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Use of Synthetic CMP Gathers for Velocity Guidance in Sub Basalt Seismic Imaging Problem: A Case Study of KG Basin

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Summary

A combined approach in time domain consisting of data driven velocity determinations integrated with model based strategies was successfully implemented in sub basalt seismic imaging in an onshore area of Krishna Godavari Basin. A forward acoustic modeling was used to verify the different geological hypothesis prior to application in actual recorded seismic data. The synthetic gathers were generated using the seismo-geological model and processed. The implemented procedures in synthetic gathers for processing facilitates the processing of the actual seismic data by allowing existing geological knowledge to complement data-driven velocity determinations.

Introduction

The sub basalt seismic imaging is problem in Krishna-Godavari basin. Event though the modalities of emplacement of the lava flow may differ in basin to basin depending upon the type of volcanic edifice, sub aqueous or sub aerial extrusions, there are some common characteristics that can be addressed by the seismic imaging tools in order to conduct successful sub basalt exploration. When large volumes of effusive volcanic are erupted the lava tends to stratify and infill the topographical undulations, creating basalt layers with varying thickness. Successive lava flows normally do not follow the same paths and are episodic, so that sedimentation, weathering may occur between one extrusive process and other. Therefore the physical properties of basalt section is directly related to the lava emplacement process causing heterogeneous bodies characterized by vertically and laterally varying velocities with irregular interfaces.

These basalt layers create problem for seismic energy propagation such as absorption, high impedance acoustic barriers, the interbed multiple generation, diffraction due to irregular interfaces etc. As a result, seismic imaging suffers from problematic velocity determinations. Bringing geological knowledge into sub basalt imaging problem limits the uncertainties. The most suitable way to do this work in time domain is through a combination of acquiring long offset seismic data, pre stack time migration as imaging tool and forward modeling as identification and verification tool. This idea has been tested in onshore area of Krishna-Godavari basin (Fig. 1). For this purpose the imaging strategy chosen consisted of a combination of data driven and model driven velocity model building in seismic imaging. To limit the degree of freedom of such a procedure the velocity determination above basalt, within the basalt layer and below basalt is constrain by seismo-geological information. The types of geological constraints adopted were derived from nearby wells and from the knowledge of overall geology of the area.

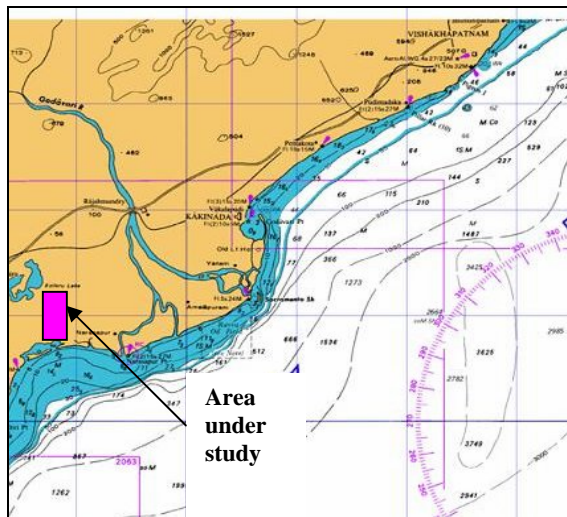


Figure 1: Map of Krishna-Godavari (KG) Basin

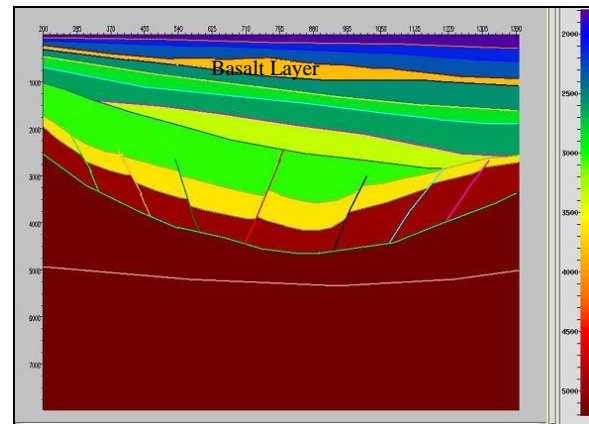


Figure 3: Velocity –depth model in GEODEPTH

About the basin

Krishna – Godavari basin is situated in east coast of India. The basin is divided in three sub basins namely Krishna, West Godavari and East Godavari sub basin, differentiated by Bapala & Tanuku horst. The area under study falls in West Godavari. The Krishna-Godavari basin was a major intra-cratonic basin during Late Carboniferous, Permian and Triassic within the greater Gondwanaland land mass. This lasted until Early Jurassic when the basin changed to a synrift basin in Jurassic up to Cretaceous. The late Jurassic rift caused mechanical extension leading to NE-SW horst and graben features and rapid clastic sedimentation during this period. Since the Cretaceous, the basin became a pericratonic basin. The Razole trap was formed during Paleocene over the earlier deposition as a sheet. The sedimentary column available in the basin ranges in age from late Carboniferous to Recent.

