Geomorphology, Elevation and Gravity Studies from the Western Rajasthan Basins (Barmer, Bikaner-Nagaur and Jaisalmer), India

Kutubuddin Ansari, Mery Biswas, Soumyajit Mukherjee, and Swagato Dasgupta

Abstract We perform geomorphic, elevation-related and gravity studies from the three petroliferous sedimentary basins in western Rajasthan (India)-Bikaner-Nagaur, Jaisalmer and Barmer basins. Using geomorphic studies, we interpret that watersheds 1, 3 (Bikaner-Nagaur basin), 4 (Jaisalmer basin) and 1 and 3–5 (Barmer basin), to be tectonically very active at present. The elevation-related and gravity studies in the Bikaner-Nagaur basin shows a different uplift rates because of neotectonic faults and lineaments that pass through the region and enhance more incision of the channel. The gravity contour map has a very clear gradient of anomalies for each watershed in the Jaisalmer basin. The gravity values are high in the Barmer basin. Gravity low is noted in the Jaisalmer basin at places. Apparently, they have positive correlation between surface elevation and free air gravity magnitudes. We anticipate that the results provided in this work will assist hydrocarbon geoscientists to undertake more research.

Keywords Rift basin · Neotectonics · Active tectonics · Sedimentary basins · Geophysical parameters

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1 Introduction

The western Rajasthan basins (Barmer, Jaisalmer and Bikaner-Nagaur) are petroliferous. In last about 20 years, there has been a renewed interest and publications on these basins (e.g. Biswas et al., 2022b, 2024; Singh, 1977; Sinha et al., 1993; Narula et al., 2000; Kar et. al., 2022, 2025; Dolson et al., 2015; Dasgupta and Mukherjee 2017; Puniya et al., 2023a, b; Dasgupta et al., 2023; Mishra et al., 2023a, b; Ansari et al., 2025a,b). In the western Rajasthan area, two drainage systems are important—(*i*) the Luni river system and its tributaries and (*ii*) the Himalayan drainage system. The later includes the Ghaggar river and its tributaries. Irregularities or abrupt changes in river gradients within the longitudinal profiles reflect tectonic events within a region (Bhattarai, 2017; Mondal et al., 2024). The correlation between bedrock uplift and river incision determines whether a longitudinal river profile is concave or convex. We perform in this work the followings. *(1)* Application of R^2 model on all the master-streams (MS) of watersheds in the three chosen basins to decode their active tectonics. (2) Elevation anomaly map was generated by taking the *General Bathymetric Chart of the Oceans* (GEBCO) (Internet ref-1) and the free air gravity (FAG) data from the International Gravimetric Bureau (Internet ref-2). Watersheds defined from the previous publications were followed in this work, viz., Biswas et al. (2022, b) for the Barmer basin, Biswas et al. (2022a) for the Jaisalmer basin and Biswas et al. (2024) for the Bikaner-Nagaur basin.

2 Methods

2.1 Geomorphological Issues

Geomorphologic analyses aid in interpreting active tectonics efficiently (e.g. Cozzi et al., 2012; Chen et al., 2017; Prakash et al., 2017; Rai et al., 2017; Bhattarai et al., 2021; Raha et al., 2023, 2025). The longitudinal profile has an upward concave shape when the rate of erosion equals that of the uplift leading to a steady-state condition (Table 1). The curve with the highest R^2 value is the best-fit curve. We compared the R^2 values with ranks for the three MS from the three watersheds of the Bikaner-Nagaur Basin, four MS from four watersheds of the Jaisalmer basin and five MS from five watersheds of the Barmer basin (Table 1).

2.2 Geophysical Issues

The tectonic boundaries, extension of gravity and its trends, are generally analysed by two or more edge detection techniques (e.g. Pal et al. 2016; Kumar et al, 2022). Several gravity parameters are estimated by these techniques commonly called first

Table 1 R^2 values and the related ranking. MS: Master-stream

Basins	Equations	R^2 values					
		Linear	Exponential	Logarithmic	Power	Highest R^2-Linear R^2	Rank
Barmer Basin							
MS 1/ Watershed1	Linear function: $y = ax + b$ (*1*)	0.9828	0.9778	0.8247	0.5182	0	1
MS 2 Watershed2	Logarithmic function:	0.9754	0.9821	0.8109	0.6432	0.0067	2
MS 3/ Watershed3	$y = a \ln x + b$ (*2*)	0.9539	0.908	0.6484	0.5024	0	1
MS 4/ Watershed4		0.9818	0.9581	0.6794	0.5368	0	1
MS 5/ Watershed5		0.985	0.9586	0.6594	0.462	0	1
Jaisalmer Basin							
MS 1/ Watershed 1	'y': elevation (H/H_0); H: elevation of each point, H_0: elevation of the source), 'x': length of the river (L/L_0; L: distance of the point from the source, L_0: total length of the stream), 'a', 'b': coefficients derived independently from each profile. (e.g. Mondal et al., 2024)	0.824	0.8737	0.9153	0.7885	0.0913	6
MS 2/ Watershed 2		0.9143	0.9571	0.887	0.7506	0.0428	4
MS 3/ Watershed 3		0.9297	0.9727	0.9174	0.7666	0.043	5
MS 4/ Watershed 4		0.993	0.9696	0.8839	0.6031	0	1
Bikaner-Nagaur Basin							
MS 1/ Watershed 1		0.9891	0.9744	0.7189	0.6373	0	1
MS 2/ Watershed 2		0.9891	0.9982	0.7251	0.6801	0.0091	3
MS 3/ Watershed 3		0.9995	0.9906	0.7696	0.7124	0	1

vertical derivative (FVD), the total horizontal derivative (THD) and the tilt derivative ratio (TDR) etc. These parameters are able to provide high and sharp amplitudes for shallower sources as well as low and rounded amplitudes for deeper sources. The FVD discloses zero amplitudes at the edge locations for the vertical source and has been effectively concerned by several investigations (e.g. Pal et al. 2016; Ganguli et al. 2019; Horo et al. 2020; Kumar et al. 2022). Subsurface structures especially lineaments can be interpreted efficiently from these parameters (review in Cheunteu Fantah et al. 2022).

The amplitude of first vertical derivative (FVD) gravity anomaly (g_h) corresponding to the elevation height (h) is estimated as per Eq. 1 (Evjen 1936):

$$\mathrm{FVD} = \frac{\partial g_h}{\partial h} \tag{1}$$

The amplitude of total horizontal derivative (THD) uses the x-axis and the y-axis directional derivatives and is calculated as per Eq. 2 (Miller and Singh 1994):

$$\mathrm{THD} = \sqrt{\left(\frac{\partial g_h}{\partial x}\right)^2 + \left(\frac{\partial g_h}{\partial y}\right)^2} \tag{2}$$

The arctan ratio of FVD to THD amplitudes is called the tilt derivative ratio (TDR), which diverges between—π/2 and π/2 and is calculated as follows (Miller and Singh 1994):

$$\mathrm{TDR} = \tan^{-1}\left(\frac{\mathrm{FVD}}{\mathrm{THD}}\right) \tag{3}$$

These types of enhancements techniques are utilized for the first-order derivatives and numerous joint derivatives, capable to offer rectangular, circular and linear tectonic boundaries enhancements with depth variation up to the Moho (Narayan et al. 2016; Kumar et al. 2022).

