

Delineation of subtle and obscure structures in West Bengal Shelf: a remote sensing and GIS-based parallel approach[†]

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In the West Bengal part of the Bengal Basin, even after five decades of seismic-based hydrocarbon exploration no commercial finds have been identified. Deep drilling revealed the presence of hydrocarbon within the thick sedimentary sequence ranging from Gondwana to Recent. However, well-defined structures suitable for hydrocarbon pool in shallower sediments are apparently not visible in seismic data. In this article, a parallel approach to seismic exploration has been attempted to delineate shallow and subtle structures in the shelf area based on analysis of surface geomorphic data. The study identifies subtle structures in shallow sediments that entrap the remigrated hydrocarbons as well as envisages a multistoried, stacked model of hydrocarbon accumulations in the area. These areas are considered as promising targets and recommended for high-resolution seismic and close grid micro-gravity exploration survey for further detailing.

Keywords: Geological domain, hydrocarbon, seismic exploration, subsurface structures.

THE Bengal Basin represents a large delta complex covering most of the geographical extent of West Bengal and Bangladesh. The basin hosts a huge sedimentary sequence ranging in age from Permo-Carboniferous to Recent. The Bengal Basin has undergone multiple phases of tectonism during its tectonic evolution¹. This consists of an extensional phase involving rifting during Gondwana followed by a compressional phase in the Tertiary due to simultaneous subduction of the Indian plate beneath the Eurasian and Burmese plates. This last phase of deformation is still active at present, thus making the basin neotectonically active with evidences of the same reported by different workers in different geomorphic and seismic events²⁻⁶.

Multiple episodes of tectonism suffered by the Bengal Basin have led to the formation of different tectonic regions in it with a varying sedimentary thickness and depth to basement (Figure 1). Such a diverse history of sedimentation and tectonism in the Basin is also assumed to result in multiple petroleum systems in it in different phases of its stratigraphic evolution. Petroleum system studies in the Bengal Basin reveal the presence of at least three different active petroleum systems^{7,8}. These are the (i) Permian–Carboniferous (Gondwana) petroleum system, (ii) Paleocene–Eocene petroleum system and (iii) Oligocene–Miocene petroleum system. All of these make the Bengal Basin prospective from hydrocarbon point of view. The West Bengal part of the Bengal Basin is identified as a Category III petroliferous basin, implying a geologically prospective sedimentary basin⁹. In spite of such diverse development of petroleum systems, even after five decades of seismic-based hydrocarbon exploration, no commercial finds have been delineated in the area. Hydrocarbon shows are observed during drilling of deep wells, mostly restricted to deep-seated structures and older formations.

The West Bengal Basin is entirely concealed under a thick layer of alluvium with no direct manifestation of its structural and geological set-up evident on the surface. Most of the subsurface information in the West Bengal Basin used for hydrocarbon exploration is derived from conventional seismic methods that are processed to target the deeper prospects. Based on these data, though a few faults and associated structural highs have been mapped in the deeper sediments, no structures are visible in the shallower sediments. One of the major reasons of the limitation of visibility of structures in the shallow sediments is vertical seismic resolution. The theoretical minimum vertical resolution is dependent on one-fourth of the dominant frequency and corresponding wavelength used in the survey¹⁰. However, this theoretical minimum vertical resolution is difficult to achieve in practice¹¹. In the present study the vertical resolution varies from 33 m to 40 m. As a result, a gap in information exists about the understanding of hydrocarbon pools residing in the

