Regional Structural Style of Chambal Valley Vindhyan Basin, Rajasthan, India*

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Abstract

The Chambal Valley Sector of Vindhyan Basin is located in eastern Rajasthan, India and covers an area of approximately 80,000 km^2. It is believed to be the western continuation of Son Valley Vindhyan Basin albeit obscured by a 40,000 km^2 drape of basalt towards the south. Chambal Valley Sector is known to possess Meso-Neo Proterozoic fill to the magnitude of over 6,000 meters based on analogy from geological database of relatively better-explored Son Valley and recently acquired 2D seismic data in the said sector. However, Chambal Valley depicts large-scale structural deformation readily evident by multitudes of eye catching surface morphological entities.

Through this article, we attempt to promote a contention of poly-history tectonics and thereby regional structural style of Chambal Valley Sector, Vindhyan Basin.

Surface geological, satellite imagery, potential field and 2D reflection seismic data has been utilized for elucidation of information and facts generation. The observations thus gathered have aided in developing an understanding of the causatives of this structural vividness.

Observations and Discussions

The surface geology of Chambal Valley depicts three prominent structural trends, namely, the Chittaurgarh N-S trend, the Rawatbhata-Aklera NW-SE trend and the Great Boundary Fault NE-SW trend (Figure 1).

The Chittaurgarh structural trend is contiguous to the towns of Chittaurgarh, Nimbahera and Bhagwanpura. It forms a complex of second-order folds, which are waveform open folds, discontinuous and generally asymmetrical having steeper western flank (Prasad, Balmiki, 1976). Faults are rare within this suite.

The Rawatbhata-Aklera structural trend comprises en-echelon disposed faults and highly asymmetrical folds with the northeastern flank depicting a scarp manifesting as the Mukundara hill range. We interpret this as a fault line scarp orthogonal to the Great Boundary Fault comprising at least three to four fault traces exhibited by steeply dipping linear and narrow Upper Vindhyan outcrops. We recognized the fault zone as a Principal Deformation Zone (PDZ). There is immense structural control on the Ahu and Kali-Sindh rivers at Gagraun Village. Ahu River, a tributary to Kali-Sindh, drains due north and is deflected towards the southeast around Suket Village, only to abide the structural compulsions, prior to meeting Kali-Sindh draining northwards. Within a short distance to the northeast from the Mukundara fault, the dips become very gentle and show well developed flatirons. The southwestern flank of these asymmetrical folds depicts extensive cuesta landforms with low dips in the range of 5° to 8°. Conspicuous among these folds are the Chechat, Suket and Jhalawar anticlines in the Rawatbhata-Aklera segment. These anticlines are in their late breaching stage and expose uppermost Lower Vindhyan rocks in their cores. The Chechat Anticline exhibits remarkable expression of a triangular valley, which is the manifestation of its northwestern plunge near Bhainsrorgarh. A geological cross-section across the Jhalawar anticline (Figure 2) depicts our rendition across the Rawatbhata-Aklera structural trend and is borne-out by subsequent and newly acquired 2D seismic (Figure 4).

Towards the south of Suket Village, a small doubly plunging anticline of roughly 5 km axial length is observed, which probably continues further to the southeast under the Trap cover. Jhalawar Anticline is disposed en-echelon towards the northeast of Chechat Anticline, with an intervening complimentary syncline northwest of Suket Village. It plunges to the northwest near Suket, and continues southeastwards under the Trap cover beyond Aklera Village. A few additional folded structures are observed southwest of Chechat-Suket-Jhalawar complex in the Ramganj Mandi-Bhanpura-Rampura area. These folds are near symmetrical and their axial traces are parallel to subparallel to the Chechat-Jhalawar folds. This NW-SE trend has been interpreted as reflecting tension release (Jha et.al, 1985).