3 Results

3.1 Bikaner-Nagaur Basin (BNB)

3.1.1 Geomorphology

MS of watersheds 1 and 3 are highly active tectonically as they come under rank 1 (difference value '0'), and MS 2 of watershed 2 belongs to rank 3 (difference value '0.0091').

3.1.2 Geophysics

We prepared a regional contour map of the selected region (Fig. 1) in the MATLAB 2017 environment, which covers the BNB and the surroundings. We perform elevation and gravity modelling of the three watersheds located at the south and southeast of the BNB to understand the tectonic prioritization of the watersheds in response to active tectonics. The total area of the three considered watersheds is ~ 27,187 km^2. The elongated asymmetric BNB extends ~ 200 km along E-W and has a maximum width of ~ 50 km (Rajak et al., 2019). Surrounding the BNB consists of a huge semi-desert area that lacks significant surface water catchment. Contour plot shows that the elevation depth along these three watersheds lie between 300 and 700 m, and it gradually increases towards north (Fig. 1). Figure 2 presents the elevation and depth plots for all the selected watersheds along the horizontal distance from their starting point. The extension and variation of shelf along the watersheds can be easily demonstrated from this figure. The shelf widths the watersheds 1 is ~ 240 km, while they are ~ 140 km for watersheds 2 and 3. The elevation plots of watersheds 1 and 2 show that their heights decrease from SE to SW, while its opposite (from SW to SE) is true for the watershed 3. This is the reason that in watersheds 1 and 2, rivers mostly flow towards SW and river flows towards SE in watershed 3. In watershed 3, the river varies between the sinuous and meandering pattern. This variation may be due to the differential uplift rates produced due to the neotectonic faults and lineaments that pass through the region and enhance more incision of the channel.

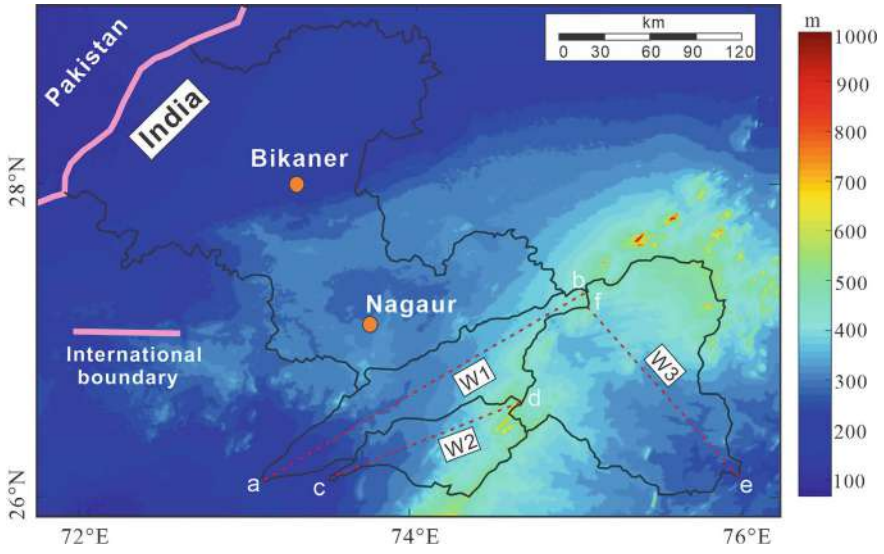

Fig. 1 Shaded relief contour map plotted from GEBCO bathymetry data over the BNB. Positive values: Elevation (m)

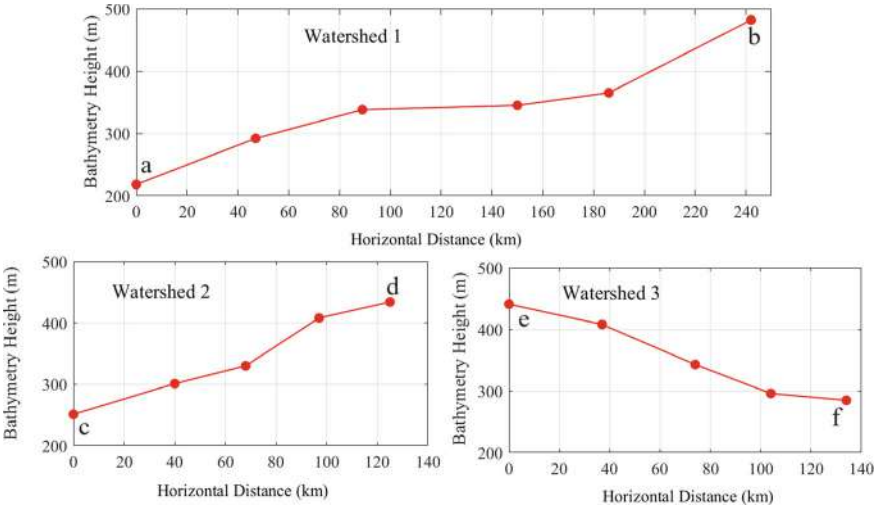

Fig. 2 Red lines: Height /elevation variations along lines ab, cd and ef (in Fig. 1) from watersheds 1–3

The free air gravity (FAG) data is used and a map is prepared for land part from the EGM2008 (Internet ref-2) data (Fig. 3). Figure 3 shows that the gravity contour map has a very clear gradient of gravity values from bottom to top of each watershed. The regional area of continental shelf demonstrates almost positive gravity anomaly for all watersheds except towards the basin areas. The studies based on gravity data shows the thinnest deposit of basin (lower than ~ 2–3 km) at margin and is surrounded by the Delhi-Aravalli fold belt at east and south, the Delhi-Sargodha ridge at northeast and the Pokhran-Nachna high at southwest (Das, 1988; Farooq et al., 2019). The free air gravity *vs.* the horizontal distance plots for all the selected watersheds from their starting points is presented in Fig. 4. Apparently, the positive correlation between surface elevation (Fig. 2) and free air gravity magnitudes (Fig. 4) can be seen for all the watersheds. However, the degree of this correlation varies for each watershed. The figure shows that the gravity anomaly along the selected watersheds is categorized by superimposed numerous lows and highs. The gravity values in the region of all watersheds ranges from ~ −20 to 40 mGal (Fig. 4).

We used eqns. 1–3 and estimated FVD (Fig. 3) and TDR plots (Fig. 4) of the Bikaner-Nagaur basin.

