

Delineation of Basement Related Fault Closures in Eastern Part of Purnea Basin Based on Morphotectonic Analysis*

S. Majumdar¹, H. D. Dave¹, J. K. Samal¹, and D. S. Mitra¹

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¹Shell Technology of India, Bangalore, India

Abstract

The Purnea basin is a polycyclic rift basin located in the eastern part of Indo-Gangetic plain in Bihar and West Bengal continuing further eastwards to the Bangladesh border and beyond. Tectonically it could be classified as an intracratonic rift basin with an approximate thickness of about 4,000 m of sediments ranging in age from Permo-Carboniferous to Recent. The basin is bounded and separated from the Ganga Basin in the west by Monghyr Saharsa ridge whereas in the east it is bounded by the Kishanganj Fault. The south and northern extents of the basin are bounded by the Malda High and Main Boundary fault respectively (Bhowmik, 2009). Geochemical data from the four drilled wells in Purnea Basin indicate that Lower Gondwana sequence has generated hydrocarbons whereas a recent gas discovery in Salbanhat, Bangladesh close to the Indo-Bangladesh border also suggests that the equivalent sediments would be prospective in this part. The arenaceous facies in Upper and Lower Gondwana act as suitable reservoir rocks whereas presence of clay/ shale beds in Gondwana and Siwaliks may act as suitable cap rocks. As such, fault closures of Basement related faults, pinch outs and wedge outs in Lower Gondwana sequence can act as interesting elements for exploration. These sub surface structures might be manifested as subtle geomorphic features on the surface as a result of reactivation due to prevalent neotectonic stresses. In this paper, an attempt had been made to identify such morphotectonic elements in order to identify probable structures of exploratory interest and to provide input for refinement of the existing geological model. The morphotectonic analysis has been carried mainly based on drainage, followed by field check to validate them. The study area is confined to the West Bengal part of the Purnea Basin bounded on the west by the Mahananda River, in the north by Kishanganj Fault, in south by Rajmahal Fault and the east by Atrai River ([Figure 1](#)).

Principle

Drainage developed in a particular terrain is very sensitive to any sort of vertical deformation along faults with any sort of active tectonic movements inducing changes in channel pattern, channel diversions and channel behaviour. Such anomalous drainage behaviour are manifested in drainage features like variations in sinuosity, development of rectangular or angular drainages, abrupt drainage offsets and compressed meanders and are found to be more prominent in drainages of lower order. Such changes in a drainage network are useful in analysing and identifying subtle structures in low relief covered basins that control the pattern and style of drainage change. Such drainage-based analysis can be done by drawing perpendiculars to tangents at the down slope convexities of the contour surfaces, which represents the slope of the terrain, and comparing them to actual flow direction of the rivers. A difference of more than 10° between them suggests a drainage anomaly (Burrato et al, 2003). Such a drainage anomaly implies some amount of subsurface structural control due to active tectonics on the drainage causing it to divert itself from the actual slope direction. The subsurface structural control delineated on basis of the above study occurs either in the form of faults or as structural highs which control the pattern and style of the surface deformation with the changes in drainage governed by the geometry and kinematics of the tectonic surface.

Drainage Analysis

The anomalous drainage that had been interpreted based on principle outline above and shown in [Figure 2](#) had been studied further for the existence of faults or geomorphic highs that had given rise to these anomalies. The detailed study was based on drainage parameters like drainage patterns, sinuosity variations, drainage offsets as well as drainage divergences from which the probable faults and structures that might cause the drainage anomalies were interpreted.

On basis of such analysis of drainage parameters, small-scale faults had been interpreted in the area to explain areas of anomalous drainage in the area. A density analysis had been carried out on these faults that act as building blocks to delineate regional and major faults in the basin area. In a similar way, geomorphic highs had also been delineated in the area from drainage parameters to explain drainage anomalies in the basin ([Figure 3](#)). Additionally longitudinal major faults like the Basin Margin Fault in the adjoining Bengal Basin had also been found to continue in the Purnea Basin suggesting similar tectonic episodes.

The above morphotectonic observations were then corroborated by subsequent field checks to validate the interpretations. The field representation of one such fault is shown in [Figure 4](#).

