Integrated Geological Interpretation Using Seismic and Non-seismic Methods for Hydrocarbon Exploration: a case Study in NELP-VI block in Mizoram, India

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Summary:

The increasing complexity of new exploration targets in the NELP-VI Block (MZ-ONN-2004/1), interpretation process has been carried out using seismic and non-seismic methods. An example is drawn from a prospect in Mizoram NELP-VI Block where geochemistry, gravity and surface geological modeling are integrated with the recently acquired 2D seismic data sets to build geological and petroleum system models. During this study an attempt has been made to investigate the depths of various formations viz. near top Bhuban, Middle Bhuban, Lower Bhuban, top Renji, Intra Renji and Intra Jenam formations to assess probable potential locations of the hydrocarbon in this study area.

Introduction:

Mizoram has geographical area of approximately 21081 sq. km. Logistic constraints have so far hampered sustained exploration efforts in this state. The surface topography of the proposed area of seismic operation is that of typical northeastern rugged hilly terrain of India. The topographic features are highly undulating with thick forest cover. The hillocks have very steep slopes ranging between 60-80 degrees with intervening deep gorges. There are hardly motorable roads in the working area except national high way NH-54.

The present study area NELP-VI block (MZ-ONN-2004/1) is situated to the south and east of established petroleum provinces, 70 km from the nearest producing hydrocarbon field. The closest well is Rengte-2 situated 54 km to the north. It is typified by a succession of sub-parallel hill ranges and long valleys. The hill ranges reach a height of around 1800m in Mizoram with most of these between 900-1300m in the working area. The general elevation increases towards east up to the Myanmar border. The block area is located in the Mizoram fold and thrust belt between Bangladesh and Myanmar. The location map of the study area has been shown in Figure 1.

The combination of geochemical, geological, gravity and aeromagnetic data information along with other geoscientific information have always complimented with 2D seismic data in the interpretation of basin structure; especially in areas hostile to conventional seismic data acquisition. Data from these methods have been used in a wide range of tasks; from definition of the tectonic setting of the sedimentary basin, to detailed mapping of the character of the basement in conjunction with information from seismic data.

Seismically, the structural style of Mizoram Block comprises a series of curvilinear east dipping thrust sheets with Oligocene and Miocene sediments deformed into a series of fault propagation folds. A series of NW-SE oriented, steeply dipping, compressional tear faults compartmentalize thrust blocks (e.g. Thenzawl fault zone) in the south central region of the Mizoram Block. Below these, Cenozoic thrust sheets of probable Mesozoic age sediments are tectonically thickened in a series of duplex horse blocks; however, the absence of reflection calibration and the wide 2D line spacing does not allow correlation of reflections or thrusts at this level. The probable basement depth has been estimated using gravity data is at 5.5 seconds (TWT).

In this paper, an attempt has been made to investigate the depths of various formations viz. near top Bhuban, Middle Bhuban, Lower Bhuban, top Renji, Intra Renji and Intra Jenam formations to assess probable potential locations of the hydrocarbon in this study area.

Structural Setting:

The development of the Mizoram fold belt began in the Late Cretaceous on the northeastern margin of the Indian craton. It consists of a series of tight elongate folds that trend roughly N-S direction. They are concave to the east and doubly plunging arranged in an en echelon fashion moving west into the Tripura fold belt (particularly the synclines) become more open and gentle. The uplift and erosion in this area are also less severe as younger strata are preserved and outcrop at surface. Miocene sediments are the youngest to outcrop within the block. The basement in the Mizoram area comprises Precambrian/Cambrian continental terrain as well as Cretaceous ophiolites, which were set during the closure of the Neo-Tethys Ocean in the Late Cretaceous to Early Tertiary.