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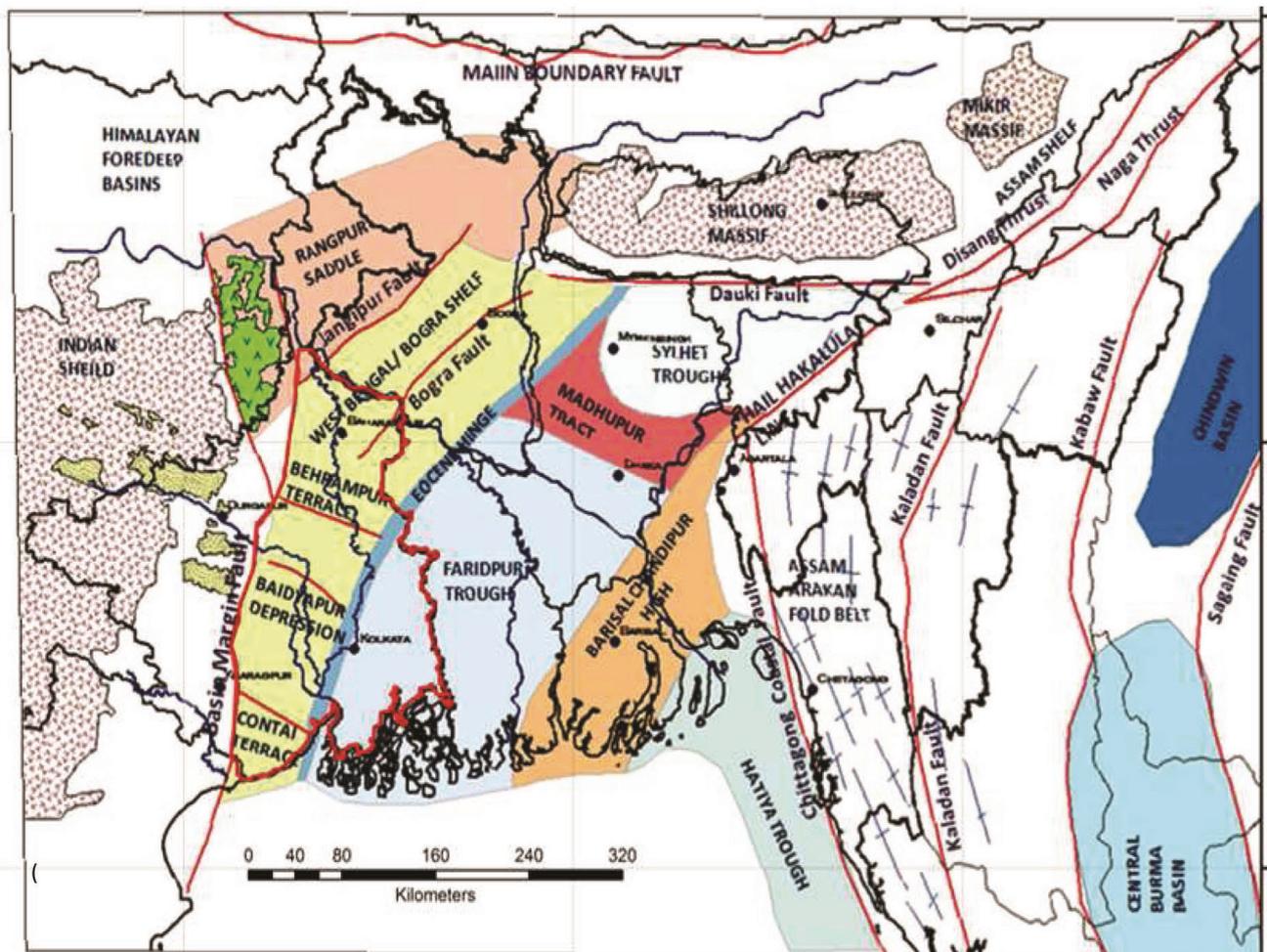


Figure 1. Tectonic provinces and tectonic elements of the Bengal Basin compiled from refs 11, 35 and 36 along with West Bengal part of the Bengal Basin (marked as red polygon).

shallower traps. In this article, a new approach is devised using an integrated geospatial analysis consisting of neotectonic influenced geomorphic parameters and multi-spectral image analysis on a GIS platform, to map the shallow and subtle structures in the West Bengal Basin that can act as potential targets for hydrocarbon exploration.

Tectonically, this basin comprises a stable shelf and a foredeep part (Figure 1) that is separated by a 2.5 km wide Eocene hinge. The stable shelf part overlies a thick continental crust with a lower sediment thickness, but the foredeep part lies on a thinner continental crust with a greater sediment thickness forming a rapidly subsiding basin^{12,13}. Most of the geographical extent of the Bengal Basin is covered by the shelf part. Structurally, based on existing studies, mostly dependent on seismic data, the shelf part is characterized by a southeasterly homoclinal dip with a uniform gradient associated with deep-seated rift-related faults and a virtual absence of faults¹³ and structural highs in younger shallow sediments.

Methodology and results

The present methodology is based on the assumption that deep-seated structures resulting from an earlier phase of tectonics were reactivated by a later phase of tectonics. However, with each phase of reactivation, the structures grew upward in shallow sediments with diminishing amplitude or displacement. Such structures reactivated by neotectonic deformations result in the formation of subtle structures in shallow sediments. However, these structures are associated with a predominantly vertical component of deformation¹⁴ that is imprinted on the surface in the geomorphic elements, especially in sensitive elements like drainage, lineaments and topography¹⁴. The analysis of these elements is based on the principles discussed in the literature^{15,16} and helps to bring out surface manifestations of the subsurface structures. These surface manifestations are then correlated with the available subsurface data to validate them and establish the subsurface continuity of these interpreted structures. Since the West

Bengal Basin is neotectonically active, with a relatively flat topography and traversed by multi-order drainages, it acts as an appropriate area for such analysis. The study area in this case is limited to the stable shelf part of the West Bengal Basin.