Integration with Subsurface Data

The morphotectonic interpretation based on drainage data had been integrated with available gravity and seismic information for better analysis and validation of the interpretation.

Seismic data: Based on interpretations of different workers (Dutta et al, 1995, Mandal et al, 1997, Mishra et al, 1993), existing seismic data from isochron maps of Basement, Lower Gondwana, Upper Gondwana, and Siwaliks had been used to analyze, correlate and validate the morphotectonic interpretations based on geomorphic data. An overlay of these faults ([Figure 5a](#)) on geomorphic data shows some match in the NE-SW trending faults. However, faults affecting the Siwaliks show a more ENE-WSW trend that is not detected from the surface morphotectonic data. This probably suggests that the faults affecting the Basement, Upper and Lower Gondwana are continuous up to the surface where as the faults interpreted at the top of Siwalik are genetically different and do not have any impact on the surface geomorphology. Similarly, on correlation of the seismic highs with surface highs ([Figure 5b](#)), a good amount of correlation is observed between the highs interpreted at the top of Lower Gondwana and Basement surface. However, no evidence of Siwalik highs is observed on the surface from morphotectonic analysis.

Gravity Data: A 3D gravity perspective generated from Bouguer data shows abrupt slopes on northern and western sides plunging northwestward into a gravity low near Katihar-Purnea region suggestive of fault control with the southward side of the slope being more gradual. The major faults that had been interpreted from geomorphic data when overlain on the 3D perspective are found to border the high on the northern, western and southern sides whereas the regional faults occurring on the high follow a similar trend as the major faults ([Figure 6](#)). These regional faults and associated geomorphic highs on the gravity high are probably effects of the uplift due to movement along surrounding major faults during basin formation.

Discussion and Conclusions

The variation of trend of the faults from Basement to the surface ([Figure 7](#)) shows that a NE-SW as well as NW-SE trend continuous from Basement to the surface. However, during Upper Gondwana, an additional NNE-SSW trend related to the Rajmahal tectonics is observed. In addition, a later ENE-WSW trend during Siwaliks is observed probably related to the Himalayan orogeny. At the surface, however, the dominant trend observed is the NW-SE trend along with a subsidiary NE-SW trend.

This suggests that only the Basement and the Gondwana related trends, i.e. both the NW-SE trending as well as the NE-SW trending faults are basement controlled, that had been continuous from gravity surface to topographic surface and had been neotectonically

reactivated controlling the slope and drainage of the Purnea Basin. However, the trends related to the Siwaliks are probably not as penetrative and had not been affected by the neotectonic effects. Faulting along these deep-seated NW-SE as well as NE-SW trends might lead to the development of fault-related structural closures, manifestations of which are found to occur on the surface as geomorphic highs in some of the cases. These geomorphic highs reflective of basement related-fault closures and falling in vicinity of depocentre areas might be seen as prospective locales for hydrocarbon accumulation in the Purnea Basin

The opinion expressed by the authors is not necessarily the opinion of the organization that they represent

Selected References

Burrato, P, F. Ciucci, and G. Valensise, 2003, An inventory of river anomalies in the Po Plain, Northern Italy: evidence for active blind thrust faulting: v. 46/5, Annals of Geophysics, p. 865-881.

Dutta, N.G., D. Dasgupta, and K.V.L. Naganandini, 1995, Construction of Depositional Model of Purnea basin and its Prospect Evaluation: Oil and Natural Gas Company (ONGC), India, unpublished report.

Mandal, N.C., P.K. Srivastava, and D. Pal, 1997, Study of fault patterns and structural styles in northern part of Purnea basin: Oil and Natural Gas Company (ONGC), India, unpublished report.

Mishra, S.N., S. Mitra, and A. Dasgupta, 1993, Integrated evaluation of Purnea Basin East of Ganga Valley: Oil and Natural Gas Company (ONGC), India, unpublished report.