Methodology

The area under study lies in the west Godavari sub basin. The seismo-geological model of the area is used to make a velocity depth model (Fig. 3). This model was subjected to ray tracing using GEODEPTH software. After ray tracing of whole model and each layer (Fig. 4) gather were synthetically generated. These synthetic CMP gathers were used for further processing steps such as velocity analysis and pre stack time migration and stacking of data.

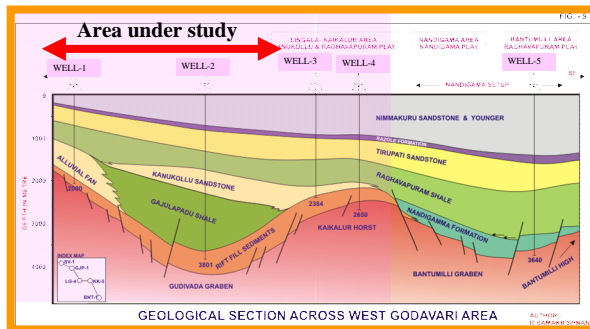


Figure 2: Seismo-geological model (Courtesy: KG Basin)

The seismo-geological model (Fig. 2), is taken for generation of synthetic gathers. A variation in thickness of basalt layer was introduced to study the effect on velocity determination below the basalt. The velocities of the formations in the model were taken from wells. The synthetic gathers were generated after ray tracing of the velocity-depth model (Fig. 3) and the seismo-geological section of the area. These gathers were processed and velocity determination was done through velocity analysis of pre stack time migrated gathers. The velocity analysis clearly shows high velocity gradient up to the basalt layer and gentle velocity gradient below the basalt layer. This model driven velocity analysis gives us a velocity trend to apply on the actually recorded data. Due to poor S/N ratio of reflected arrivals in pre stack migrated gathers do not allow us to proceed in a completely data driven velocity model building approach, therefore, after initial determination of RMS velocity, the rest of velocity determination is carried out in model driven fashion. The geologic hypothesis and geophysical assumptions deriving from above method were verified by means of forward modeling.



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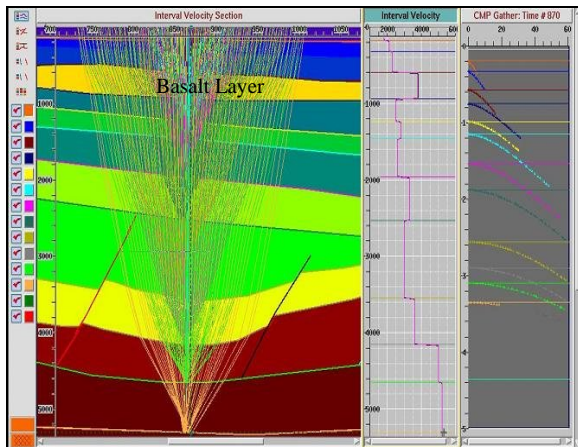


Figure 4: Ray Tracing of velocity –depth model

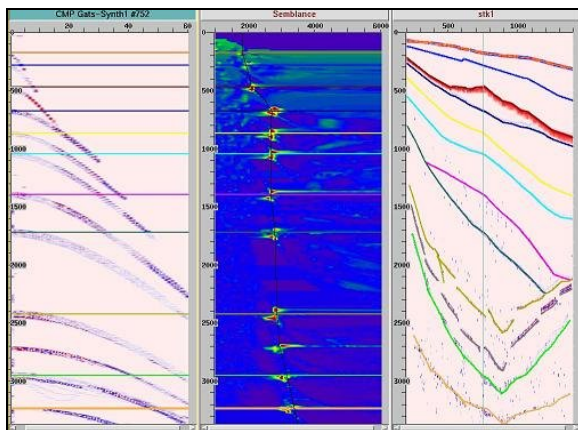


Figure 5: Velocity analysis of synthetic gathers

The velocity analysis of this synthetic data gives following observation.