The Great Boundary Fault (GBF) structural entity forms the upturned margin of the Chambal Valley basin towards the northwest. It runs from northeast of Sawai Madhopur (concealed under Gangetic Alluvium) towards south through Indergarh, Bundi, and Mandalgarh and beyond Chittaurgarh and comprises an imbricate system incorporating several ENE-WSW trending faults and tight folds. Some of these folds are known as Gowta, Dolaria, Satar, Bichor-Parsoli and Bijolia. Towards the southwest, it is not traceable

in the metamorphic and granitic terrain. The Great Boundary Fault juxtaposes the Pre-Vindhyan rock suits with the Vindhyan rocks and it is a northeast verging thrust fault. It has a listric trace as can be surmised on the DSS transect (Prasad et.al, 2006). Different sectors along the GBF show variable throw and juxtaposition of formations and their folded disposition (Punjrath et.al, 1988).

Chambal River drains towards the northeast in an anomalously rectilinear course and exhibits enormous structural control. This attribute has been recognized by previous workers as Kota-Dhaulpur Wrench or Chambal Thrust. Chambal thrust is known to juxtapose low dipping undeformed Vindhyan rocks to the east with folded and faulted Vindhyan rocks to its west (Verma, 2001). Its NE-SW trend is consistent with the GBF trend and presumably Chambal Thrust is a younger splay of the Great Boundary fault.

Neotectonic nuances seem to be prevalent in the Chambal Valley. North of Mukundara Hills, the Bhander Formation outcrops are disposed as anticlinal inliers. These form the young structures with consequent drainage on either topographical slope. An instance of drainage antecedence by Parwan River is observed in one of the anticlines. These features are at best in their early breaching stage. Satellite data depicts numerous drainage anomalies in the alluvial covered northeastern portion of Chambal valley as unusual deflections in the streams and rivers rendering a circular to quasi-circular pattern (Dey, 1996). These morphological forms (Figure 1) are presumed to be neotectonic reactivations of the subsurface structures. A peculiar circular morphological feature is observed at Ramgarh locality northeast of Baran Town, It was interpreted by Crawford (1972) as a meteorite impact. However, Sharma (1970) opines that the feature is topographically a circular basin and structurally a dome having quaquaversal dips. It is termed as Ramgarh Dome. The dome rises 150 meters above the ground level and exhibits radial dips in an area of about 14 km^2.

The surface geological configuration of Chambal Valley is corroborated by the observations on Bouguer Gravity map (Figure 3), which conspicuously depicts Singoli-Rajgarh High trending NW-SE that is disposed orthogonal to the GBF and regional trends occurring in the Son Valley (ENE-WSW) to the south.

The authors interpret this high trend as shallow basement owing to a regional NW-SE trending fault none other than Mukundara PDZ. A gravity-low nosing juxtaposes this gravity-high to the northeast in Bundi-Kota-Jhalawar sector. This configuration is in conformity with the geological cross section across the Rawatbhata-Aklera structural trend (Figure 2). The 2D reflection seismic also corroborates these surface geological manifestations and clearly brings out the trace of Mukundara PDZ revealing it as a reverse fault with colossal up throw towards the south. Besides elucidating structural vibrancy, the seismic data has also aided in demarcating the hanging wall, south of Mukundara Fault. Numerous four-way and fault closures exist in the footwall, while pop-up structures predominate the hanging wall north of Mukundara PDZ (Figure 4).

Vindhyan geology is commonly understood to be a system of unmetamorphosed sediments lying over a stable craton and structurally deformed on its upturned margins; the NE-SW trending Great Boundary Fault in the northwest and ENE-WSW trending Son Narmada Lineament to the south. The present studies reveal yet another predominant but orthogonal NW-SE structural grain: the Mukundara Deformation Zone.

The Chambal Valley Sector, Vindhyan Basin of southeastern Rajasthan, India appears to have undergone at least four tectonic episodes, prior to neotectonic influences presumably related to Himalayan tectonics. These evidences are borne out by surface morphology and the subsurface configuration offered by reflection seismic. A distinct deformation pattern with relative timing of deformation is apparent in Chambal Valley and can be traced from N-S trending second order folds in Chittaurgarh-Bhagwanpura area through NW-SE trending folds of Chechat-Jhalawar, which are in their late breaching stage (see the geological cross-section for an estimate of erosion) to the orthogonal NE-SW GBF trend and finally the unbreached antiforms southwest of Baran township. The Mukundara fault probably has a dextral strike slip component with linkages between Chambal Thrust and Son-Narmada Lineament.

