Regional Fault Architecture at Rohtas Formation, Son Valley, Vindhyan Basin, India

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Abstract

Occurrence of gas within Lower Vindhyan Rohtas and Mohana Fawn Limestone and Upper Vindhyan Kaimur Sandstone in Son Valley, Vindhyan Basin has been emphasized to be controlled by presence of fault and fracture related plays. This necessitated a review of the regional fault pattern in Son Valley with focus on the fault architecture at Rohtas Limestone level and its relationship with fracture development and hydrocarbon entrapment.

The basin witnessed extensional as well as compressional regimes during the poly phase deformation history. In the early extensional regime, basement controlled deep seated faults formed horst and graben features. In the later part, compressional and shear stress have led to repeated reactivation and slip reversals along these faults. In these episodes of compressional tectonic events, a major structural inversion took place.

Of the two main sets of faults, one set (E-W to ENE-WSW) is parallel / sub-parallel to Son Narmada Lineament while the other set is oblique to SNL. A number of faults either intersects or joins with each other. Maximum intensity of fractures developed at the intersections of two major regional faults (Damoh and Jabera faults), and such locales form favorable corridors for hydrocarbon accumulation.

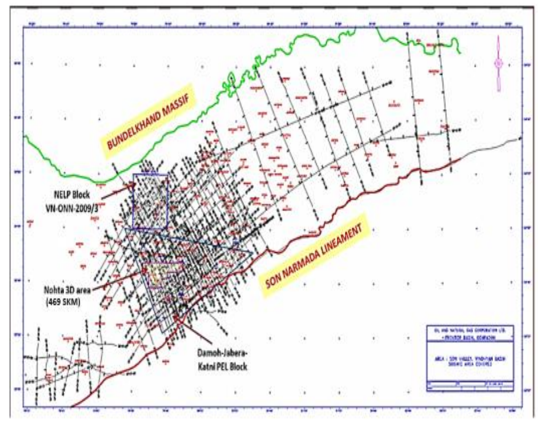

Figure.1 Seismic coverage map of the study area

Introduction:

Damoh-Jabera-Katni nomination block, which falls in the central part of the study area (Fig.1) has established the presence of gas in the unconventional tight Lower Vindhyan Mohana Fawn Limestone, Rohtas Limestone and Upper Vindhyan Kaimur Sandstone. In order to understand the role of fault/fracture network and characteristics of limestone reservoir, a detailed analysis of the fault pattern was carried out on regional level.

Methodology:

To achieve the above objectives, detailed structural frame work was prepared using the available seismic, geological, gravity-magnetic and well data for the entire basin in terms of time structure and time thickness maps of the Rohtas Formation. Geological modeling incorporating the surface lineaments, fault network and paleogeography during the Rohtas Formation has been attempted.

Tectonic setting:

The Vindhyan Basin is a poly historic basin and the detailed studies of the basin including the fault systems, paleo-structures, structural inversions and deformation history has been described by many workers from time to time (Jokhan Ram etal, 1996, Mahendra Pratap et al 1999). The Vindhyan Basin associated with two mega tectonic elements: Great Boundary Fault (GBF) to the northwest and Son-Narmada Lineament (SNL) to the south, remained active throughout geologic history till the present day. The Vindhyan sediments of Son Valley define a broad ENE–WSW trending regional syncline in the central part. The axis of the syncline is slightly curved (convex towards north) and plunges gently towards west.

The northern and eastern margins of basin have gentle gradient. Intense structural deformation of the Lower Vindhyan Sequence in vicinity of SNL is evidenced by the presence of tight folds, normal and reverse faults, thrusted contacts and mylonitisation. Early phase of tectonic evolution of Vindhyan Basin is controlled by basement related rift tectonics which formed a number of horst and grabens (Fig.2) along planes of weakness. The major half grabens are located along the down thrown side of these rift related faults. Some of these faults show syn-sedimentary vertical movements. In later phase of evolution, compressional reactivation of pre-existing extensional faults (Fig. 3) under the influence of wrench related strike–slip movement along the Son-Narmada Lineament (SNL) resulted in the formation of inversion structures like Damoh, Jabera and Kharkhari. Major oblique faults divide Son Valley into a number of tectonic blocks; notable among these are Udaipur-Tendukhera block, Jabera-Damoh block and Satna-Rewa-Kaimur block. Among these blocks, the Jabera-Damoh block is tectonically the most disturbed.

