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Improvement in Basement imaging through spectral and geo steering filter for geological model building in Neduvasal area.

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Summary

Enhancement of seismic data quality is a key task for geophysicist while interpreting the seismic data. Post stack processing is one of the key step to improve the continuity of a seismic reflector. While interpreting seismic data of Neduvasal-Vadatheru area of Cauvery Basin mapping the reflector close to Basement is found very difficult as no reflection is visible for correlation due to extremely poor signal to noise ratio. To improve the seismic data continuity a post stack processing step in form of spectral whitening is adopted. The result was quite encouraging. Due to this the mapping of basement related reflection improved. The paper presents the method and result to enhance the signal to noise ratio by spectral whitening and its effect on delineation of fault mapping.

The study also shows that in areas of poor reflection zone objective oriented adoption of spectral whitening for frequency bandwidth of reflector of interest offer significant improvement in mapping.

Introduction

In India ONGC Ltd carried out study for Vadatheru-Neduvasal area of Cauvery Basin during 2009-10 to evaluate hydrocarbon potentials of basement rocks. The study analysed the conditions favourable for oil accumulation in the fractured / weathered basement in the study area. The objective was also to present a methodology for fracture prediction based on geological occurrence of fractures and seismic attribute analysis. 3D seismic data volume was available in the area and used for the mapping of a reflector close to top of basement. While mapping the area in the south-west corner and near gas producing well from Basement

Enhancement of seismic data quality is key process for subsurface mapping and geological feature analysis.

Area of study

The area of study is located in the southern part of Tanjore Sub-Basin around Vadatheru-Neduvasal-Krishnapuram (figure.1).

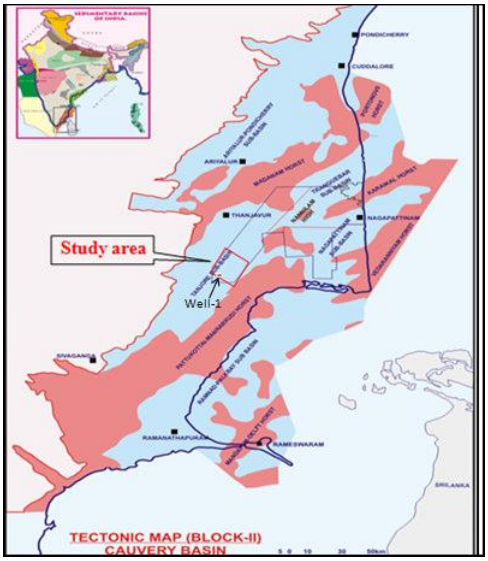

Figure-1. Map Showing location of study area.

Basic geological setting of the area

The Cauvery basin is believed to have formed due to extension between India and Sri Lanka at the time of break-up of Eastern Gondwanaland (Katz 1978) during Late Jurassic or Early Cretaceous. The extension was initiated

in NW-SE direction resulting in rifting along weak zones parallel to the Precambrian Eastern Ghat trends (NE-SW). This extension was controlled to a certain extent by the NW-SE lineaments (Dharwarian trends) present in the Precambrian basement. This is also corroborated by the presence of transverse faults subdividing the basin into various blocks from northeast to southwest.

Several stages of reactivation of syn-rift extensional faults are noticeable in the basin. However, majority of them were active only up to Cretaceous top, with a few showing evidence of activation up to the Lower Tertiary. Inversion of the faults, which formed hanging wall anti-forms, is also observed in the basin.

The Cauvery basin also witnessed post- Cretaceous south-eastward tilting. The tilting is probably related to the uplifting of western peninsular India during the passage of India over the Reunion hot-spot concomitant with the magmatic outpourings of the Deccan basalts. The post-rift tilting drastically obliterated the syn-rift structural geometry of the basin.

Thus a review of evolutionary history and tectonic features of the basin suggests that Cauvery basin is characterized by all elements- rifting, shearing, inversion, tilting, etc - which may cause fracturing of basement. Together with this, discovery of oil and gas in the basement reservoir in wells falling in Tanjavur sub basin. This strongly recommend that fractured/weathered basement can be a potential target for exploration in Cauvery basin, particularly in the Tanjavur sub basin.