It is understood that crustal shortening due to northeasterly directed compressive stresses and eventually transpressive stress predominated the region subsequent to a short spell of extensional stress regime during the basal sedimentation. These stresses are presumed to have been caused by the counter strike-slip movements along SNL and GBF. The Bundelkhand Massif in the northeast possibly played a role in offering resistance to these stresses causing relatively much larger deformation and displacements in the hanging wall of the Mukundara PDZ and pop-up structures in its footwall.

Conclusion

The present work is an attempt to comprehend the regional structural style of Chambal Valley Sector, Vindhyan basin. These efforts have corroborated the surface geology with potential field and 2D reflection seismic data to provide an insight into the subsurface configuration, spatial organization and structural evolution.

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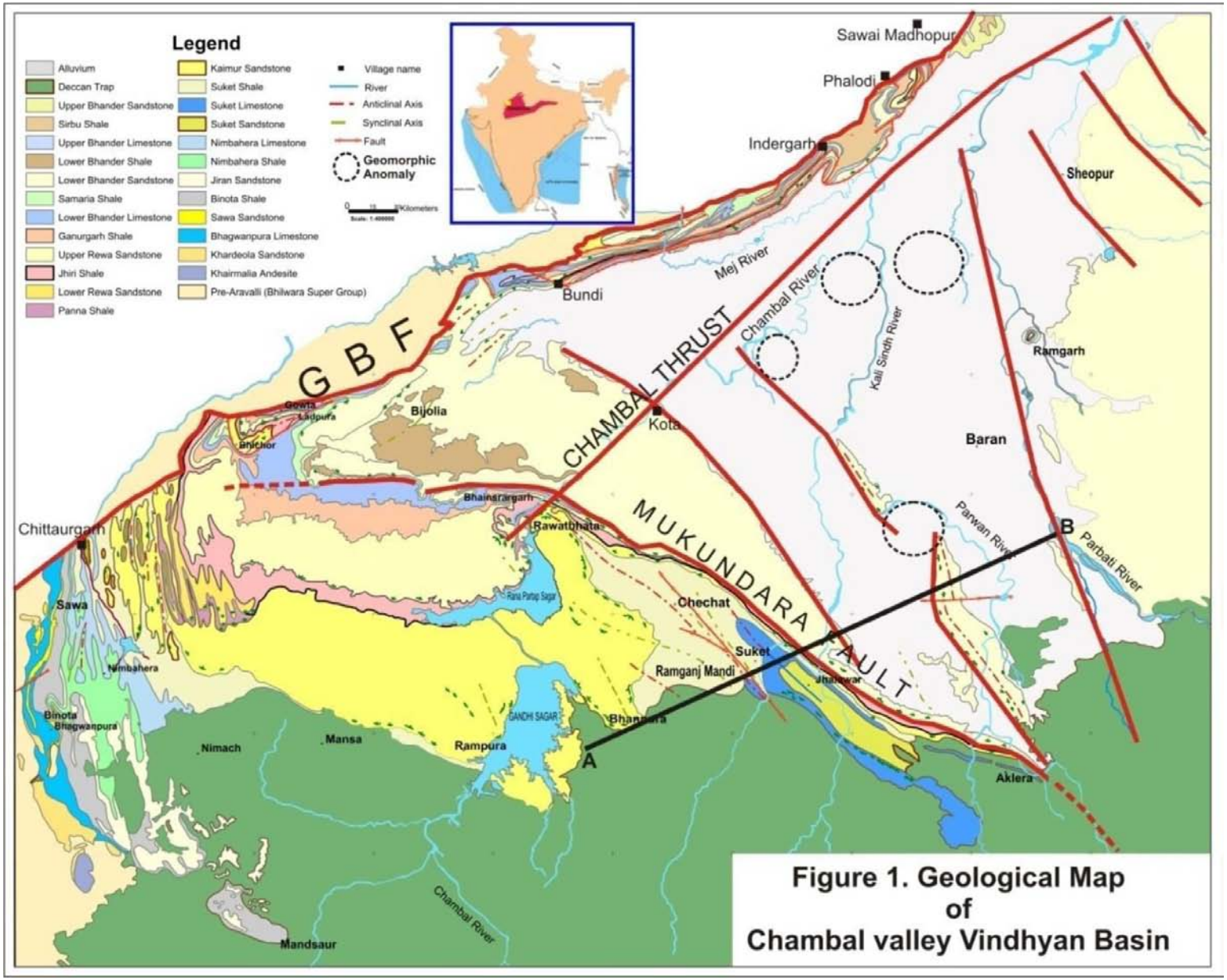