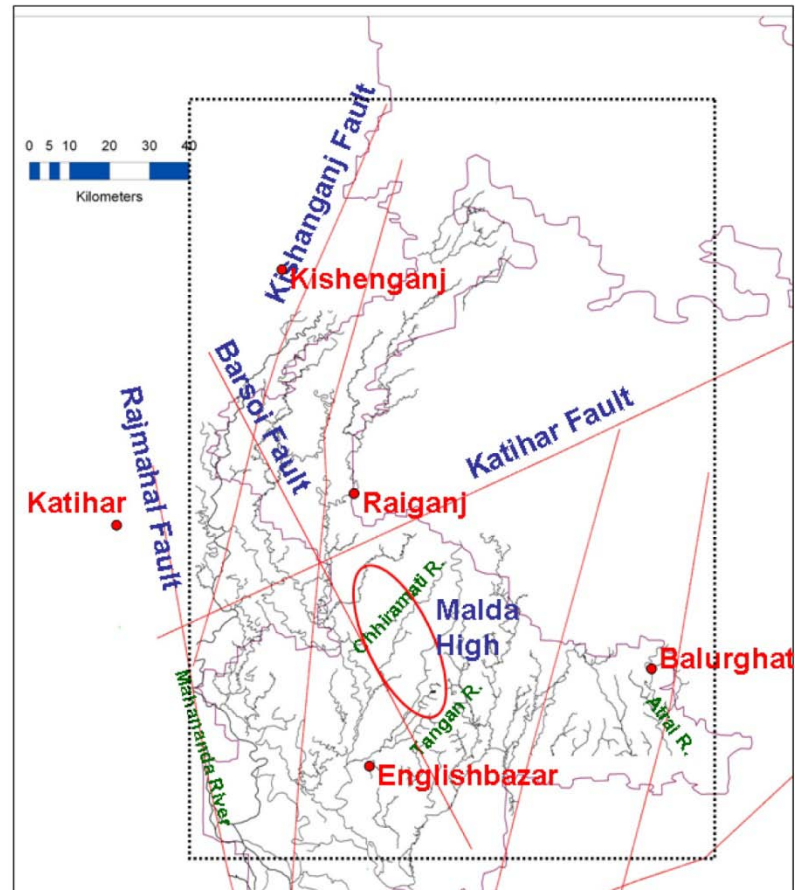


Figure 1. Tectonic features and drainage in Purnea Basin. Dotted line indicative of study area.

