been observed in many deepwater areas, that hydrocarbon bearing sands in channels and levees may show low resistivity.

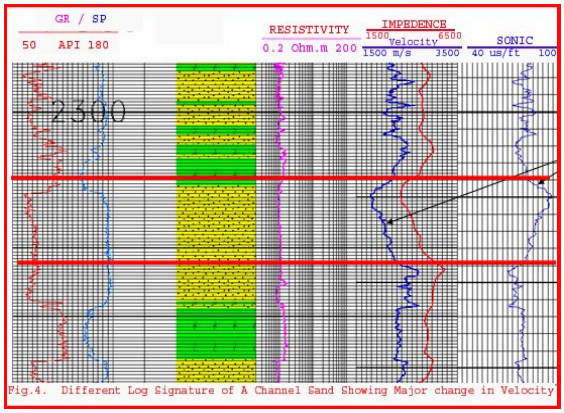

Fig.4. Different Log Signature of A Channel Sand Showing Major change in Velocity

Fig4. Indicates low resistivity channel sand in gamma ray log. When the impedance and velocity logs have been generated from sonic and density it has been found that a major lowering of velocity from 2400m/s to 1800m/s has occurred near the top of sand unit. The most interesting observation is that there is again increase of the velocity and impedance from the middle of the sand unit which seems to be due to fluid contact, though there is no resistivity building up within the sand unit to call it as hydrocarbon bearing in conventional sense. But the velocity vis-à-vis impedance change in both P and S wave (not shown) has to be explained before inferring the sand unit as devoid of hydrocarbon. All possibilities should be explored for finding out suitable answers for explaining the observed data.

Case –III – Variability of sand genesis

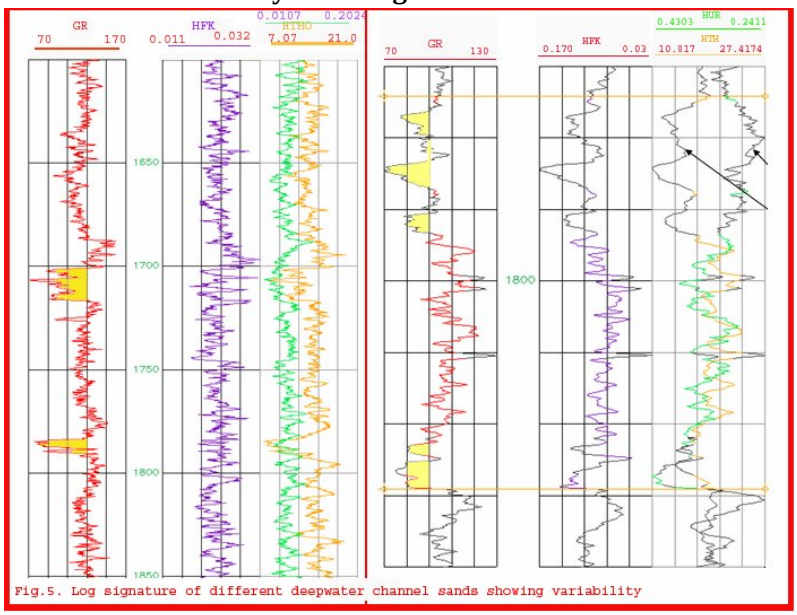

Fig.5. Log signature of different deepwater channel sands showing variability

The high amplitude channels shown in Fig.1 contain good quantity of coarser clastics, from high amplitude zones.

Though channel morphologies are different but the amplitude is high in all the cases. But study of these sands through Natural gamma ray spectrometry (NGS) indicates the variability of radioactive content of these sand units indicating difference in transportation and deposition of these sand units. Here logs of channel shown in Fig. 1B &C have been analyzed.

Fig 5. indicates two wells separated by around 10 km distance and two sand units of nearby channel system of same depositional period. The gamma ray signature is similar but as we analyze the GR signature with NGS logs the variability becomes apparent. In left location, the sand unit is low K-Th-Ur content in the indicated portion which shows long distance transportation of sand grains whereas the sands in the other channel have high Ur and low K-Th indicating marine influence. This indicates the difference in provenance, transportation and genesis of these sand units though they were deposited in nearby areas with same slope system.

In deepwater areas the genesis of the sand units may be further correlated with hydrocarbon presence or absence with subsequent drilling. It is also important to have knowledge of sand genesis to have understanding of the generation of biogenic gases. Sands of the same genesis may be the targets for future exploration of biogenic gas reserves.

Conclusions

- Deepwater channels are high risk areas because of their varied genesis and complex litholgy variation. If analyzed and causes of these variability is understood these channels may be highly rewarding.
- Seismic amplitude distribution and related attributes may be misleading as the same amplitude distribution may be generated by several lithology-fluid combinations. The prediction on depositional environment plays a crucial role in deciding the lithology type and the modeling the amplitude pattern.
- The integration of all geoscientific data is needed for suitable explanation of anomalous zones in the well logs.

- NGS logs analysis may indicate the variability of sand genesis.

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