Figure 1. Geological map of Chambal Valley, Vindhyan Basin.

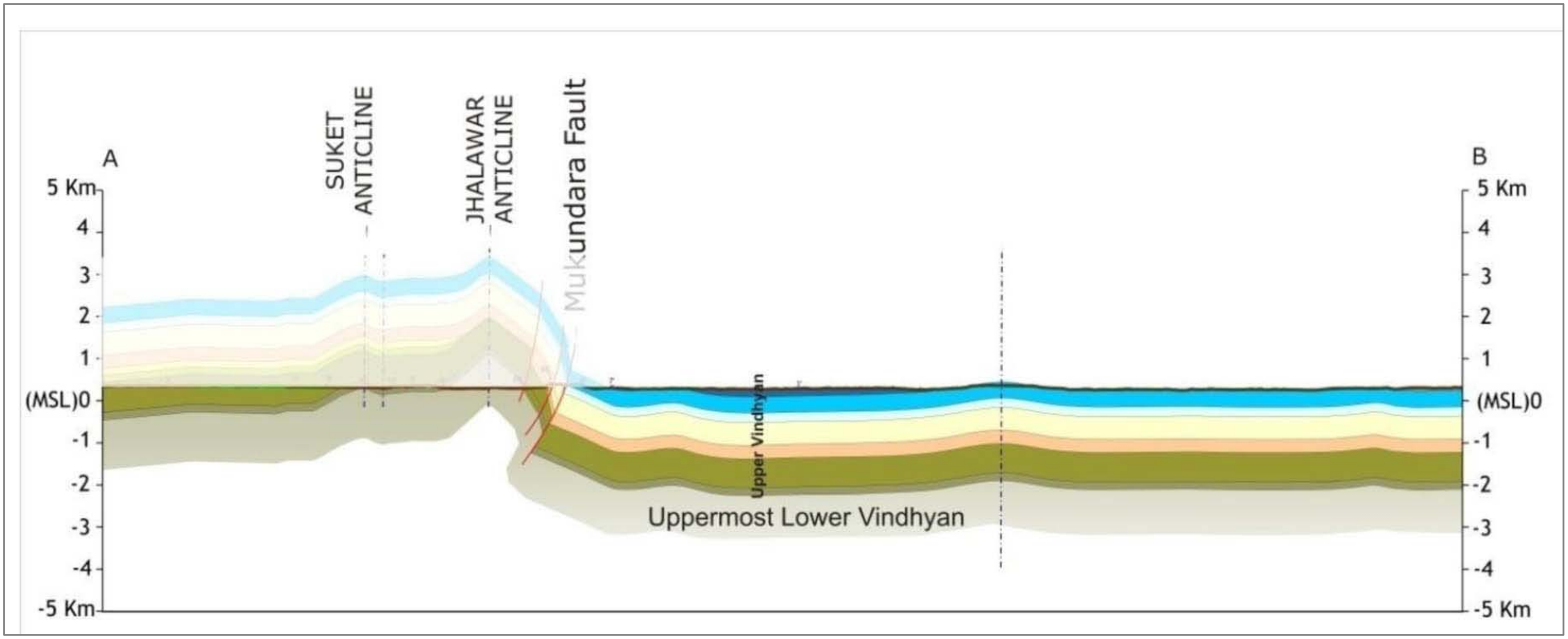

Figure 2. Author's pre-seismic rendition across Bhanpura-Jhalawar transect, Chambal Valley, Vindhyan Basin.