Gravity data:

The Residual Gravity anomaly map (Fig. 4) indicates that the basin is generally dipping towards south with occurrence of a series of ENE-WSW trending gravity highs and lows between Bundelkhand massif in the north and SNL in the south, mostly parallel to the trend of SNL. These gravity highs and lows correlate well with the horst and graben type of basement configuration. The basin is controlled by basement faults and is divided into several sub-basins separated by intervening horst blocks (Fig 2). An ENE-WSW trending regional gravity high belt is seen in the northern part of the area along the southern fringe of Bundelkhand massif (gravity values -16 to -34 mGal). This high trend extends from Narsinghgarh in the west through Bina, Amanganj, Satna to Mirzapur in the east. In the area of present study, this gravity high belt is correlatable with the ENE-WSW trending Singoli-Rajgarh-Banda ridge situated to the north of Hatta. The gravity lows, corresponding to the major depocenters, occur in the close proximity of SNL.

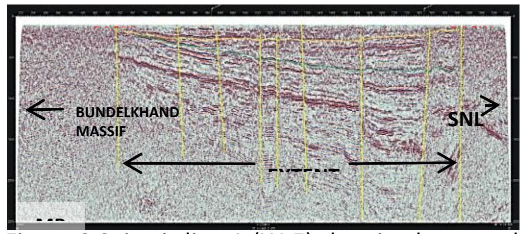

Figure.2 Seismic line A (W-E) showing horst graben set up

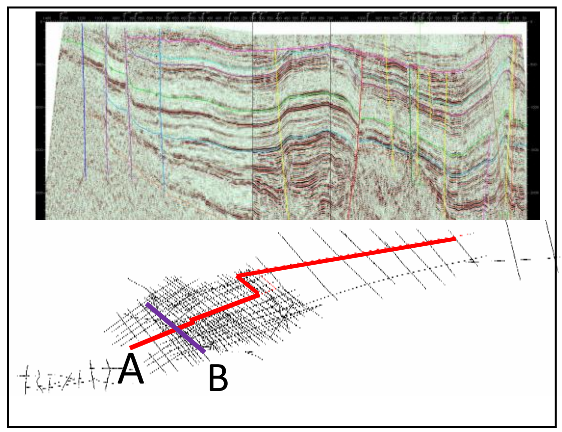

Figure.3 Seismic line (B) (N-S) showing reactivated normal/ reverse faults in the area

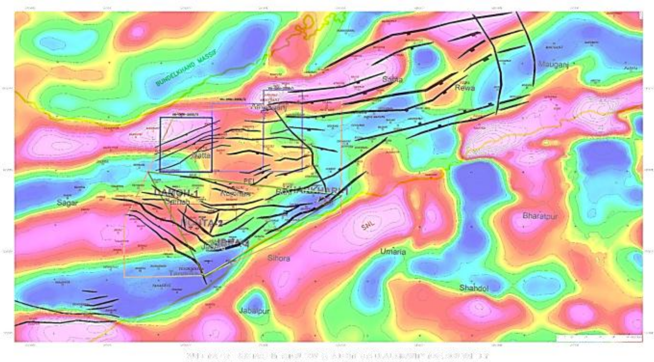

Figure.4 Major faults at Rohtas Limestone Top overlain on Residual Gravity anomaly map (Source: KDMIPE reports)

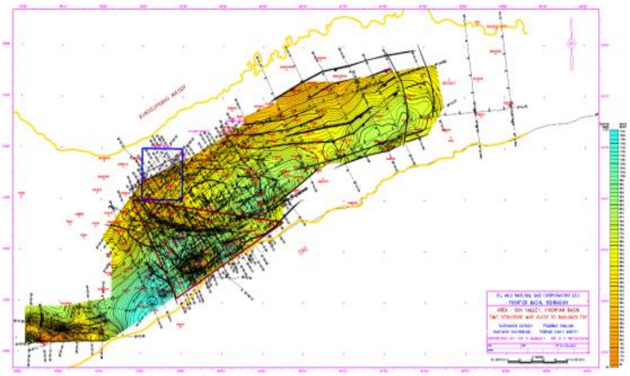

Fig.5 Time structure map at the top of Rohtas Limestone.

Seismic data:

An integrated interpretation of 6675 LKM of 2D seismic data coupled with newly acquired and processed 469.6 SKM of Nohta 3D seismic data was taken up to understand the distribution of fault pattern in the area of study. Being the primary gas bearing reservoir, the present analysis was targeted at the Rohtas Limestone (Lower Vindhyan).