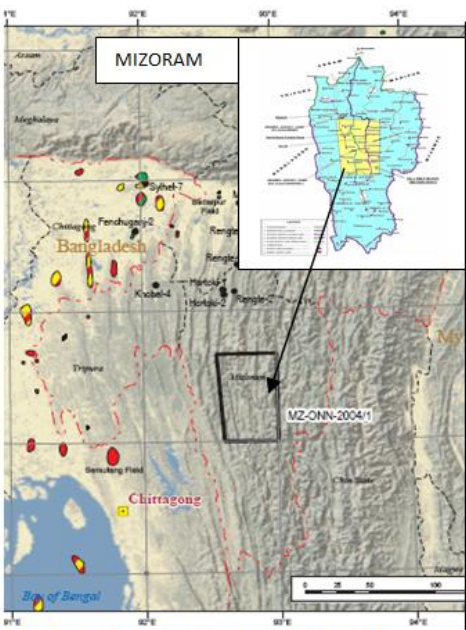

Fig.1. Location map of the study area

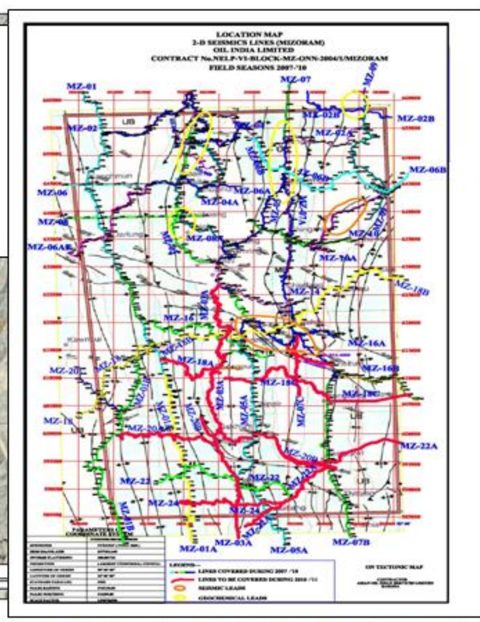

Fig. 2. Crooked lines survey and tectonic map

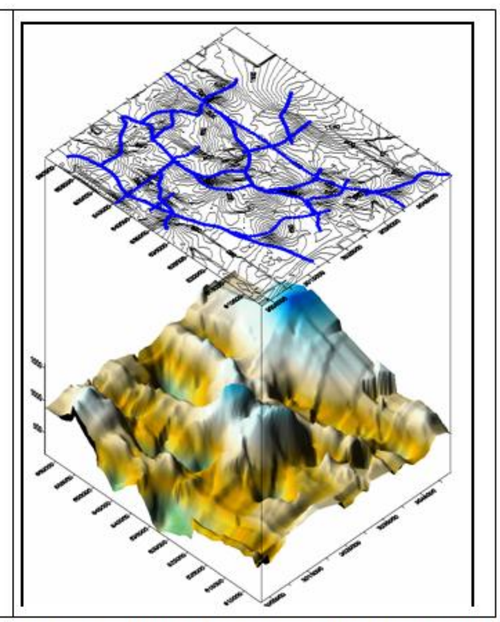
Fig .3. Topographical view and the crooked Seismic lines

2D Seismic data acquisition:

The study area is logistically difficult, complex in nature and very challenging to acquire 2D seismic data. The elevation is varying from 300 m to 1500m. 2D Seismic data acquisition was started initially in the Block with straight line spread but owing to severe topography and logistical problems, it was subsequently changed to crooked line survey as shown in Figure 2. However, since the area is falling under complex geology and great surface undulations with thrusting and faulting, this has been very challenging task for velocity picking using the seismic data. The details topography of the area and the crooked line survey is shown in Figure 3.