Morphostructural analysis

The neotectonics-based geomorphic analysis comprises two independent parts: one of them is to delineate morphostructural faults that represent surface manifestations of subsurface faults, whereas the other helps identify geomorphic highs that probably imply subsurface structural highs. The methodology of delineating subsurface faults in the study area is described in the workflow from different geomorphic datasets. These consist of the following:

(1) Lineaments delineated from processed and mosaicked LANDSAT ETM+ images of 30 m resolution as well as AWiFS data with a near nadir resolution of 56 m based on tonal variations (Figure 2 *a*).

(2) Drainage parameters indicating probable structural control on drainage in alluvial areas like drainage offsets (Figure 2 *c*), rectangular drainages (Figure 2 *d*), abrupt sinuosity variations like appearance of compressed meanders (Figure 2 *e*) and straight-line rectilinear drainages derived from a drainage map. The drainage map is prepared incorporating all orders of drainage extracted from LANDSAT ETM+ image of 30 m resolution, IRS P6 LISS 4 imagery of 5.8 m resolution and SOI topographic sheets of 1 : 50,000 scale of the area (Figure 2 *b*).

(3) Topography-derived parameters like lines of abrupt slope variation computed from slope map derived from CARTOSAT-1 DEMs with 1 arc sec (~30 m) posting.

All of these datasets can be considered as surface representations of a small part of a subsurface fault. As such, the small parts of faults can be regarded as minor elements or building blocks of larger faults and hence are referred as minor faults or minor linears (Figure 3 *a*). The reconstructed faults (Figure 3 *b*) are further tested for validation with fault-sensitive geomorphic parameters like abrupt changes in drainage morphology and abrupt variations of surface topography (Figure 2 *f*). To verify the results, a detailed field work has been carried out in the entire study area, where neotectonic evidences of faulting like incisions in lower-order drainages, development of unpaired terraces and abrupt bends in drainages are used to corroborate the fault interpretations (Figure 2 *g*).

Geomorphic highs are delineated from anomalous localized drainage geometries like radial drainages (Figure 4 *a*) and peripheral/curved drainages (Figure 4 *b*)^{15,16}. These features are used for initial delineation of geomorphic highs in the study area identified from the drainage map of the area. The delineated geomorphic highs are

then checked for association with drainage features like rectangular drainages, barbed tributaries, drainage density lows and pondings^{15,17}. Additionally, association of topographic features like isolated contour depressions (Figure 4 *c*) and image-based parameters like areas of lower tone and lower values of soil moisture attributes computed after considering and studying multi-date image data is also checked. A positive association of any of these features with geomorphic highs adds to the certainty that these highs are manifestations of subsurface structural highs. Based on the number of events of correlation/association of the geomorphic highs with the aforesaid parameters, the geomorphic highs are weighted (Figure 4 *a*). The greater the weightage of the geomorphic high, higher will be its degree of confidence of representing a subsurface structural high.

Correlation with collateral data

The above methodology results in a network of regional faults and a number of geomorphic highs that are arranged according to their degree of confidence. However, to establish the subsurface continuity of these interpreted structures, they are correlated with other available collateral geological and geophysical data like groundwater well data, deep well data, seismic data, gravity data and earthquake epicentre data. Stratigraphic sequences encountered in shallow groundwater wells (Figure 5 *a*) and deep hydrocarbon wells (Figure 5 *b*) placed on either side of an interpreted fault are correlated. If a structural separation of equivalent stratigraphic units is observed in these wells, it validates the fault and indicates that the fault is continuous from its demarcated surface manifestation to at least the depth indicated by the well.

The surface structural features have also been correlated with deep-seated faults and structural highs imaged in available seismic surveys, in maps at different levels (Figure 6 *a, b*) as well as in sections (Figure 7). Conventional seismic data have been used to structurally map the different layers based on two-way time for a seismic wave to travel from its source to a given reflector and subsequently to a detector. Seismic maps corresponding to different stratigraphic horizons are mapped as two-way time contours where abrupt variations in time indicate faults. Correlation of faults mapped at different subsurface levels on overlay with the surface faults depicts a similarity in trend and spatial disposition between the two sets depending upon the dip of the faults. This implies continuity of the subsurface faults from their mapped horizons onto the surface through the intervening sediments. In case of seismic sections, faults delineated in deeper horizons when extrapolated to the surface are found to match with geomorphic faults interpreted at the surface, thus validating them. Similarly, structural highs mapped in deeper horizons are observed to be manifested