Stratigraphically, two important horizons, ie Rohtas Limestone and Basuhari Shale were correlated over the entire seismic coverage area in the Son valley. Time structure maps (Figure.5) close to the top of Rohtas Limestone Formation were prepared to bring out their morpho-tectonic pattern. Change of axis of the structure indicates the strikeslip movement and cross fault occurrence. Time thickness map (Figure.6) clearly shows that Rohtas Limestone is thickening towards S-W of the area where as it is shallowing and thining towards N-E.

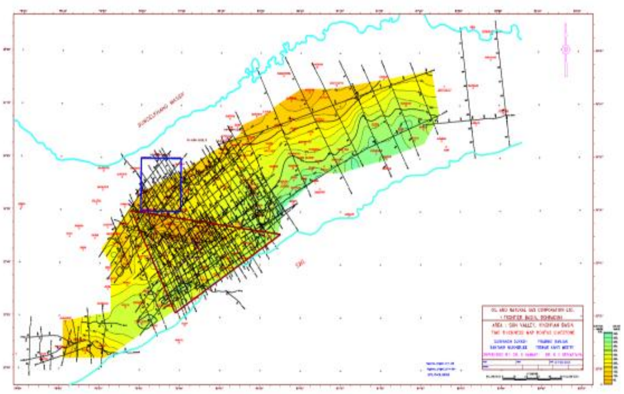

Figure.6 Time thickness map of Rohtas Limestone

Fault Architecture:

In the area of present study, two dominant fault trends are observed (Fig.7), faults parallel/sub-parallel to SNL (E-W to ENE-WSW) and oblique to SNL (NW-SE to WNW-ESE). Most of these faults exhibit composite signatures of extensional and shear stress regimes due to poly phase deformation history. The southernmost fault in the study area to the south of Jabera structure runs parallel to the Son-Narmada Lineament (ENE-WSW). The SNL has acted as a major basin margin fault zone and remained active throughout the geological history. A number of collinear step faults have developed parallel to SNL and such faults are seen to intersect/ join with each other. Although, these faults originated as normal faults during rifting stage, they were subsequently reactivated under inversion related compressional stress leading to slip reversal during the formation of Jabera anticline. These fault trends are also extending in the Satna-Rewa-Kaimur Block as southern basin margin faults with dips towards N-NW. In the northern part of the study area, four prominent ENE-WSW trending normal graben bounding faults, with dip to the south, are seen to the north of Hatta block. These faults take a swing in the trend from ENE-WSW to almost EW and extends towards east in the Satna-Rewa-Kaimur Block as basin margin faults. The trends of these faults is parallel to the trend of Rajgarh-Banda ridge on the fringe of Bundelkhand massif.

Surface lineament Trends:

Surface lineament trends in the area are studied exhaustively and mapped by KDMIPE. On, superimposing the fault pattern over the surface lineament map (Fig.7), it is observed that most lineaments coincide with surface and subsurface faults. Fracture intensity is maximum along axis of Vindhyan Syncline. Another notable observation is that the southern margin close to SNL is tectonically more disturbed and more fractured while the northern limb of syncline shows fewer fractures. Fractures are mostly open on the surface around Jabera and Kharkhari structures.

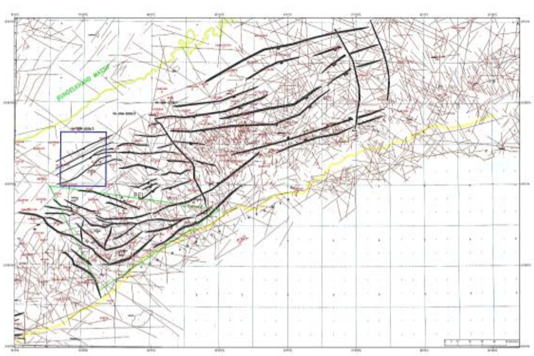

Figure.7 Fault Pattern Overlain on the surface Lineament Network

Conclusion:

Review of the basin architecture and evolution suggests an initial incipient rift architecture followed by episodic compressional tectonics which led to the formation of major inversion structures. Two dominant fault trends, ENE-WSW and NW-SE and the NW-SE to WNW-ESE trending oblique faults, divide the sub basin into a number of tectonic blocks.

Integrated analysis of the fault pattern, surface fracture and lineament trends led to the identification of several areas having high fracture density around Maihar, Amarpatan, Govindgarh, West of Nohta and Tendukhera.

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