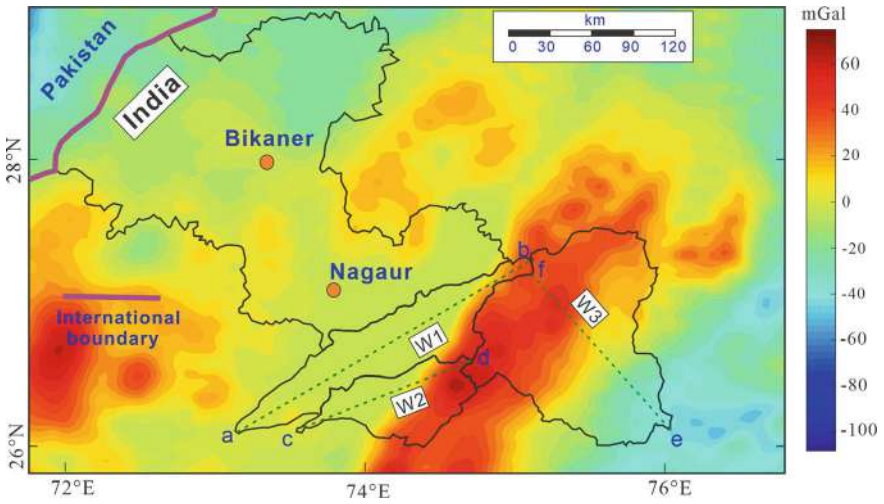

Fig. 3 Free air gravity anomaly contour plot in the BNB. W1–3 are the three watersheds

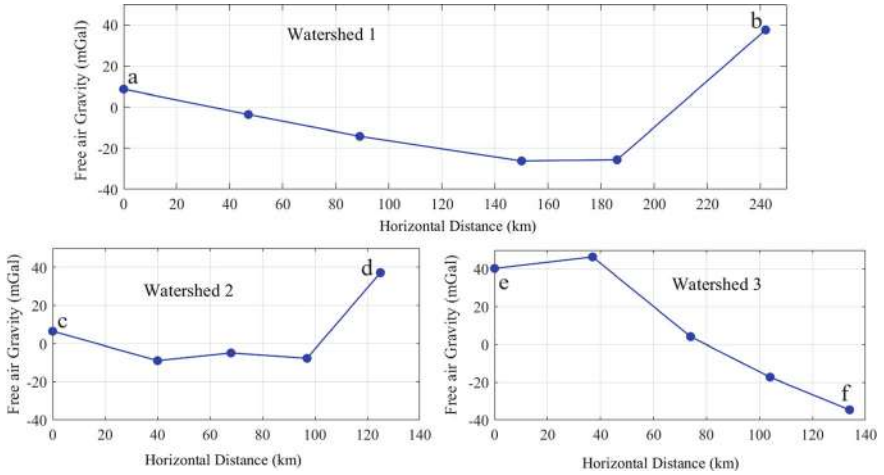

Fig. 4 Blue lines: Gravity variations along watersheds, 1–3 along lines ab, cd and ef, respectively, as shown in Fig. 3

3.2 Jaisalmer Basin

3.2.1 Geomorphologic Aspects

The MS of watershed 4 is determined to be active by a standard long profile analysis using actual distance and elevation with an exponential curve fit. The MS is under rank 1 (difference value = 0). MS of watersheds 2 and 3 belong to ranks 4 and 5

(difference values 0.9571 and 0.9727, respectively) that reflect tectonically moderate activity. MS 1 of watershed 1 is having low tectonic activity as the logarithmic curve has the highest R^2 value and belong to rank 6 (difference value = 0.9153) (Table 1).

3.2.2 Geophysical Aspects

The regional elevation contour map of the Jaisalmer basin in the MATLAB 2017 environment, which includes four drainage watersheds (Fig. 5). The map presents the regional topographic variation from the high in the east to the low in NW and SW part. The NW part of the selected region has Kishangarh sub-basin and SW part has Shahgarh sub-basin (Biswas et al 2022a). Contour plot shows that the elevation along these four watersheds lie between 0 and 900 m. Pati et al (2006) defined these four drainage watersheds to establish the role of basement tectonics with reactivation of the sub-surface structure that control the topographic slope variation. The elevation and depth plots for all the watersheds are presented in Fig. 6. The shelf widths of the watersheds 1–4 are ~ 160, 80, 140 and ~ 140 km, respectively. Watershed 3 and parts of watersheds 1 and 4 have higher slope (> 9°). The remainders are of lower magnitude within 1.5°. Presence of dunes in NW and SW parts of the basin impose gentle slope (Biswas et al 2022a).

The data is used and a map is prepared for land part from the EGM2008 data (Internet ref-2) (Fig. 7). Figure 7 shows that the gravity contour map has a very clear gradient of gravity anomalies for each watershed. Watersheds 1 and 2 are near-circular indicating a very low effect of active tectonics, whereas watersheds 3 and 4 are elongated and indicate moderate and high influence of active tectonics, respectively (Biswas et al 2022a). The tectonically active watersheds belong to the Shahgarh and the Miajlar depressions. Channels of watershed 3 and 4 originated from the major NNW-SSE trending Ramgarh-Kanoi strike-slip fault zone (Pandey et al. 2019). The gravity anomaly variation of each watershed differs and varies from ~ −35 to 25 mGal (Fig. 8). Figure 8 shows free air gravity verse horizontal distance for all the watersheds from their starting point. Apparently, the positive correlation between surface elevation (Fig. 6) and free air gravity magnitudes (Fig. 8) can be seen for all watersheds. However, the degree of this correlation varies for each watershed.

Using eqns. 1–3, the FVD (Fig. 7) and the TDR (Fig. 8) are plotted for the Jaisalmer basin.

3.3 Barmer Basin

3.3.1 Geomorphological Points

MS 1 of watershed 1 is very active as it belongs to rank 1 (difference value 0) and is followed by the MS 2 of watershed 2 with a rank 2 (difference value 0.0067). The mater streams of watersheds 3-5 are also under rank 1, as the difference values