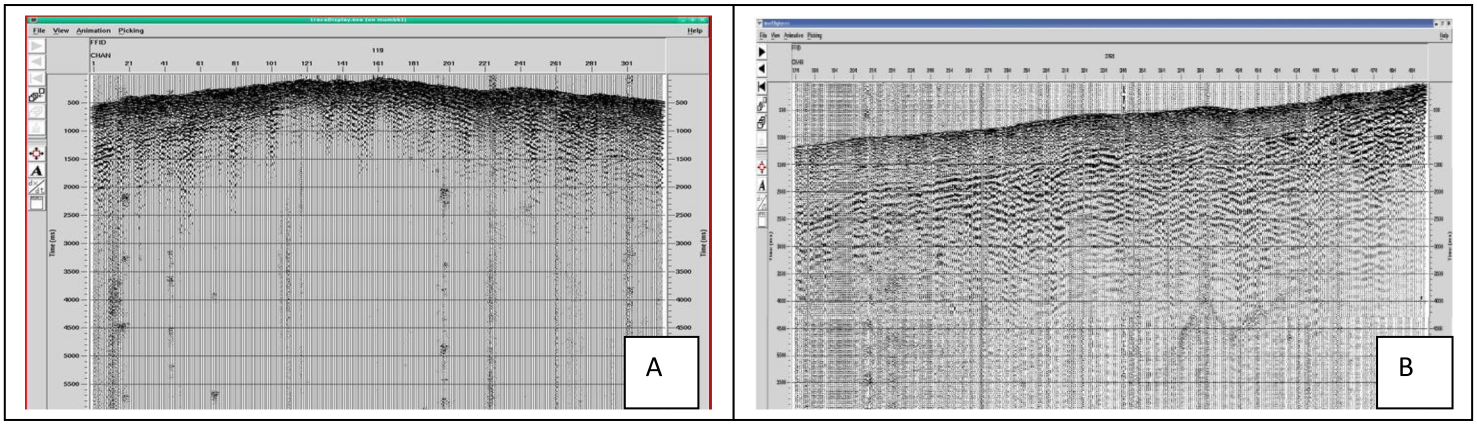

Fig. 4. Split-Spread (Fig 4. A: Poor signal quality) and End-On shooting (Fig 4. B: better quality)

Initially the 2D seismic lines acquisition was started with split-spread shooting with 160-160 channels with group interval 25 m and source interval of 50 m, after preliminary experimental work, however later on it was further decided to go for end on shooting with 320 channel to 500 channel keeping 12.5 m of group interval with keeping the source interval as 50 m. It was remarkably improved the data quality and it is able the pick up the far reflected data. The two processed sections using spilt spread survey and the enhanced quality of data through end on shooting are shown in Figure 4 (A) and Figure 4 (B).

Integrated Interpretation using seismic and non-seismic data:

During the first phase of the project, acquisition of 22 seismic lines covering 761.60 ground line kilometers (GLKM) are completed also seismic data was interpreted. Data has been processed by In-house processing centre of R and D Department of OIL, Duliajan and parallelly processed at M/s Fugro Geoscience Ltd, Mumbai. After processing the seismic lines, interpretation has been carried out to understand subsurface and prospect generation.

The interpretation has been carried out using 22 seismic crooked lines with processed seismic section of DMO, Pre-STM, Post STM seismic sections and other OIL subsurface geochemical data, Gore's geochemical data, gravity, aeromagnetic and surface geological data have been discussed here. To integrate the results for different depth of near top Bhuban, Middle Bhuban, Lowe Bhuban, depth of top Renji, Intra Renji and Intra Jenam formations have been discussed. Fig. 5 (A) shows the PSTM of a straight line (MZ-06) and Fig. 5 (B) shows the PSTM of the Crooked line (MZ-06A). Though these lines are not identical, however in the nearest vicinity through crooked line survey, the results are improved to a great extent. Fig. 6 shows the Pre-STM and DMO stack of the seismic line MZ-06A. It is clearly indicated that Pre-STM shows the better resolution of the horizons. It is also observed that crooked line profiles exhibited an improved subsurface imaging over the straight lines that were acquired from seismic data.

For comparative study, one seismic profile covering more seismic lines passing the Central Mizoram area along structural axis of MZ-02, MZ-03, MZ-05A has been interpreted (Fig.7). The different geological formations

Nr Top Middle Bhuban, Nr Top Lower Bhuban, Nr Top , Intra , Intra Jenam and Nr Top Basement have been interpreted. Another seismic profile covering more seismic lines passing through Central Mizoram along structural axis of MZ-16, MZ-16A, MZ-07A and MZ-16B (Fig.8). The interpreted different geological formations are also indicated in Fig.7 and Fig. 8 respectively.

Interpretation of the geochemical survey data is based on geochemical model results in the form of petroleum probability. The evaluations of the report include evidences of an active petroleum system in the region, and migration of hydrocarbons into the area. OIL has interpreted sub surface geochemical data and probable leads are identified using seismic data (Fig. 9A) and based on OIL's in-house and Gores Geochemical Model (Fig. 9B) **(Gore, 2009)** for petroleum influence probability.