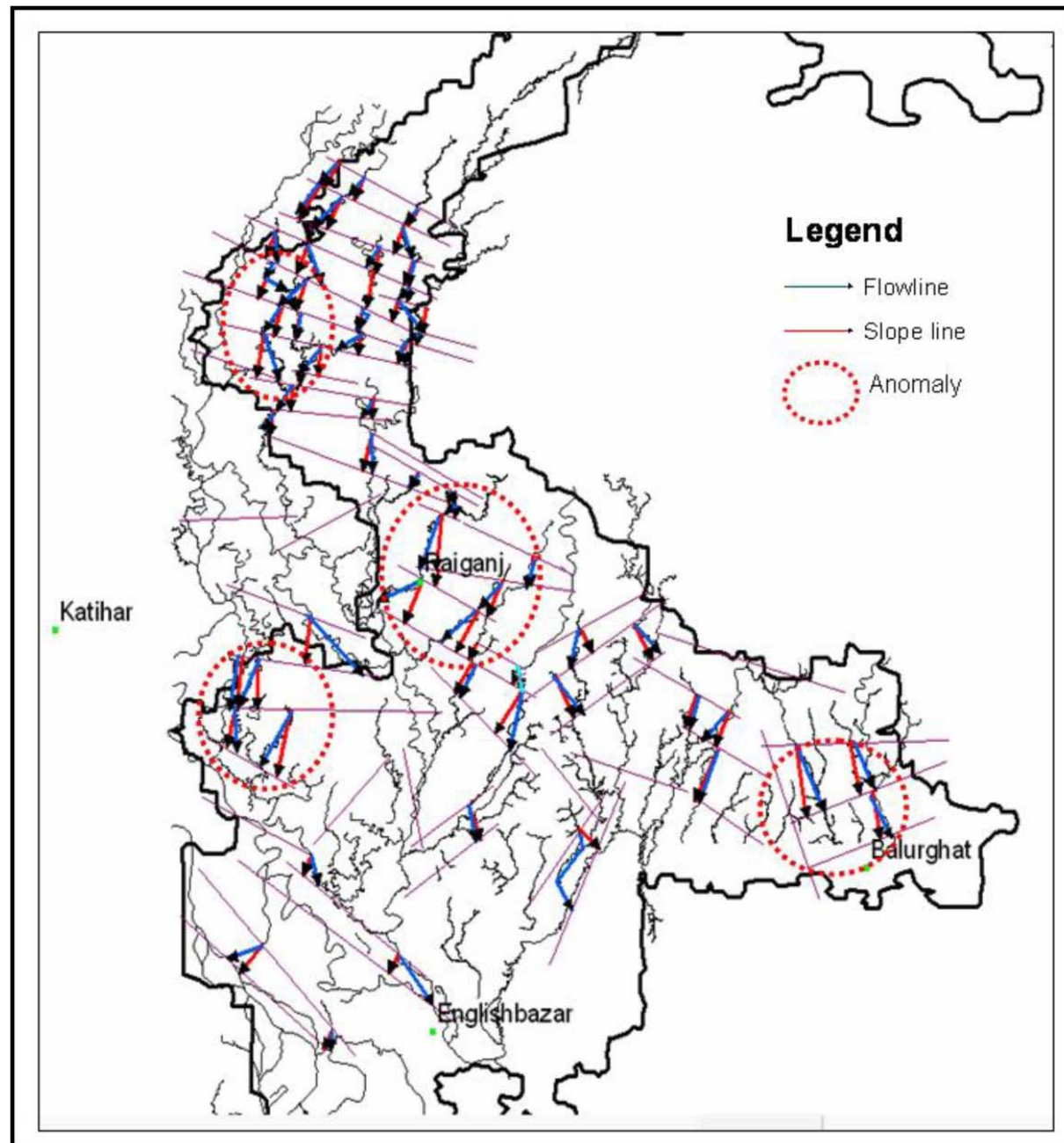


Figure 2. Structure controlled drainage anomalies in study area.