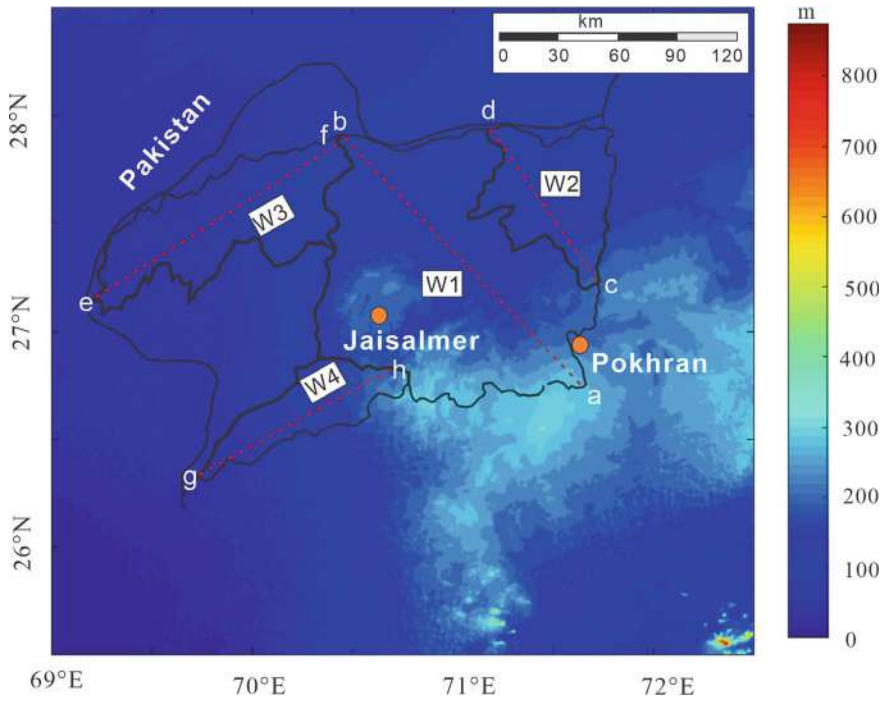

Fig. 5 Shaded relief contour map plotted from GEBCO bathymetric data over the Jaisalmer basin. Positive values: Elevation (m). W1–4: Four watersheds

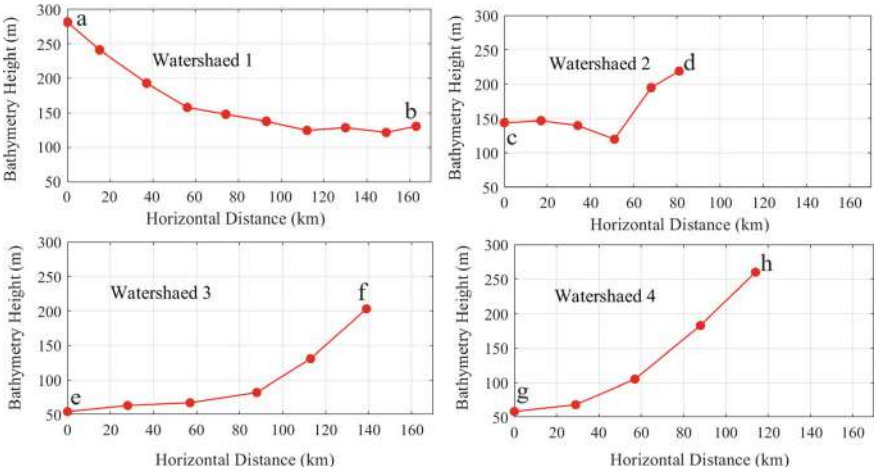

Fig. 6 Red lines: Elevation variations along lines ab, cd, ef and gh (in Fig. 5) from watersheds 1–4

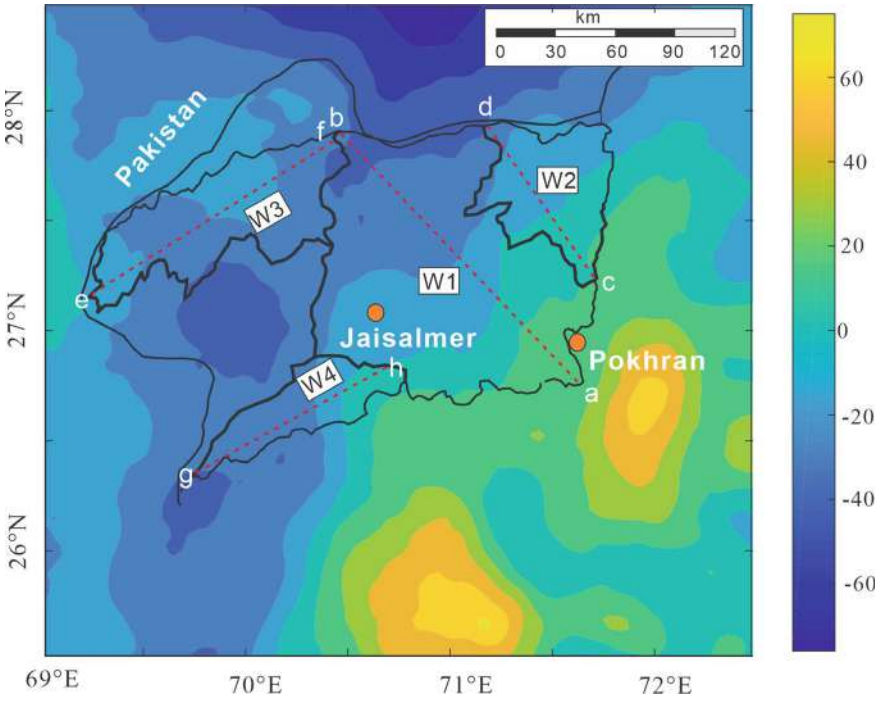

Fig. 7 Free air gravity anomaly contour plot in the Jaisalmer basin. W1–4 are the four watersheds

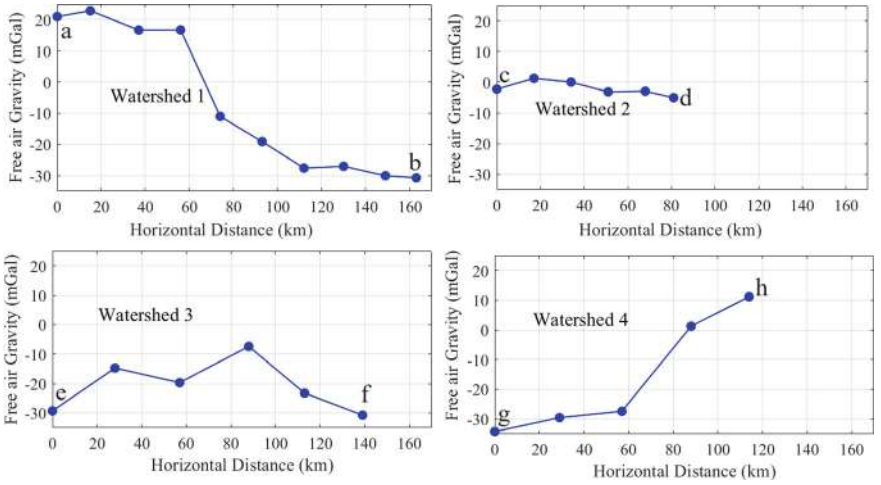

Fig. 8 Blue lines: Gravity variations along watersheds, 1–4 along lines ab, cd, ef and gh, respectively, as shown in Fig. 7

between the highest R^2 and linear R^2 are 0 (Table 1). These results broadly support the tectonic activeness of the basin proposed by Biswas et al. (2022a).