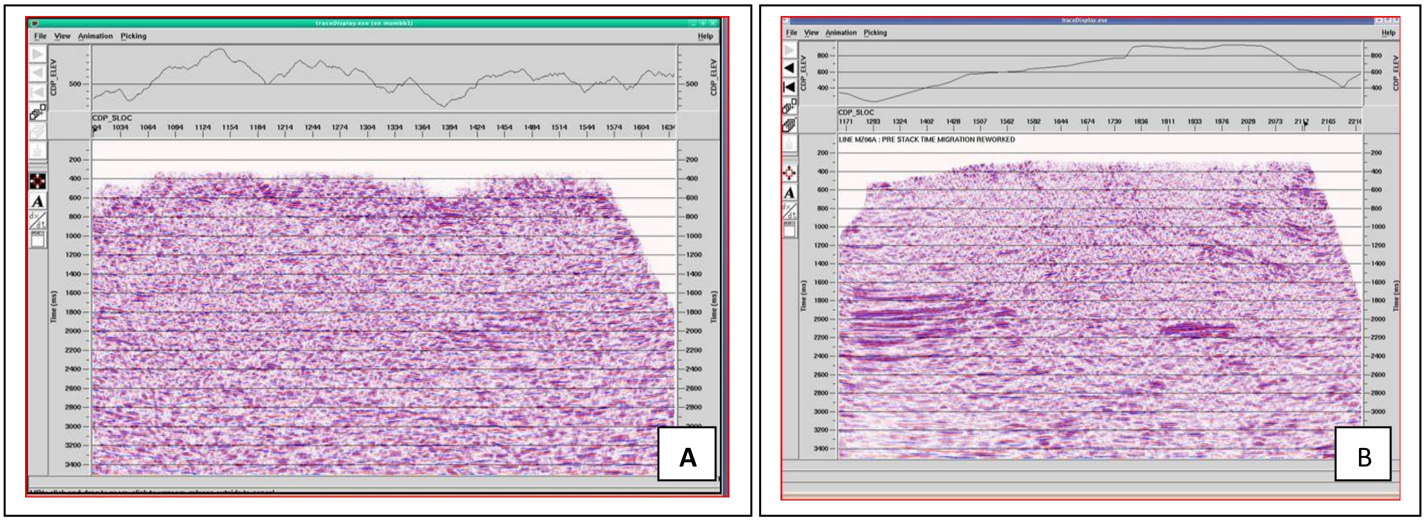

Fig 5. (A). PSTM of MZ-06 (Straight line) (A), PSTM of Crooked line (MZ-06) (B)