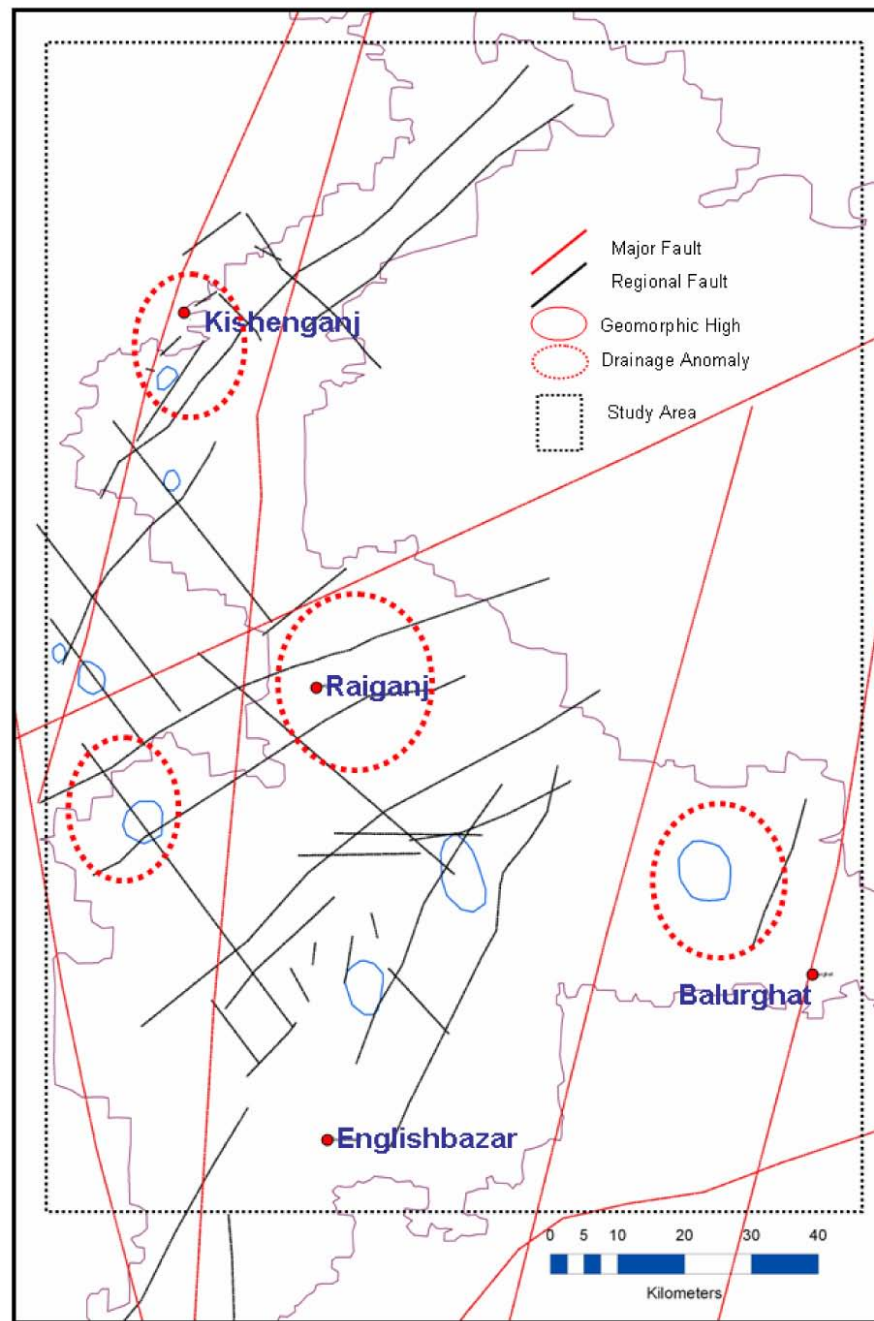


Figure 3. Faults and geomorphic highs interpreted in the study area.