- The RMS velocity of synthetic gathers follow different gradient above and below the basalt layer (Fig. 5).
- The change in gradient depends on the thickness of high velocity layer i.e. Basalt layer (Fig. 6a, 6b & 6c).
- The velocity gradient shows more sharp variation for thick high velocity layer and gentler variation at thinner portion of same high velocity layer (Fig. 6a, 6b & 6c).
- The correctness of RMS velocity is obvious by the flatness of synthetic gathers (Fig. 6a, 6b & 6c).
- The picks of velocity semblance in velocity analysis are verifying the actual depth velocity model (Fig. 5).

The above observations are experienced on model driven velocity determination. The similar velocity trend is expected in the data driven velocity determination of the actual recorded seismic data.

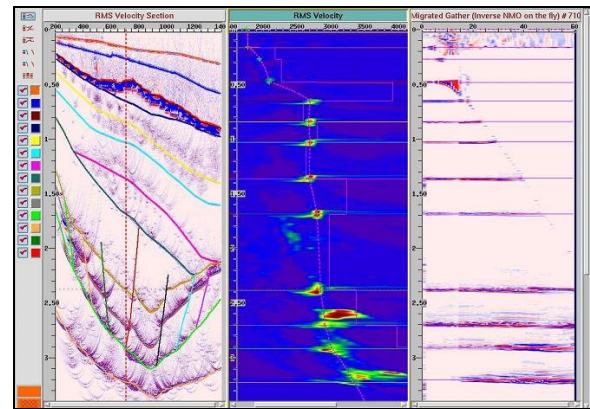


Figure 6a: Velocity analysis at thick portion of high velocity layer

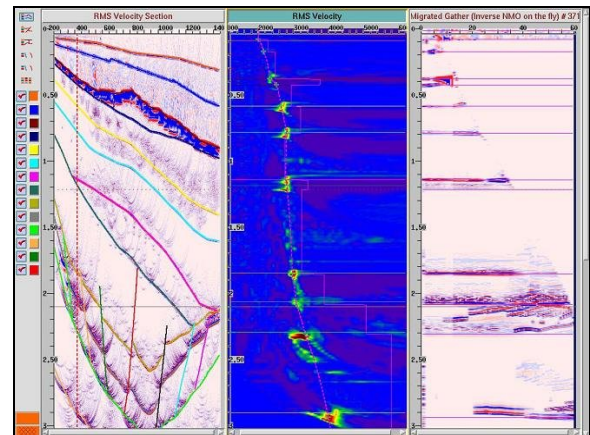


Figure 6b: Velocity analysis at thin portion of high velocity layer

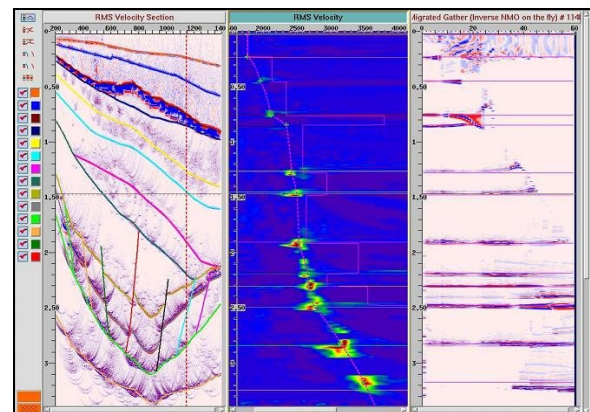


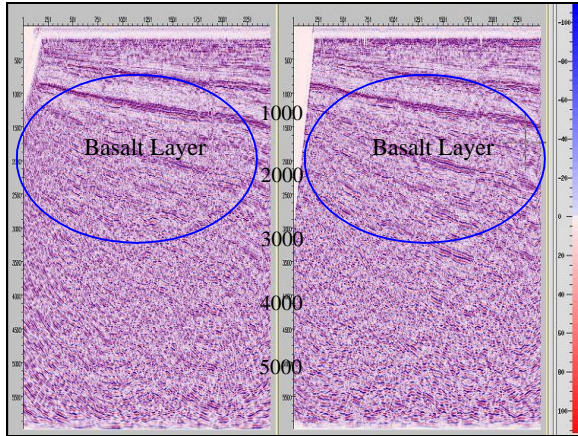
Figure 6c: Velocity analysis at thin portion of high velocity layer

Applications

Each geologic hypothesis tested had to be supported by the improvement of the migrated seismic section. The actual recorded 2D seismic lines passing through the area is taken for processing. The velocity analysis of the real data follows same trend as in synthetic gathers. This data is subjected to pre stack migration using new velocity estimated through above methodology. The stack section clearly shows a considerable improvement over the earlier



processed section. The sub basalt seismic imaging is better in comparison with old processed section (Fig. 7).