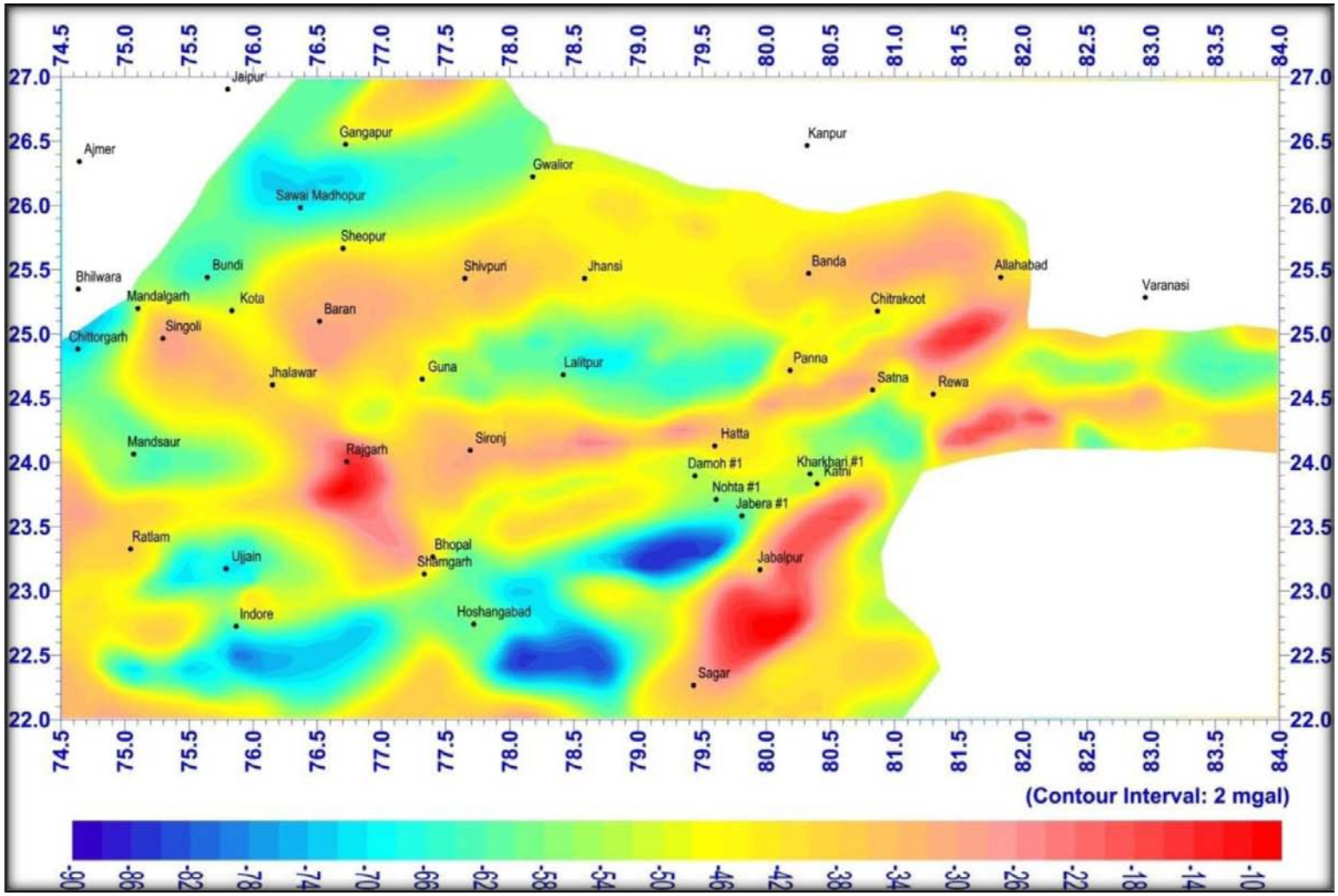

Figure 3. Bouguer Gravity image of Vindhyan Basin and Contiguous areas; red depicts high trend and blue indicates low trend.