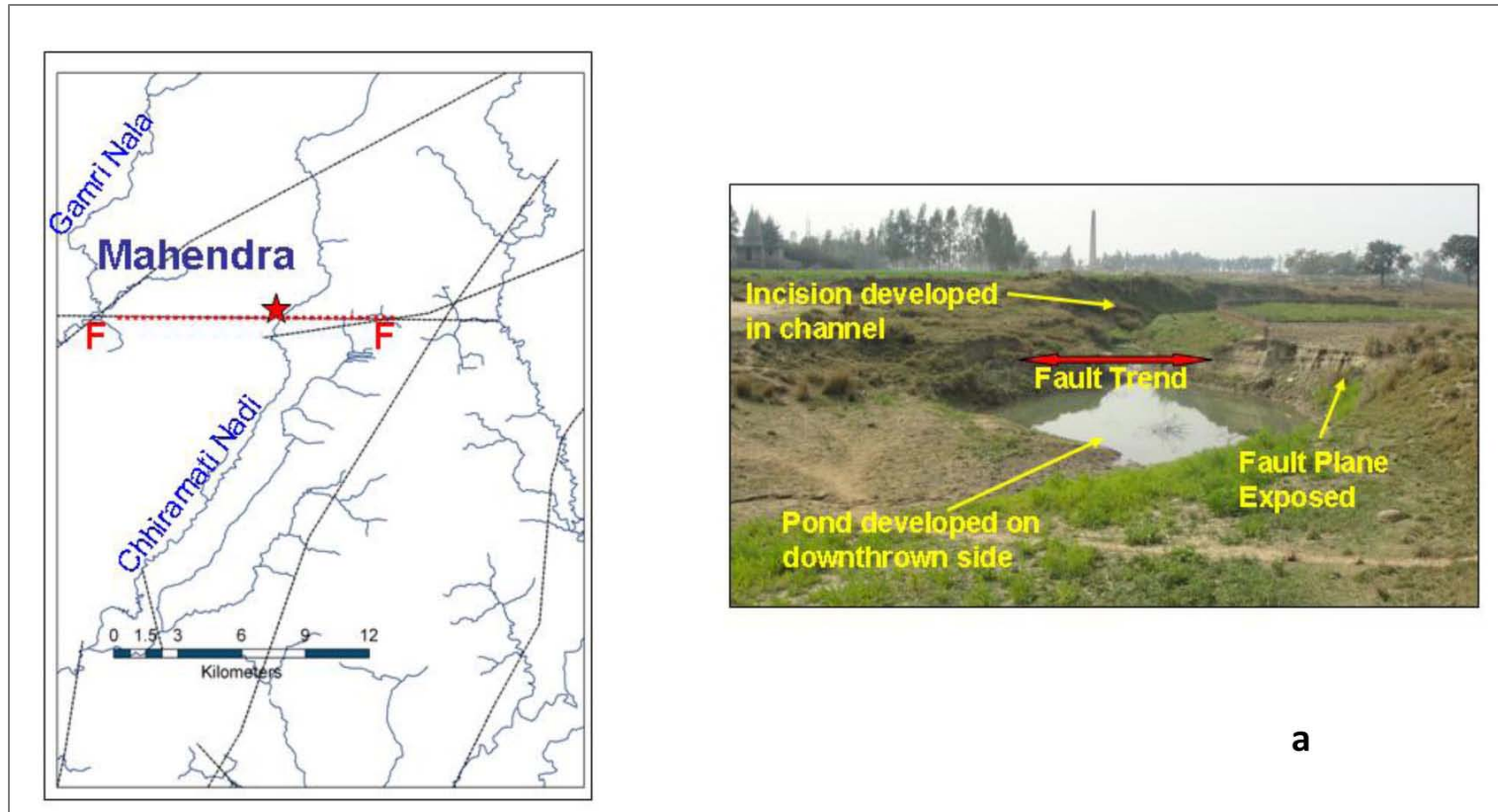


Figure 4. a) Near Srikrishnapur, fault plane of fault FF exposed in alluvium leading to the development of drainage along the fault trace. b) At Mahendra, due to effect of fault FF, pond developed on the downthrown side and prominent incision developed on the up thrown side. Fault plane exposed in alluvium.