Earlier processed data Processed with new method
Figure 7: comparison stack data

The velocity analysis of actually recorded seismic data shows two clear velocity gradients in the semblance plot. The shallow portion shows high velocity gradient and below basalt that is in deeper portion, it indicates gentle velocity gradient which is verified by the geological model. The Fig. 8 & Fig. 9 shows the semblance plot obtained on actual seismic data at two different locations on the seismic section.

Conclusions

The sub basalt seismic imaging is better addressed by incorporating geological information during the phase of velocity model building. The velocity determination on this seismic section has been done in data driven as well as model driven fashion limiting the velocity trend to be constrain by geological hypothesis. The obtained results suggest that an effective sub basalt imaging approach should involve

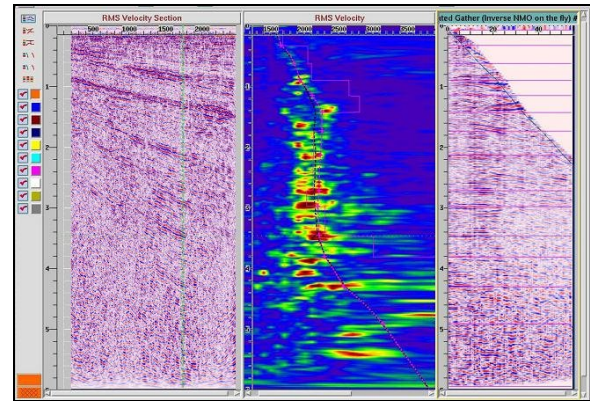
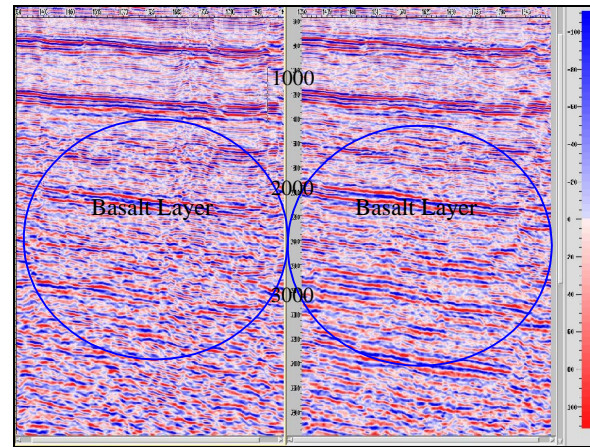


Figure 9: Velocity analysis of actual recorded data



Earlier processed data Processed with new method
Figure 10: comparison stack data (a zoomed section of Fig. 7)

induction of geological constraints and forward modeling during velocity model building and its verification. The processed seismic section with this method provides us seismic imaging consistent with wells and existing geologic information and hypothesis, and finally provides enhanced seismic image for the sub basalt section (Fig. 10). The comparison between the out put obtained by pre stack time migrated section after model driven and data driven velocity estimation clearly indicates the improvement obtained for sub basalt section.

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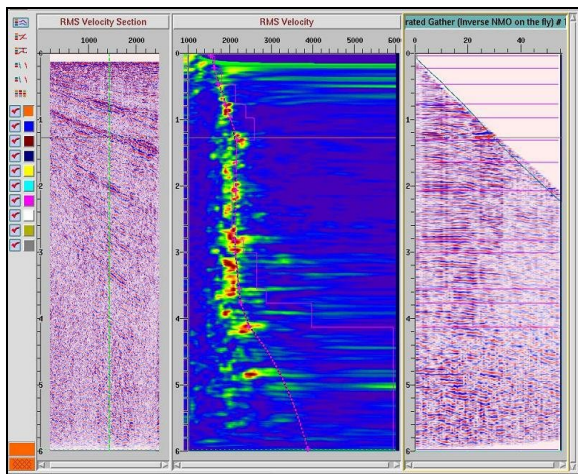


Figure 8: Velocity analysis of actual recorded data



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