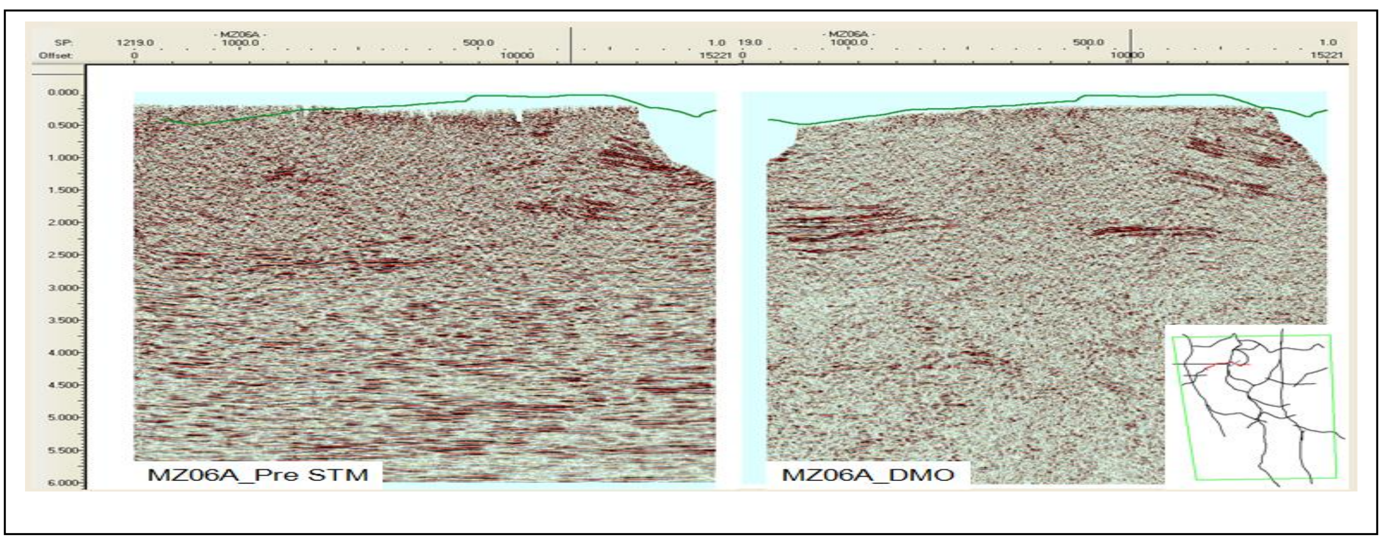

Fig. 6. Pre-STM and DMO stack of the seismic line MZ-06A.

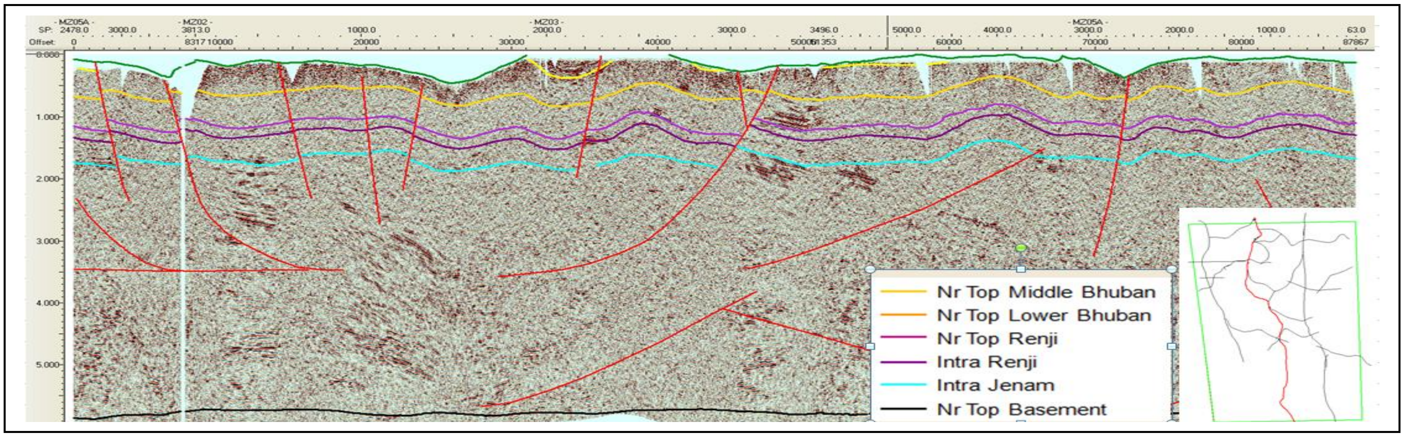

Fig. 7. Seismic lines passing the Central Mizoram along structural axis of MZ-02, MZ-03, MZ-05A. The different geological formations are also indicated.