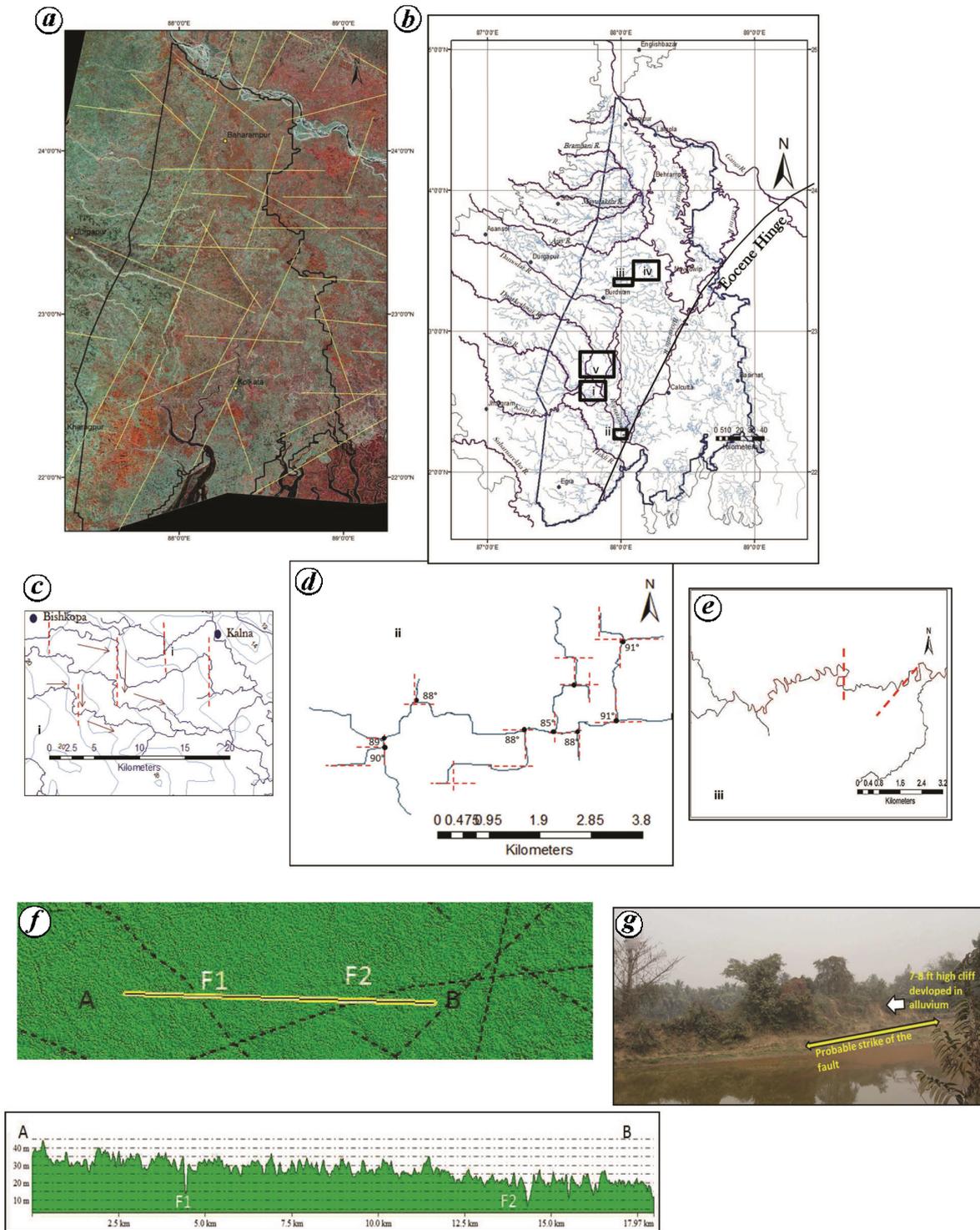


Figure 2. *a*, Lineaments marked as yellow lines interpreted from the edge-enhanced IRS P6 AWiFs image. *b*, Drainage base map as extracted from toposheets and mosaicked images with the deeper coloured rivers representing the main drainages. Rectangles indicate areas where drainage-related interpretations have been cited. *c*, Drainage offset in the study area with the probable faults marked in red. Brown arrows are indicative of flow direction. A contour (marked in light blue of 2 m interval) parallel flow implies probable faults. *d*, Instances of rectangular drainage in the study area. The black dots indicate tributary junctions and right-angled bends with angles ranging between 85° and 95° considered to be anomalous. Red lines are probable faults. *e*, Areas of channels showing sinuosity value >1.75 (marked in red) indicating a compressed meander morphology. Probable faults are marked on the downstream side of it. *f*, Cross-section of the mosaicked CARTOSAT DEM drawn along line AB. Sudden appearance of narrow and deeper valley-forms corresponds to areas where the line crosses the interpreted faults F1 and F2. The line of section is marked in Figure 5 *b*. *g*, Field photograph showing abrupt appearance of a 7–8 ft (about 2.5 m) cliff developed in alluvium along an abnormally straight bank of a channel at point P corresponding to the interpreted fault F3–F3 marked in Figure 5 *b*.