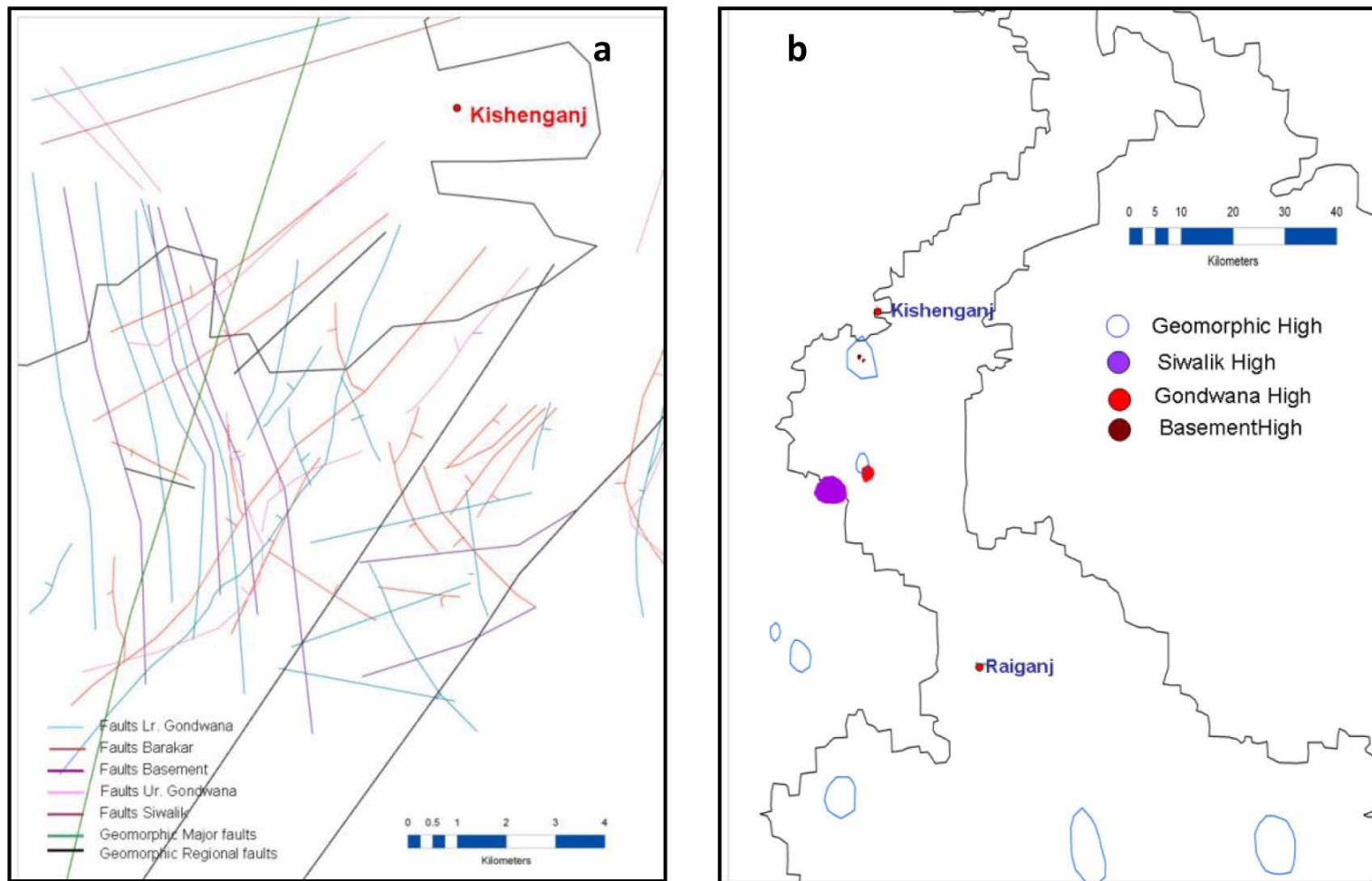


Figure 5. a) Overlay of faults interpreted from drainage with faults interpreted from seismic. b) Overlay of highs interpreted from drainage with highs interpreted from seismic.