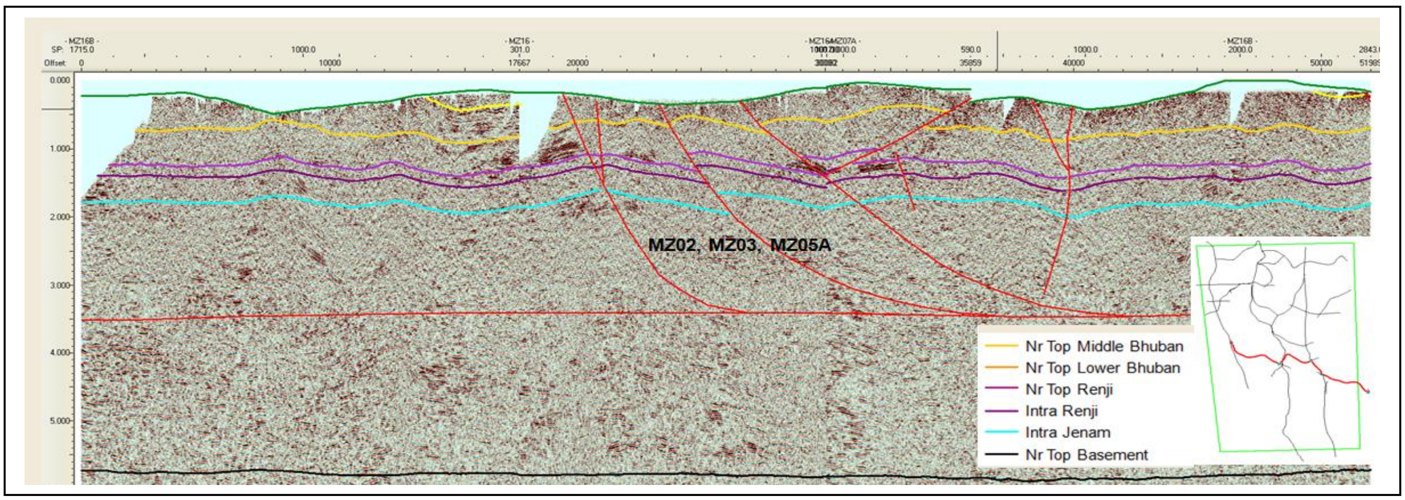

Fig. 8. Seismic lines passing the Central Mizoram along structural axis of MZ16, MZ16A, MZ07A, MZ07B, MZ16B. The different geological formations are also indicated.

Regional gravity data suggest that basement dips towards the east as gravity anomalies decreases in values from east to west (Fig.10) indicates that probable basement is higher in the east of the basin (Nettleton, 1971). Bouguer gravity anomaly data in the study area is orienting in the north-south trend varying from maximum -25 mGal to minimum -70 mGal (Fig. 10). Initially the trend is N-S direction in the north-eastern part, however in the south-western part, gravity trend is orienting from N-S to N-SW direction.