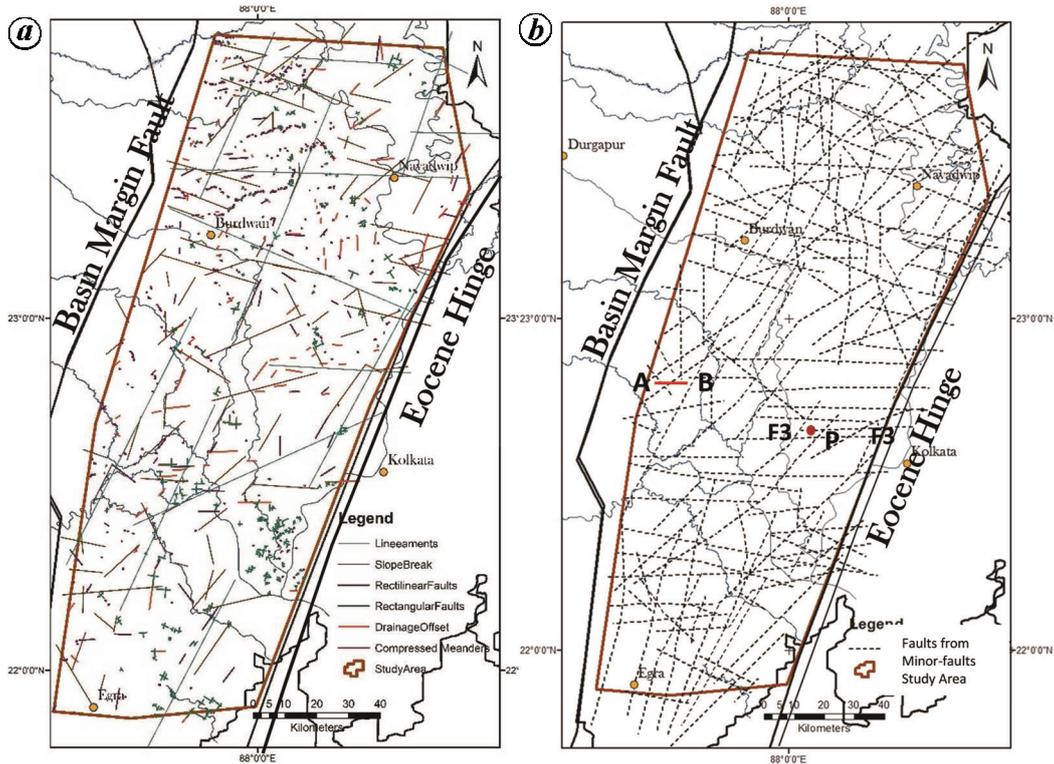


Figure 3. *a*, Minor faults or elemental parts of faults derived from image, drainage and DEM data. *b*, Minor faults joined according to the trend and continuity to reconstruct regional morphotectonic faults in the area.