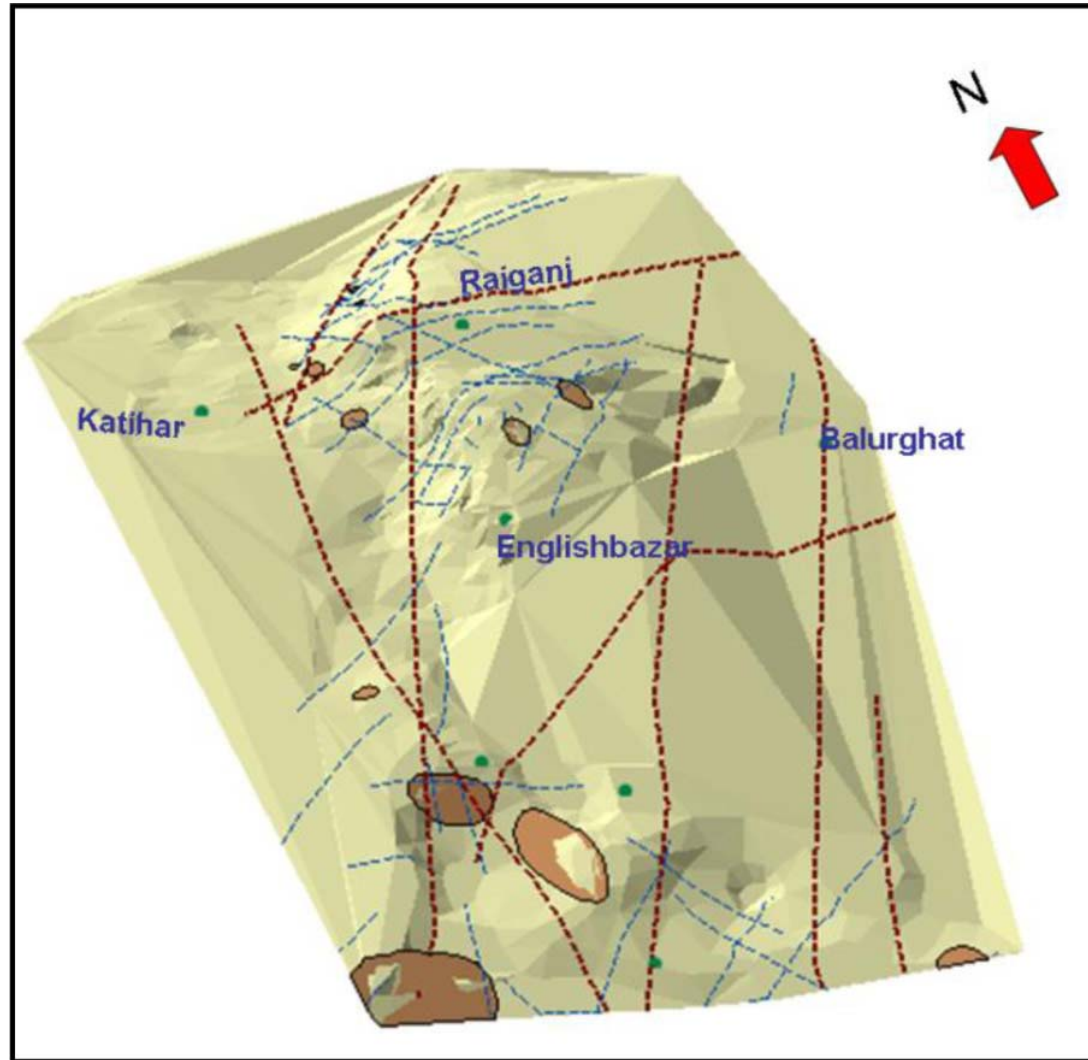


Figure 6. Morphotectonic elements superimposed on 3D perspective of gravity data, Purnea Basin.

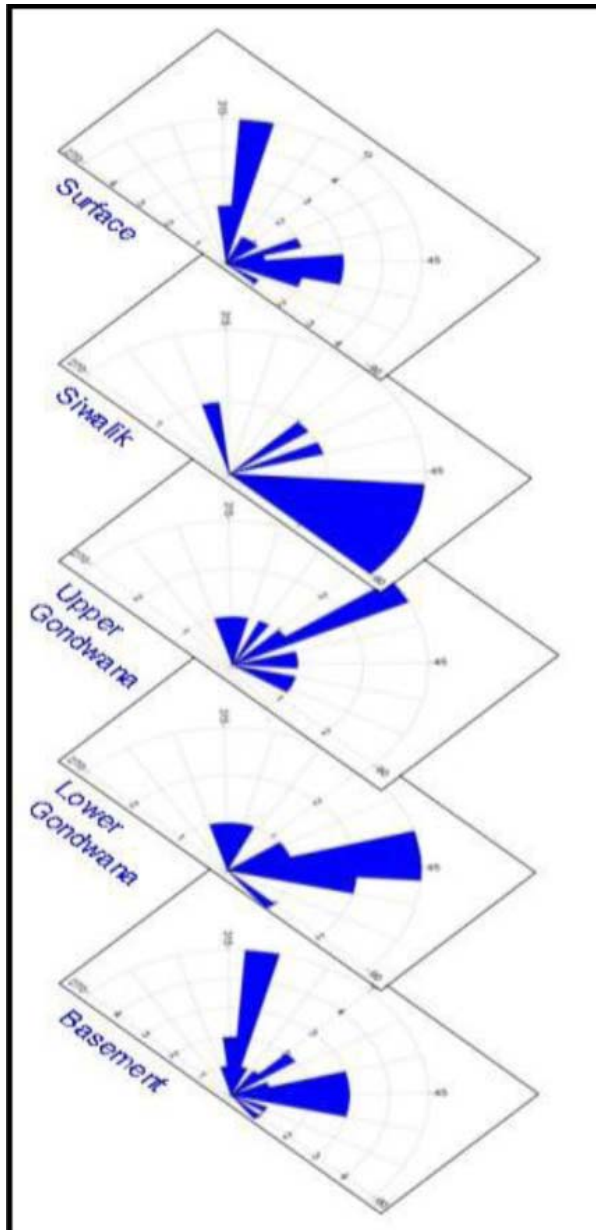


Figure.7) Variation of fault trends from Basement to surface.