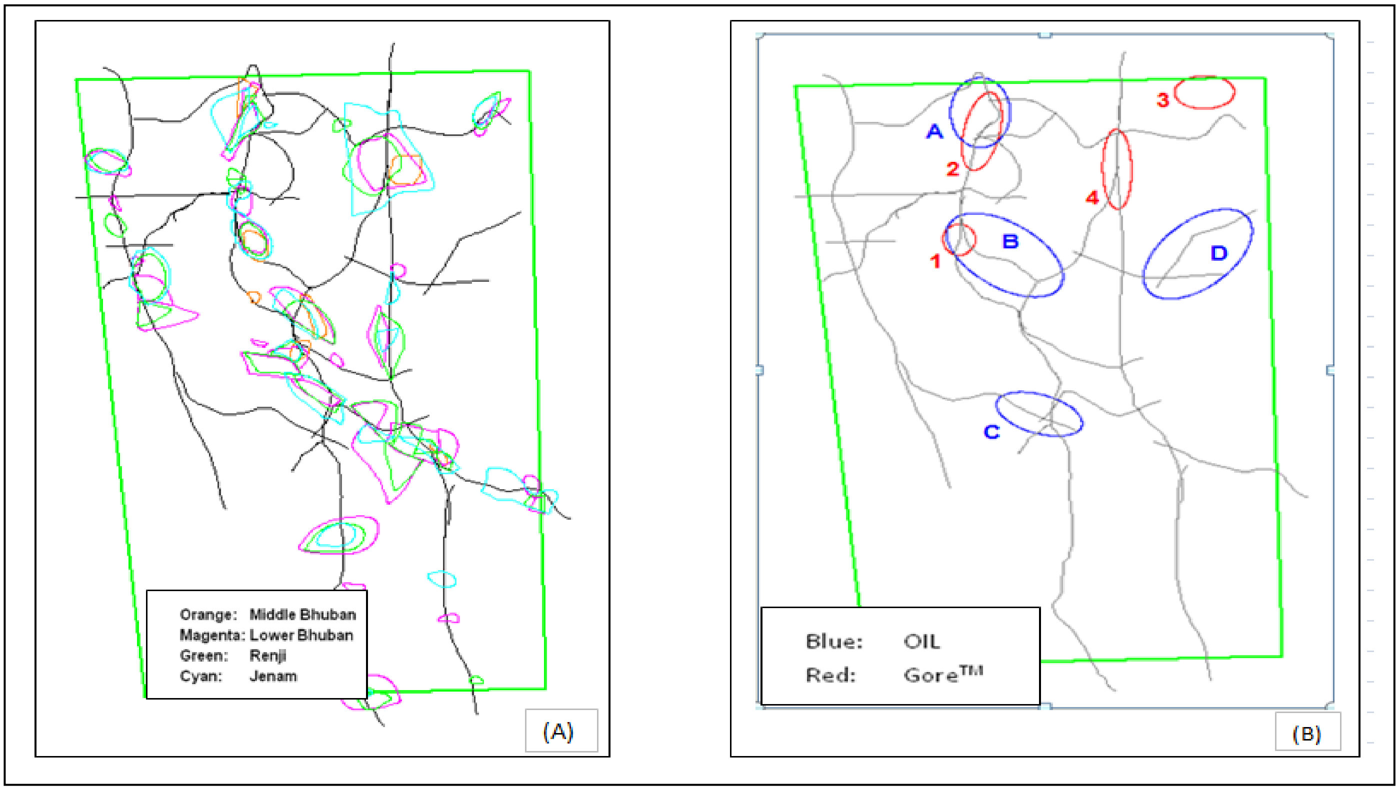

Fig. 9. Various leads are identified using seismic data (A) and Gore's and OIL's geochemical samples (B)

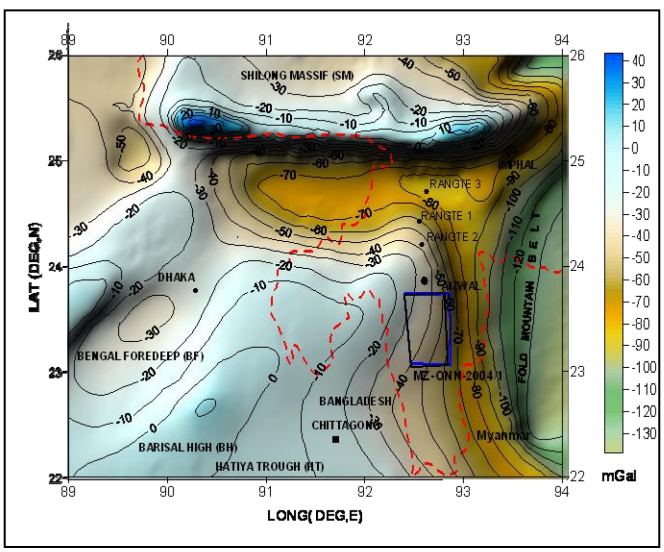

Fig. 10. Bouguer anomaly map of Assam-Arakan Basin. The marked area shows the area of study.

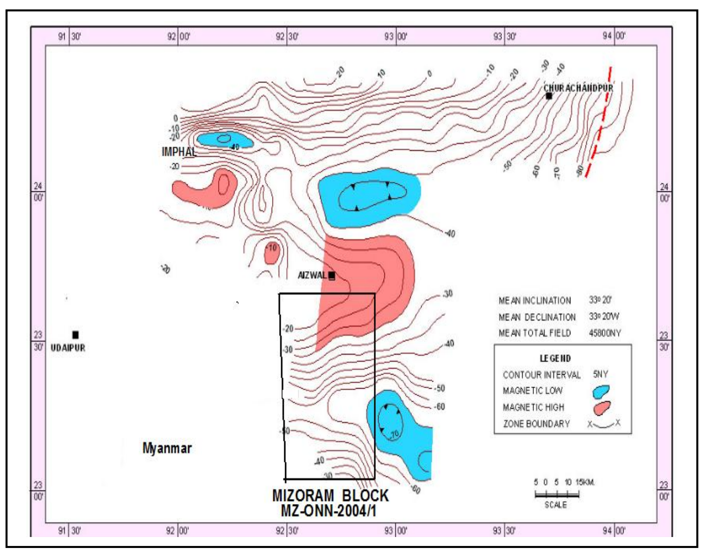

Fig. 11. Aeromagnetic contour map of the study area and its surrounding.