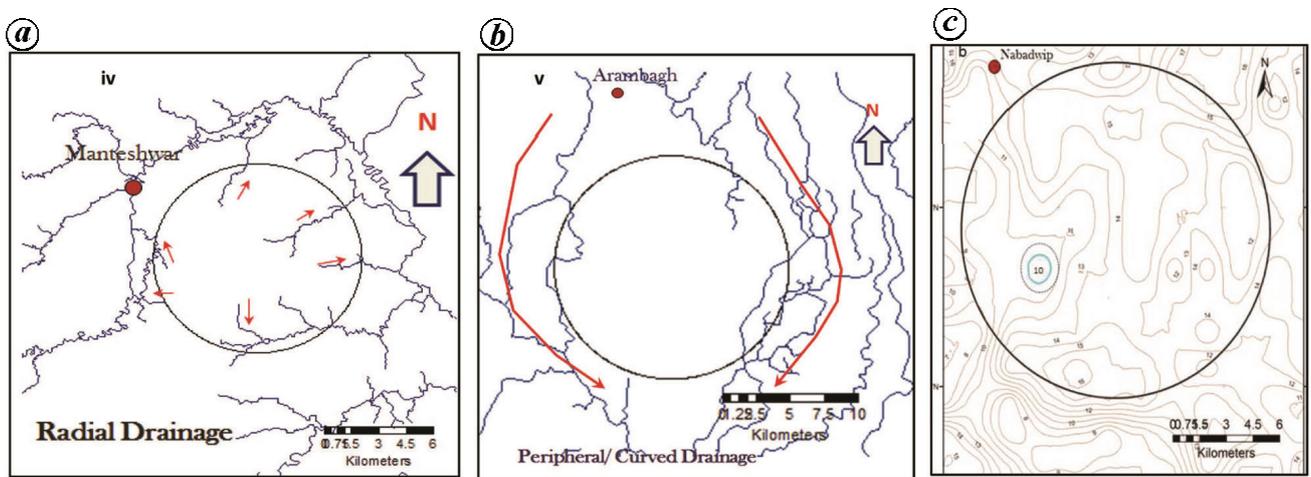


Figure 4. *a, b*, Examples of radial and curved/peripheral drainages in different parts of the study area marked as rectangles in Figure 2 *b*. *c*, Isolated topographic depressions within the geomorphic highs. These are demarcated from isolated lowest contour closing from 1m interval topographic contours, and act as a substitute for pondings.

on the surface as geomorphic highs and can be considered as subtle structures in shallower levels (Figure 7).

The surface interpretations have also been correlated with available Bouguer gravity data. A slope map has been derived from the regional gravity map of West Bengal¹⁸, where an abrupt break in the gravity slope would represent very deep-seated crustal-scale faults. Such

breaks in slope in gravity data within the study area exhibit a positive correlation in trend and disposition with surface faults (Figure 8).

The subsurface continuity of some of the surface-interpreted faults has also been validated by correlating them with earthquake epicentres derived from the archives of USGS, ASC and seismotectonic studies