Seismic data study

VSP data of a well in the south-west corner of the 3D seismic volume was used to identify the reflector close to the basement top (figure-2.a). However signal to noise ration of original data is so low that correlation of Basement was difficult to extend beyond the wells. Therefore suitable post stack processing to improve the signal/ noise ratio was a critical requirement, after few trial of filter setting for noisy portion it was observed that spectral whitening is able to improve the Signal to noise ratio(figure 2(b)). This made possible to extend the correlation of basement top in nearby area of well#1.

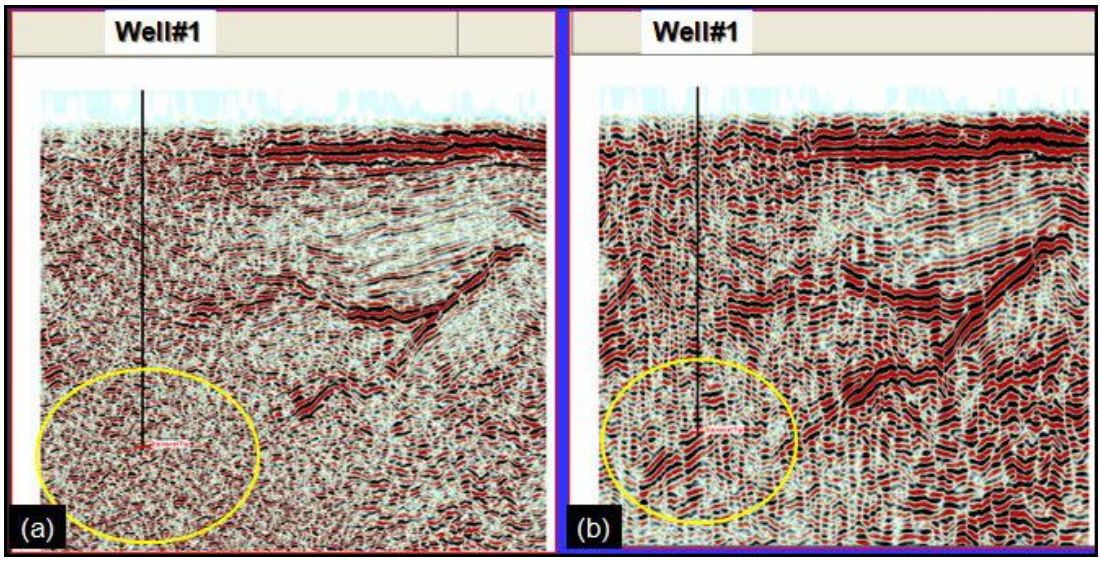

Figure.2(a). Seismic cross-section passes through Well#1 before processing

Figure.2(b). Processed cross-Seismic section passes through Well#1

The processed and unprocessed data were used to generate horizon slice along Basement top for comparison. An amplitude horizon slice is shown in figure 3(a) for unprocessed data and in figure 3(b) for processed data.

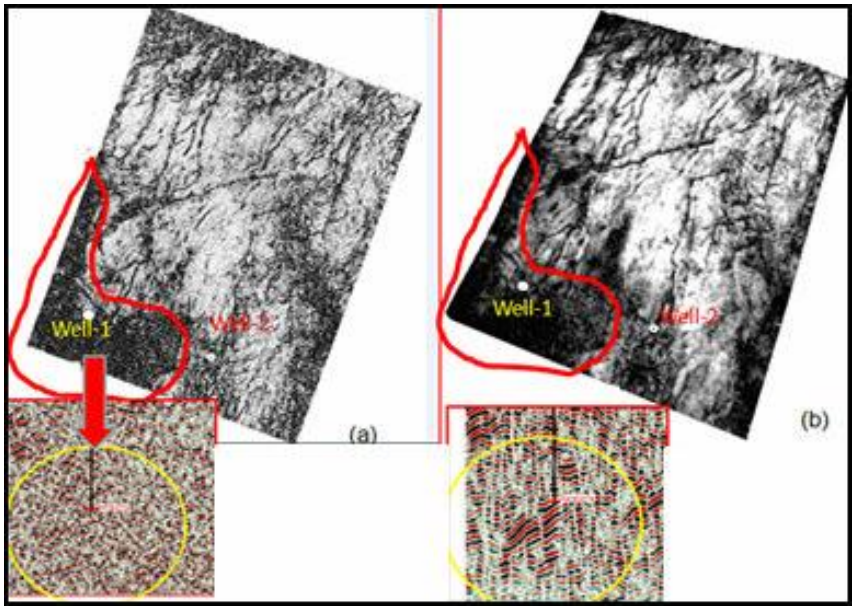

Figure 3. (a) Horizon slice of amplitude extracted from original data and (b) Horizon slice of amplitude extracted after spectral whitening along Basement top from original data.