The gravity higher values in the western part shows the lesser basement depth and lesser elevation however in the eastern part, gravity values are decreases in and indicating more elevation (Fig. 1) and expecting more basement depth causing isostatic adjustment. The basement depth calculated through gravity data is varying from 12 km to 16 Km from the west to east direction in the study area. These duplex structures detach above probable basement at more than 5.5 seconds (TWT). The aeromagnetic contour map (Fig. 11) shows that the contours are oriented in the east west direction and the contour patters are converging in the westward side and diverging in the eastward sides. The basement depth contour map shows comparatively higher basement at the middle of the survey area and increasing towards the east as per interpretation (Fig. 12).

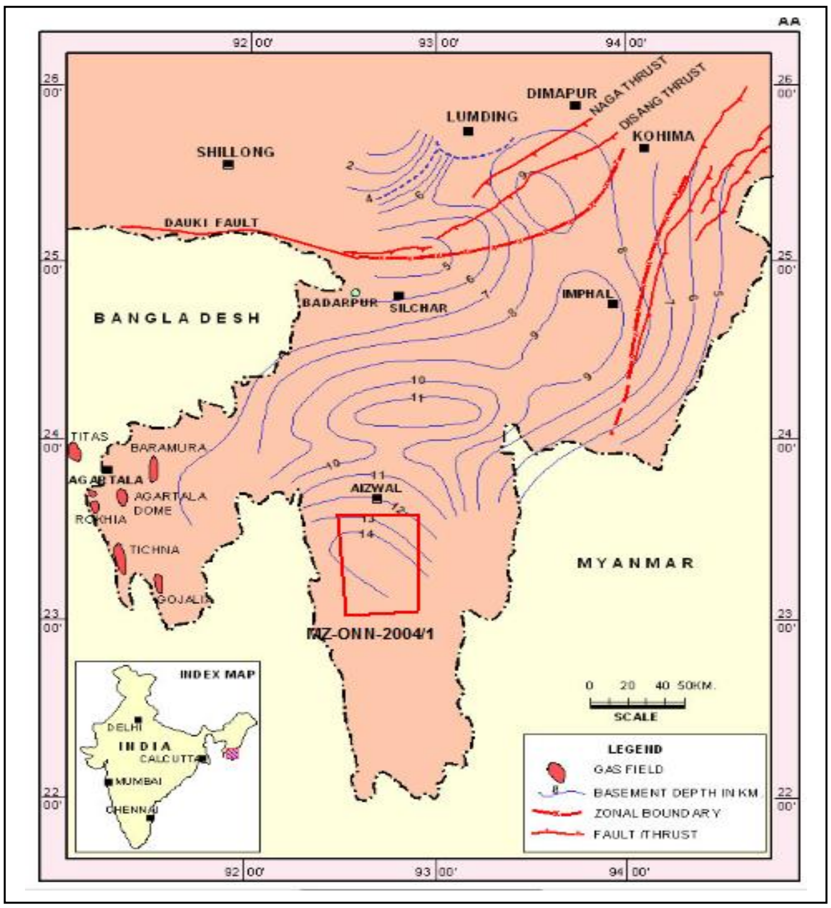

Fig. 12. Basement depth Contour map of Assam-Arakan Basin. The depth of basement at Mizoram Block is more than 14 km.

Conclusions:

Integrated Interpretation process has been carried out using seismic and non-seismic methods basically gravity, aeromagnetic, geochemical and surface structural modeling in the NELP-VI Block (MZ-ONN-2004/1) at Mizoram. The prospect has been identified using seismic along with geochemical, gravity and surface geological modelling. Gravity data interpretation shows that gravity values are decreasing from west to east direction causes more basement depth and more sedimentary deposits. However from the aeromagnetic data the contour are oriented in the east-west direction. The basement depth has been interpreted as more than 14 km which correlates up to 5.5 seconds (TWT). The integrated data was interpreted and a number of probable leads were identified and suggested for further study for the hydrocarbon exploration through drilling.

A c k n o w l e d g e m e n t:

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