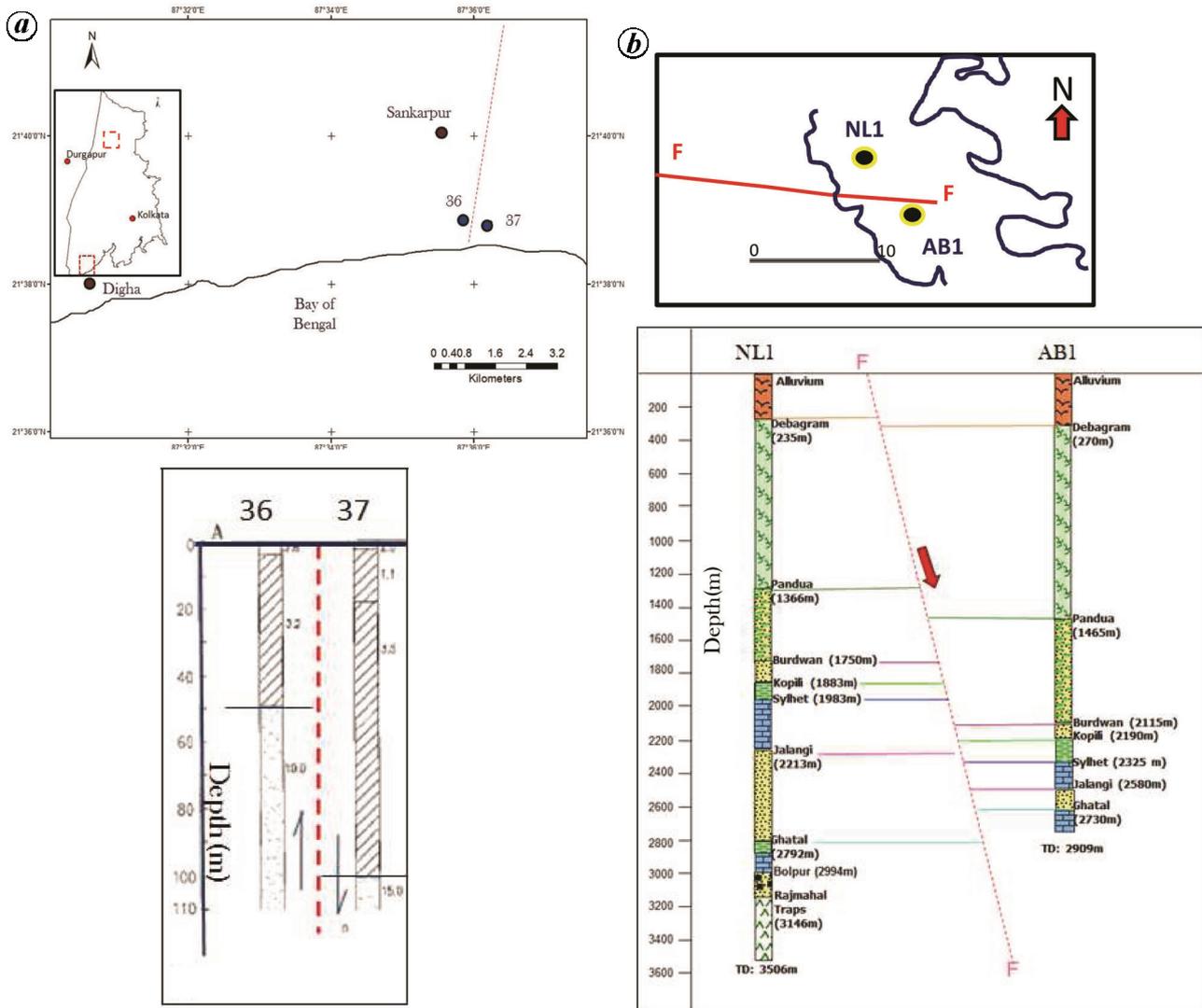


Figure 5. *a*, Groundwater wells 36 and 37 on either side of the interpreted fault (marked in red) in Digha Sankarpur area (marked by the lower red rectangle in the inset) characterized with a formation dip amount of 2° . Structural offsets observed between stratigraphically equivalent horizons on either side of the fault suggest the fault to be downthrown towards SE (redrawn after Chowdhury and Saha³⁷). *b*, Structural correlation of ONGC deep wells NL1 and AB1, on either side of the interpreted faults (marked *FF*) from mean sea level showing vertical offset of equivalent formation tops, thus validating the faults (marked by the upper red rectangle in the inset)¹¹. A structural inversion of formation tops is also observed in the wells at stratigraphic level.

carried out by different workers^{19–22}, reconfirming their down-dip continuity to lower crustal levels.

Overall, these correlations serve as a validation and calibration of the surface interpretations based on which further associated analysis could be performed.

Discussion

Structural implications from correlations with collateral data

Correlation of the surface morphostructural interpretations with subsurface data not only helps define the downdip extent of the structures, but also characterize

these surface structures. Correlation of deep wells drilled on either side of the morphostructural faults indicates that the offset of equivalent formations along the fault appears to be nonuniform in both amount and sense (throw). One of the probable reasons for this may be multiple reactivation episodes of the same fault with each episode characterized by a particular unique offset depending upon the prevailing tectonics. The well-based correlations also indicate that the NE–SW trending faults are found to be broadly downthrown towards SE, whereas most of the E–W or ENE–WSW faults are found to be downthrown towards south. The amount of structural throw in the NE–SW trending faults is found to be much greater than the E–W trending faults. Additionally, a GIS-based overlay of surface faults with seismic maps prepared on the top of

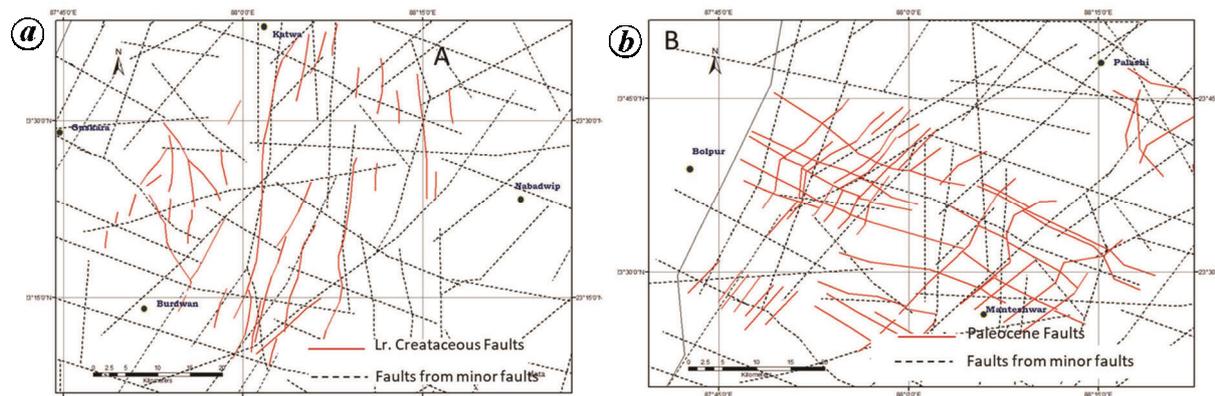


Figure 6. *a*, Faults extracted from isochron map (in red) at the top Lower Cretaceous equivalent to Rajmahal Top³⁵ in Burdwan, Nabadwip, Katwa area. These faults have been correlated with surface morphotectonic fault. Here too the longitudinal faults are found to show a better correlation, implying their validation and subsurface continuity. *b*, Faults extracted from isochron map (marked in red) at the top of Paleocene (equivalent to Jalangi Top) has been correlated with interpreted surface faults³⁸. A positive correlation is observed between the different sets both NW and NE faults. This validates the surface interpretations and implies that the surface faults are continuous at least down to Jalangi level.