3.3.2 Geophysical Points

Barmer basin is one of the major petroleum-producing rift basins in the western Indian rift system, which is 200 km long, <40 km wide and ≤6 km deep (Bladon et al. 2015; Dolson et al. 2015; Dasgupta et al., 2023). Biswas et al (2022b) identified five watersheds out of which four are the tributaries of the river Sukri/Luni. The contour map using bathymetric heights/elevations in the MATLAB 2017 environment of Barmer basin with five watersheds have been presented in Fig. 9. Figure 9 shows the bathymetric height/elevation along these four watersheds lie between 0 and 900 m. Biswas et al (2022b) noticed that a slope up to 4° covers ~ 45% of the watershed area. Elevation of the area ranges 50–350 m and the easternmost pocket of watershed 5 is more elevated. It decreases towards the south (in watersheds 1–4) and west (part of watershed 5) ranging from 50 to 265 m. The bathymetric heights /elevations with respect to their distances of these watersheds have been shown in Fig. 10. The figure shows that watershed 1 has maximum horizontal length extended up to 150 km while others lie within 150 km.

The FAG data is used and a map is prepared from the land part of the EGM2008 data (Internet ref-2) (Fig. 11). Distinct Bouguer anomaly gravity lows along the Cambay basin extend into the Barmer rift basin, accompanied by high-amplitude gravity highs along the rift shoulders on either side. The gravity low at the Jaisalmer basin is separated by a prominent gravity high in the Barmer basin. The NE-trending gravity and magnetic anomalies in the Barmer region indicate low-amplitude basement highs and lows (Biswas et al, 2022b). Figure 11 shows that the gravity anomaly along the selected watersheds is categorized by superimposed numerous lows and highs. The gravity values in the region of all watersheds ranges from ~ −80 to 90 mGal (Fig. 9). The FAG values along the horizontal direction for all the watersheds are presented in Fig. 12. The regional area of continental shelf demonstrates almost positive gravity anomaly for all watersheds except the watershed 5. Apparently, like other above basins, the positive correlation between surface elevation (Fig. 10) and free air gravity magnitudes (Fig. 12) can be seen for all watersheds. However, the degree of this correlation varies for each watershed.

Applying eqns. 1–3, the FVD (Fig. 11) and the TDR (Fig. 12) are plotted for the Barmer basin.

4 Discussions

The longitudinal profile preserves relevant information about landscape evolution with certain anomalies and abrupt changes in river gradients within the profile. The break of slope along the channel indicates the tectonic anomalies and is evident as

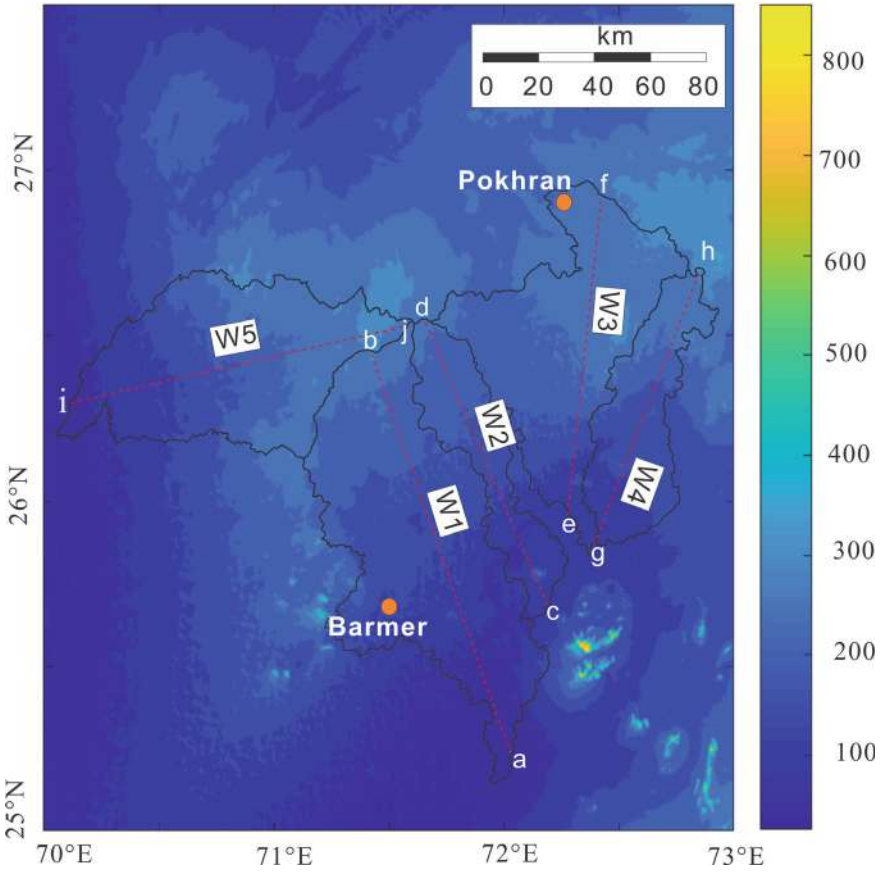

Fig. 9 Shaded relief contour map plotted from the GEBCO bathymetric data over the Barmer basin. W1–5: Five watersheds. Positive values: Elevation (m)

rejuvenation near the knick points. In the BNB, the south-eastern part seems to be tectonically active, as the MS of watershed 3 is under rank 1. In the Barmer basin, watershed 3 belongs to the moderately active class on the IAT scale (Biswas et al., 2022a), but the MS of watershed 3 denotes the channel to be very active as it is under rank 1. MS 4 of the Jaisalmer basin is ranked 1, and the MS 1 of the adjacent Barmer basin also ranked 1, denoting tectonic activeness in the transition zone of two basins. MS 3 of this basin is also under rank 1 (Table 1) Amongst all the MS, MS 1 of watershed 1 of the Jaisalmer basin is least active, as it is under rank 6. In this basin, MS of watershed 4 is very active as it carries rank 1.