On observation of both horizon slice from Figure 3.(a) and 3(b), it quite clear that processing has improved the delineation of geological feature on horizon slice of amplitude from processed data.

Signal to noise ratio is improved on processed data and one can easily delineate the reflection from top of Basement on vertical section Figure 3(b),.

Geo-steering filter

The process of following the dip from trace to trace is called steering and requires a Steering Cube as input. To compute the Steering Cube a sliding 3D Fourier analysis technique uses a small (typically 7x7x7) cube that is transformed to the Fourier domain where the maximum is determined. The maximum value corresponds to the dip, which is stored in the Steering Cube in two components: inline dip and crossline dip. The process of geo steering uses Directivity in which dip and azimuth information is used to improve attribute accuracy and geological object detection power. This improves the interpretation. In the present study, horizon slice with proper filtering (Dip Steering) has shown a subtle NE- SW trending fault (figure-4) which was not observable in figure 3(a).

Effect of spectral whitening is shown in figure 2(b) and can be compared with figure 2(a). Figure 2(a). In spectral whitening limited frequency bandwidth is used. Figure-4 shows the effect of using geo-steered data and can be compared with figure-3 which is without geo-steering filter.

The effect in improving the fault delineation is observed after application of spectral whitening and geo-steering.

After integrating other information from well, core and seismic fault pattern this fault was crucial in understanding the geological model. The geological model envisaged that NNE- SSW trending fault are providing the weathering within basement whereas NE-SW fault is acting as fluid migration or charging route. This explains the oil in Well-2 in figure-4, where well -2 is close to intersection of two different fault set. Well-1 is not close enough to intersection of the faultset (NNE-SSW, NE- SW). It is envisages in the model that charging corridor is limited within basement for charging, therefore well very close to the intersection of two fault set (NNE-SSW, NE- SW). This may be reason for limited producibility of hydrocarbon from weathered basement.

Maximum curvature attribute generated to delineate the major and minor fault in the area (figure-5).

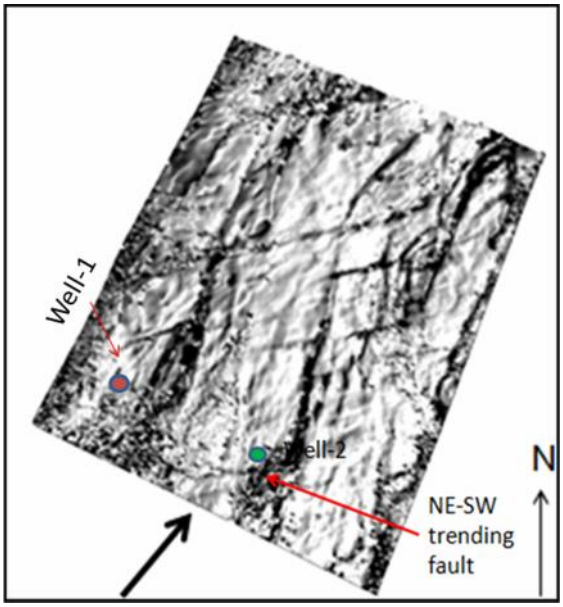

Figure:4 The subtle fault in NE-SW direction on Amplitude horizon (basement top) slice of Dip Steered data better than without dip steered data(figure-3(b)).

The curvature attribute is providing the distribution of major and subtle fault even better than dip-steered data as it uses the geometric relationship and sensitive to minor changes in dip orientation of reflection. The network observed on curvature attribute (figure -5) led to improved understanding of hydrocarbon distribution mechanism. Using well data, core data, spatial occurrence of hydrocarbon pattern, it is deciphered that NE- SW faults extending to depositional centre (in the west) are probably acted as carrier of hydrocarbon to the positive structure closure bounded by North south graben forming fault and creating footwall high (Figure-6).

As one of the footwall high situation has provided the reservoir condition through weathering within basement and presence of hydrocarbon has given clue to envisage the geological model. The model envisaged is Foot wall highs close to the intersection of NNE- SSW & NE-SW faults are the likely locales of HC accumulation in the Vadatheru-Neduvasal area. Based on this inferred geological model number of areas has been identified for hydrocarbon within basement fracture/weathered portion figure-7.