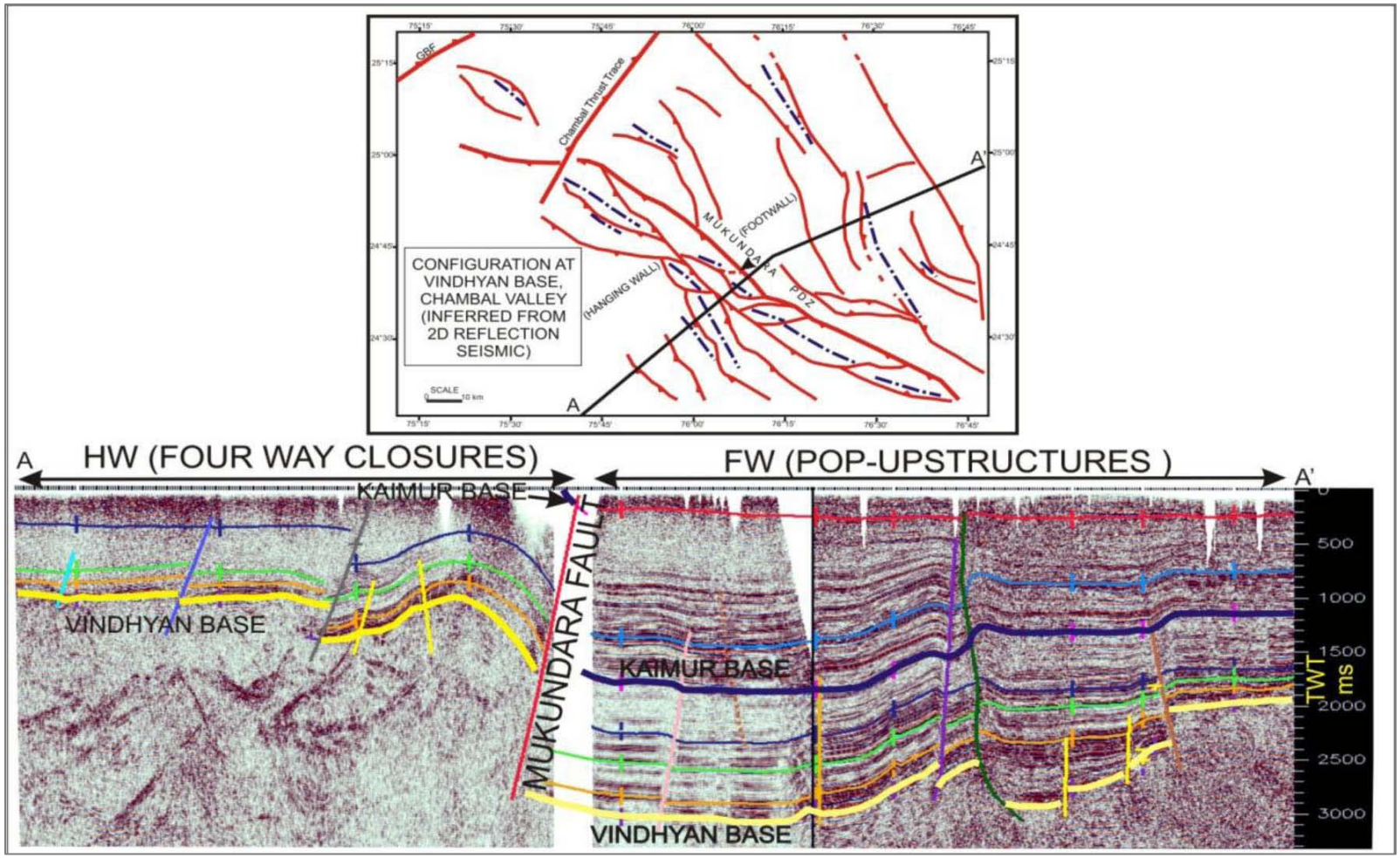

Figure 4. Subsurface configuration, Chambal Valley.