The study also investigates the Bathometric height and gravity anomalies variations from the three basins namely BNB, Jaisalmer basin and Barmer basin located in western Rajasthan, India. These basins are studied on the basis of watersheds. The number of selected watersheds and their respective outcomes has been given

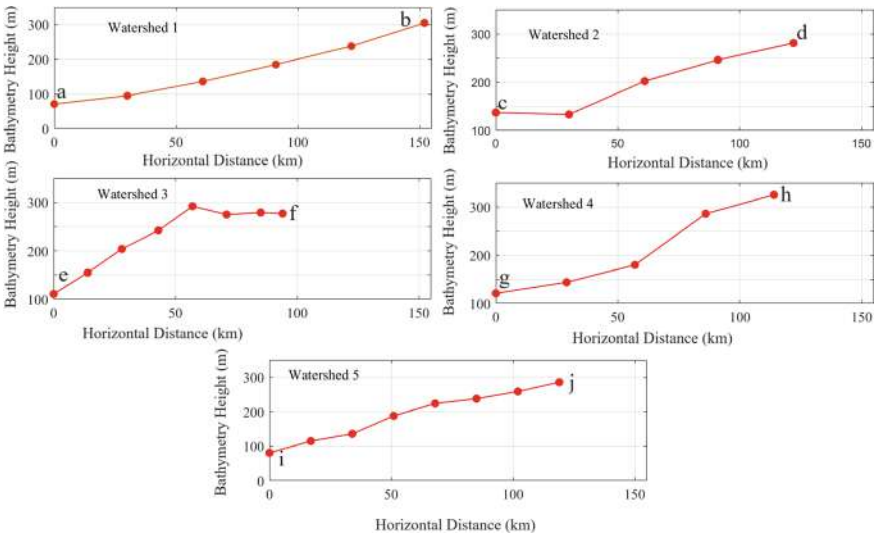

Fig. 10 Red lines: height variations along lines ab, cd, ef, gh and ij (in Fig. 9) from watersheds 1–5

in Table 2. Three watersheds were selected in the BNB. The elevation plots in the BNB watersheds 1 and 2 show that their height decreases from SE to SW, while its opposite (from SW to SE) is true for the watershed 3 because of rivers mostly flow towards SW and river flows towards SE in watershed 3. The FAG results in the BNB show that the gravity anomaly along the selected watersheds is categorized by superimposed numerous lows and highs with the values ranges from ~ −20 to 40 mGal for all watersheds. The regional bathymetric height/elevation plot in Jaisalmer basin shows that these heights along these four watersheds lie between 0 and 900 m. The shelf widths of the watersheds 1–4 are ~ 160, 80, 140 and ~ 140 km, respectively. The gravity anomaly variation of each watershed in Jaisalmer basin differs within ~ −35 to 25 mGal. Watersheds 1 and 2 are near-circular indicating a very low effect of active tectonics, whereas watersheds 3 and 4 are elongated and indicate moderate and high influence of active tectonics, respectively. The bathymetric height /elevation along these four watersheds in Barmer basin lie between 0 and 900 m. Watershed 1 shows maximum horizontal length extended up to 150 km, while others lie within 150 km. The regional area of continental shelf in Barmer basin demonstrates almost positive gravity anomaly for all watersheds except watershed 5. Apparently, the positive correlation between surface elevation and free air gravity magnitudes can be seen for all the basins' watersheds. However, the degree of this correlation varies for each watershed.

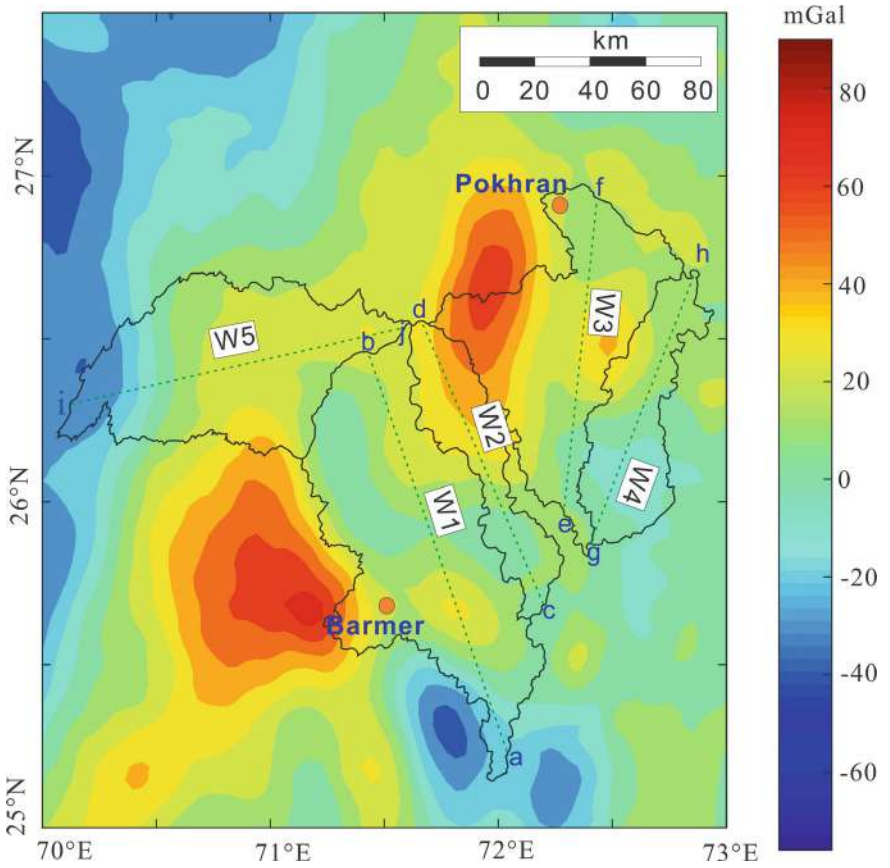

Fig. 11 FAG anomaly contour plot in the Barmer basin. W1–5 are the five watersheds

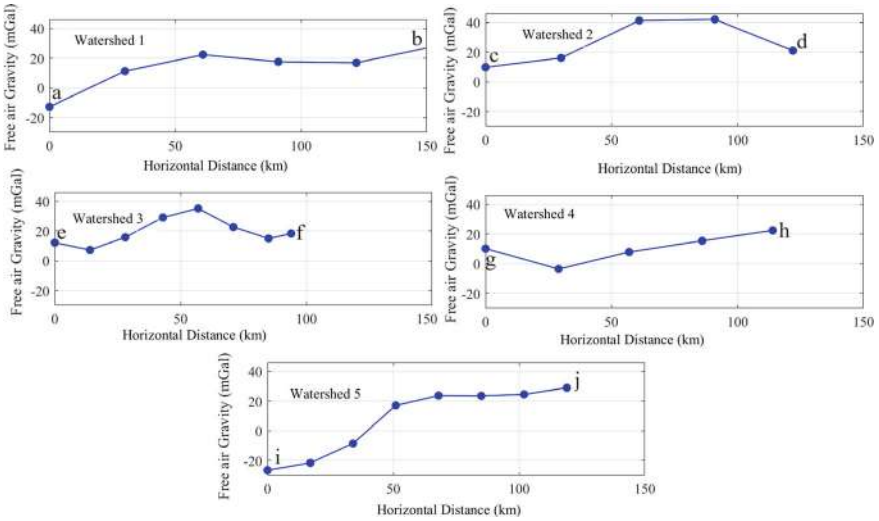

Fig. 12 Blue lines: Gravity variations along watersheds, 1–5 along lines ab, cd, ef, gh and ij, respectively, as shown in Fig. 11