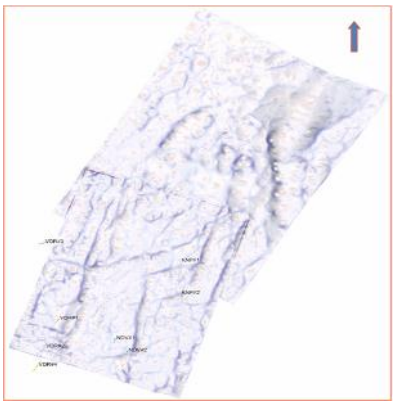

Figure-5. Maximum curvature attribute for delineation of major and minor fault distribution network in the area of study.

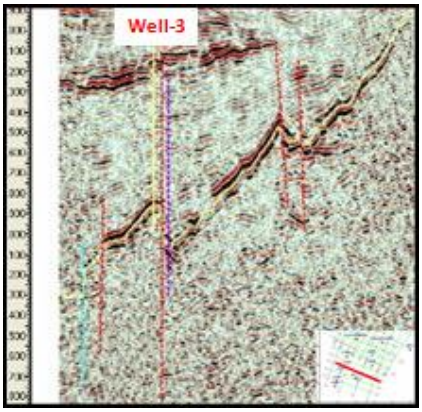

Figure-6. Graben forming fault and footwall high on vertical seismic section. One of the footwall has given hydrocarbon within basement. Vertical Yellow line shows the Well-3 (location identified).

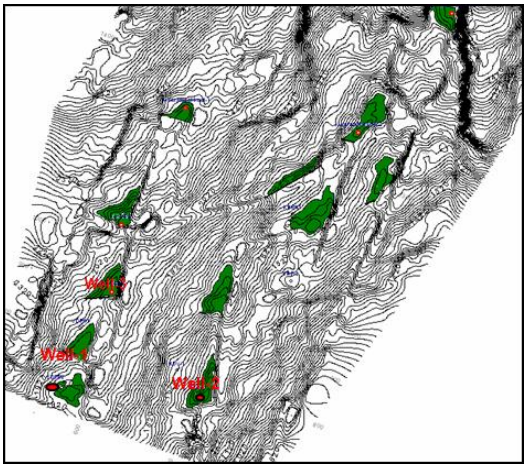

Figure-7. Depicting the probable prospective areas (green color) identified through envisaged geological model.

Though geological model explains the entrapment, reservoir condition and charging mechanism, however capping mechanism for hydrocarbon is still to be uncertain. Therefore, the seismic data of prospective areas was used for model based inversion to compute the velocity for full 3D volume. On observation of inversion derived velocity section it is found that a thin layer of marine shale interpreted from well log is extending in one of the area of prospects identified. Same has been proposed and considered for drilling by basin management (figure-8).

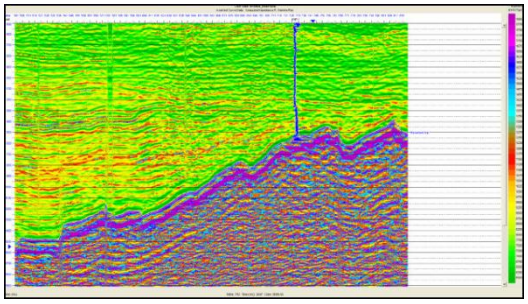

Figure-8: The presence of a thin shale facies (green color) over the basement as probable seal for basement prospects.

Conclusion

It is observed that conventional sub surface mapping requires special filtering to enhance the seismic resolution to bring out the reflection masked by noise in this area. There is no standard filter is available therefore the trial with different type of filter on testing basis can lead to find the suitable filter.

Study has used spectral whitening and geo- steering filter to improve the correlation a reflector close to top of basement. Extraction of amplitude along this reflector brought out fault delineation better.

This has helped in understanding the presence of hydrocarbon in well-2. A geological model envisaging that locations close to intersection of NNE-SSW, and NE-SW are probable regions for future exploration in this area basement exploration.

This study has provided confidence in considering a location for the drilling to explore an unconventional basement exploration, a high risk hydrocarbon play.

Acknowledgement

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Reference

K M Shukla et.al (2010), "Evaluation of hydrocarbon potential of fractured basement in Vadatheru- Neduvasal area, Cauvery Basin", project report of ONGC, (Unpublished).