Table 2 Geophysical results summarized from the three studied basins

	Bikaner-Nagaur basin	Jaisalmer basin	Barmer basin
Number of watersheds	03	04	05
Watershed extension	The shelf widths the watersheds 1 is ~ 240 km, while they are ~ 140 km for watersheds 2 and 3	Shelf widths of the watersheds 1–4 are ~ 160, 80, 140 and ~ 140 km, respectively	Elevation of the area ranges 50–350 m and the easternmost pocket of watershed 5 is more elevated. It decreases towards the south (in watersheds 1–4) and west (part of watershed 5) ranging from 50 to 265 m
Gravity anomalies	Along the selected watersheds, lows and highs of anomalies. Range for all watersheds: ~ -20 to 40 mGal	Gravity anomaly variation of each watershed differs and ranges ~ -35 to 25 mGal	The gravity values in the region of all watersheds ranges from ~ -80 to 90 mGal

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Abbreviations

BNB	Bikaner-Nagaur basin
FAG	Free air gravity
FVD	First Vertical Derivative
GEBCO	General Bathymetric Chart of the Oceans
IAT	Index of Active Tectonics
MS	Master-stream
TDR	Tilt derivative ratio
THD	Total Horizontal Derivative
W	Watershed

References

Ansari, K., Biswas, M., Das, S., Mukherjee, S. 2025a. Morphometric, gravity and bathymetric (Topographic) analysis of Bayana basin, Rajasthan, India. In Mukherjee, S., Kar, N.R. (Eds) 2025. Geosciences of the Rajasthan basins, India. pp. 43–56. Singapore: Springer. ISBN 978-981-96-3004-2.

Ansari, K., Biswas, M., Das, S., Mukherjee, S. 2025b. Morphometric and geophysical studies from a part of Aravalli-Delhi fold belt, Rajasthan, India. In: Mukherjee, S., Kar, N.R. (Eds) 2025. Geosciences of the Rajasthan basins, India. Springer. pp. 57–70. Singapore: Springer. ISBN 978-981-96-3004-2.

Bhattarai, I., N.D. Gani, and L. Xue. 2021. Geomorphological responses of rivers to active tectonics along the Siwalik Hills, Midwestern Nepalese Himalaya. *Journal of Mountain Science* 18: 1268–1294.

Biswas, M., M.P. Gogoi, B. Mondal, T. Sivasankar, S. Mukherjee, and S. Dasgupta. 2022a. Geomorphic assessment of active tectonics in Jaisalmer basin (western Rajasthan, India). *Geocarto International* 37: 12382–12413.

Biswas, M., M.K. Puniya, M.P. Gogoi, S. Dasgupta, S. Mukherjee, and N.R. Kar. 2022b. Morphotectonic analysis of petroliferous Barmer rift basin (Rajasthan, India). *Journal of Earth System Science* 131: 140.

Biswas, M., A. Raha, S. Mukherjee, and V.S. Kotak. 2024. Geomorphic imprints of active tectonics of the Bikaner-Nagaur Petroliferous rift basin and its surroundings (western Rajasthan, India). *Journal of the Geological Society of India* 100: 377–390.

Biswas, M., S. Das, and S. Mukherjee. 2025. Morphometric, gravity and bathymetric (Topographic) analysis of Bayana basin, Rajasthan, India. In: Mukherjee, S., Kar, N.R. (Eds) 2025. Geosciences of the Rajasthan basins, India. Springer. pp. 43–56. Singapore: Springer. ISBN 978-981-96-3004-2.

Bladon, A.J., S.D. Burley, S.M. Clarke, and H. Beaumont. 2015. Geology and regional significance of the Sarnoo Hills, eastern rift margin of the Barmer Basin, NW India. *Basin Research* 27: 636–655.

Chen, L., R.J. Steel, F. Guo, C. Olariu, and C. Gong. 2017. Alluvial fan facies of the Yongchong Basin: Implications for tectonic and paleoclimatic changes during Late Cretaceous in SE China. *Journal of Asian Earth Sciences* 134: 37–54.

Cheunteu Fantah, C.A., Mezoue, C.A., Mouzong, M.P., Tokam Kamga, A.P., Nouayou, 519 R., Nguiya, S. 2022. Mapping of major tectonic lineaments across Cameroon using potential 520 field data. Earth, Planets and Space 74:1–19.

Cozzi, A., Rea, G., Craig, J. 2012. From global geology to hydrocarbon exploration: Ediacaran-Early Cambrian petroleum plays of India, Pakistan and Oman. In: Bhat, G.M., Craig, J., Thurow, J.W., Thusu, B. and Cozzi, A. (Eds) Geology and hydrocarbon potential of Neoproterozoic–Cambrian Basins in Asia. Geological Society, London, Special Publications, 366, 131–162.

Das, A.R. 1988. Geometry of the superposed deformation in the Delhi Supergroup of rocks, North of Jaipur, Rajasthan. Geol. Soc. India–Mem, 247–266.

Dasgupta, S., S. Mukherjee, N. Vanik, R. Chatterjee, and S.K. Pal. 2023. Paleostress analyses and rift kinematics of the petroliferous Barmer rift basin, Western Rajasthan. *India. Marine and Petroleum Geology* 156: 106442.

Dasgupta, S., and S. Mukherjee. 2017. Brittle shear tectonics in a narrow continental rift: Asymmetric non-volcanic Barmer basin (Rajasthan, India). *The Journal of Geology* 125: 561–591.

Dasgupta, S., Mukherjee, S., Chatterjee, R. 2024. Tectonics and geodynamics of a narrow continental rift: Barmer basin, Rajasthan, India. In: Ciner, A. et al. (Eds) Recent Research on Sedimentology, Stratigraphy, Paleontology, Geochemistry, Volcanology, Tectonics, and Petroleum Geology, Advances in Science, Technology and Innovation. Springer. pp. 223–227.

Dasgupta, S. 2023. Paleostress analyses and tectonic evolution of the Barmer continental rift basin, western Rajasthan, India. Unpublished Ph.D. thesis. IIT (ISM) Dhanbad.

Dolson, J., S.D. Burley, V.R. Sunder, V. Kothari, B. Naidu, N.P. Whiteley, P. Farrimond, A. Taylor, N. Direen, and B. Ananthakrishnan. 2015. The discovery of the Barmer Basin, Rajasthan, India, and its petroleum geology. *AAPG Bulletin* 99: 433–465.

Evjen, H.M. 1936. The place of the vertical gradient in gravitational interpretations. *Geophysics* 1: 127–136.

Farooq, U., Chetia, R., Mathews, R., Srivastav, S., Singh, B. and Singh, V. 2019. Palaeodepositonal conditions and hydrocarbon source characteristics of lignites from Bikaner-Nagaur Basin (Rajasthan) western India based on organic petrographic studies. Coal Operators Conference.

Ganguli, S.S., S. Singh, N. Das, D. Maurya, S.K. Pal, and J.V. Rama Rao. 2019. Gravity and magnetic survey in southwestern part of Cuddapah Basin, India and its implication for shallow crustal architecture and mineralization. *Journal of the Geological Society of India* 93: 419–430.

Horo, D., S.K. Pal, S. Singh, and S. Srivastava. 2020. Combined self-potential, electrical resistivity tomography and induced polarisation for mapping of gold prospective zones over a part of Babaikundi-Birgaon Axis, North Singhbhum Mobile Belt, India. *Exploration Geophysics* 51: 507–522.

Internet ref-1: URL: http://www.gebco.net/data_and_products. Accessed July 12, 2023.

Internet ref-2: URL: https://bgi.obs-mip.fr/data-products/outils/egm2008-anomaly-maps-visualization/. Accessed July 13, 2023

Kar, N.K., D. Mani, S. Mukherjee, S. Dasgupta, M.K. Puniya, A.K. Kaushik, M. Biswas, and E.V.S.S.K. Babu. 2022. Source rock properties and kerogen decomposition kinetics of Eocene shales from petroliferous Barmer basin, western Rajasthan, India. *Journal of Natural Gas Science and Engineering* 100: 104497.

Kar, N.R., Mani, D., Seetha, B.S., Babu, E.V.S.S.K., Mukherjee, S., Dasgupta, S., Mudiam, M.K.R. 2025. Biomarker Evidence of Shifts in Organic provenance and depositional environment of Eocene carbonaceous rocks from petroliferous Barmer basin, Western Rajasthan, India. *Journal of the Geological Society of India* 101: 112–122.

Kumar, U., S. Narayan, and S.K. Pal. 2022. Structural and tectonic interpretation of EGM2008 gravity data around the Laccadive ridge in the Western Indian Ocean: An implication to continental crust. *Geocarto International* 37: 3179–3198.

Miller, H.G., and V. Singh. 1994. Potential field tilt—a new concept for location of potential field sources. *Journal of Applied Geophysics* 32: 213–217.

Mishra, P., G. Karthikeyan, S. Dash, S. Konar, A.K. Bora, U. Kuila, D.K. Mukhopadhyay, and M.D. Zoback. 2023a. In situ stress state in the petroliferous Barmer Basin, northwestern India: A new geomechanical approach. *AAPG Bulletin* 107: 1639–1667.

Mishra, P., G. Karthikeyan, S. Dash, S. Konar, A.K. Bora, U. Kuila, D.K. Mukheopadhyay, and M.D. Zoback. 2023b. In situ stress state in the petroliferous Barmer Basin, northwestern India: A new geomechanical approach. *AAPG Bulletin* 107: 1639–1667.

Mondal, B., M. Biswas, S. Mukherjee, and M.A. Shaikh. 2024. Geomorphic signatures and active tectonics in western Saurashtra, Gujarat, India. *Geodesy and Geodynamics* 15: 82–99.

Mukherjee, S., and N.R. Kar. 2025. Introduction to *Geosciences of the Rajasthan basins, India.* Springer. pp. v–viii. Singapore: Springer. ISBN 978-981-96-3004-2.

Narayan, S., S.D. Sahoo, S.K. Pal, U. Kumar, V.K. Pathak, T.J. Majumdar, and A. Chouhan. 2016. Delineation of structural features over a part of the Bay of Bengal using total and balanced horizontal derivative techniques. *Geocarto International* 32: 351–366.

Narula, P.L., Acharyya, S.K. and Banerjee, J. 2000. Seismotectonic Atlas of India and its Environs; Geological Survey of India, New Delhi. ISSN: 02540436.

Pal, S.K., T.J. Majumdar, V.K. Pathak, S. Narayan, U. Kumar, and O.P. Goswami. 2016. Utilization of high-resolution EGM2008 gravity data for geological exploration over the Singhbhum-Orissa Craton, India. *Geocarto International* 31: 783–802.

Pandey, R., D. Kumar, A.S. Maurya, and P. Pandey. 2019. Hydrocarbon generation potential of source rocks in Jaisalmer Basin, Rajasthan, India. *Current Science* 116: 822–827.

Pati, J.K., V.P. Malviya, and K. Prakash. 2006. Basement reactivation and its relation to neotectonic activity in and around Allahabad, Ganga plain. *Journal of the Indian Society of Remote Sensing* 34: 47–56.

Prakash, K., T. Mohanty, J.K. Pati, et al. 2017. Morphotectonics of the Jamini River basin, Bundelkhand Craton, Central India; using remote sensing and GIS technique. *Applied Water Science* 7: 3767–3782.

Puniya, M.K., Kaushik, A.K., Mukherjee. S., Dasgupta, S., Kar, N.K., Biswas, M., Choudhary, R. 2023a. New structural geological input from the Barmer Basin, Rajasthan (India). In: Mukherjee, S. (Ed) Structural Geology and Tectonics Field Guidebook–Volume 2. Springer Geology. pp. 285–296.

Puniya, M.K., Kaushik, A.K., Mukherjee, S., Kar, N.R., Biswas, M., Choudhury, R. 2023b. Structural geology and stability issue of the Giral Lignite Mine, Rajasthan, India. In: Mukherjee, S. (Ed) Structural Geology and Tectonics Field Guidebook–Volume 2. Springer Geology. pp. 297–310.

Raha, A., M. Biswas, and S. Mukherjee. 2023. Application of TOPSIS model in active tectonic prioritization: Madeira watershed, South America. *Journal of South American Earth Sciences* 129: 104502.

Raha, A., K. Ansari, S. Mukherjee. 2025. Geomorphic and geophysical studies from the Sukri River watersheds, Rajasthan, India. In: Mukherjee S, Kar NR (Eds) Geosciences of the Rajasthan basins, India. Springer. pp. 153–168. Singapore: Springer. ISBN 978-981-96-3004-2.

Rai, P.K., K. Mohan, S. Mishra, et al. 2017. A GIS-based approach in drainage morphometric analysis of Kanhar River Basin, India. *Applied Water Science* 7: 217–232.

Rajak, P.K., V.K. Singh, P.K. Singh, M.P. Singh, and A.K. Singh. 2019. Environment of paleomire of lignite seams of Bikaner-Nagaur basin, Rajasthan (W. India): Petrological implications. *International Journal of Oil, Gas and Coal Technology* 22: 218–245.

Singh, S.S. (Ed.). 1977. Geomorphological investigation of the Rajasthan Desert. Central aried Zone research institute, Jodhpur. pp 1–47.

Sinha, A.K., Yadav, R.K. and Qureshi, S.M. 1993. Status of exploration in south Shahgarh Subbasin of Jaisalmer Basin, Rajasthan. In: Biwas, S.K., Pandey, J., Dave, A., Maithani, A., Garg, P., Thomas, N.J. (Eds) Proceeding of the Second Seminar on Proliferous Basins of India. Vol 2: West Coast Basins. Indian Petroleum Publishers. Dehradun. pp. 285–333. ISBN 81-900361-10320-6.