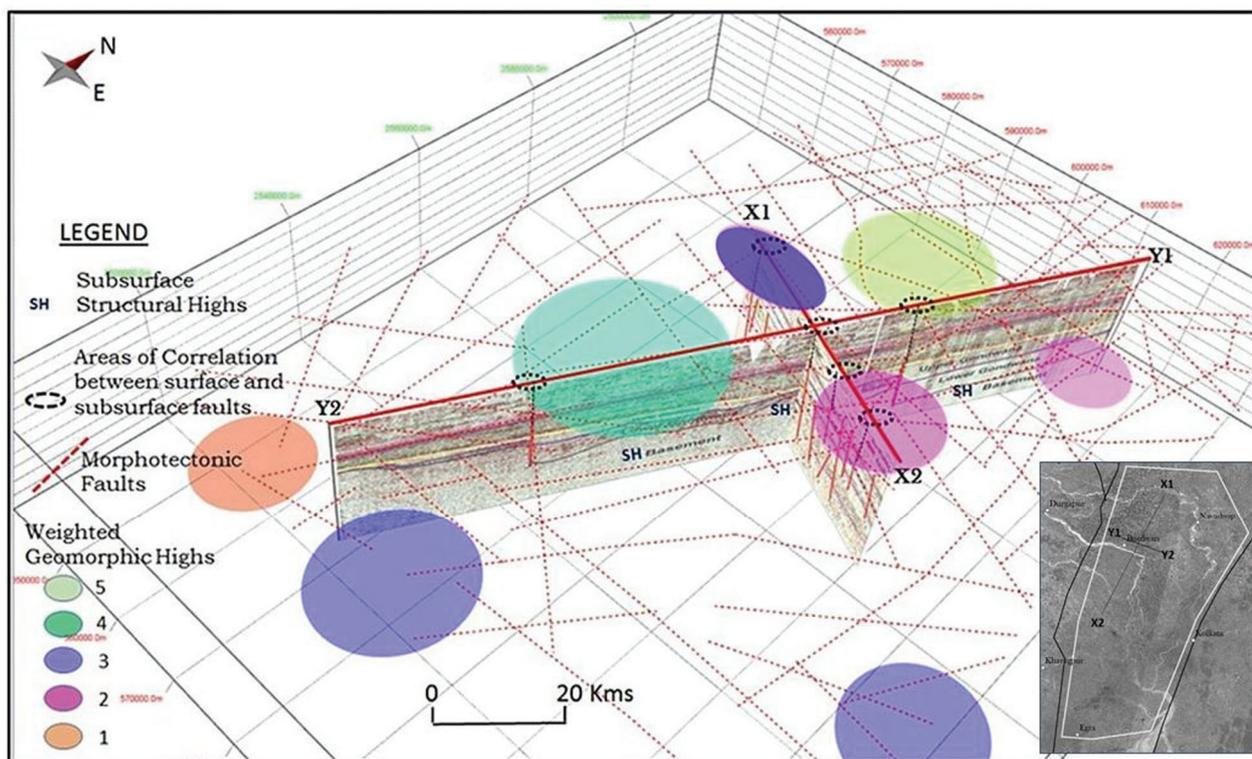


Figure 7. Faults interpreted in seismic sections in profile X_1 - X_2 and Y_1 - Y_2 (inset), if extrapolated to the surface are found to correlate with their surface morphotectonic counterparts. Deep-seated structural highs interpreted below Sylhet level (Eocene) are also found to correlate with geomorphic highs in the surface implying their validation.

different horizons (Gondwana to Paleocene; Figures 6 *a*, *b*) shows very few evidences of E–W faults. However, both NE–SW and E–W faults are represented on the surface, suggesting reactivation of both trends. This absence of E–W faults may be due to a low displacement associated with them that is not seen in the available seismic data. Similarly, correlation with gravity data implies that

surface structures penetrate deep into the subsurface and in some cases are even linked to deep-seated faults in the basement. Another point worth noting is the prominent existence of E–W faults in gravity data, whereas similar counterparts in seismic data have a subtle representation though it has prominence in surface geomorphic interpretations. Correlation of earthquake epicentres with surface

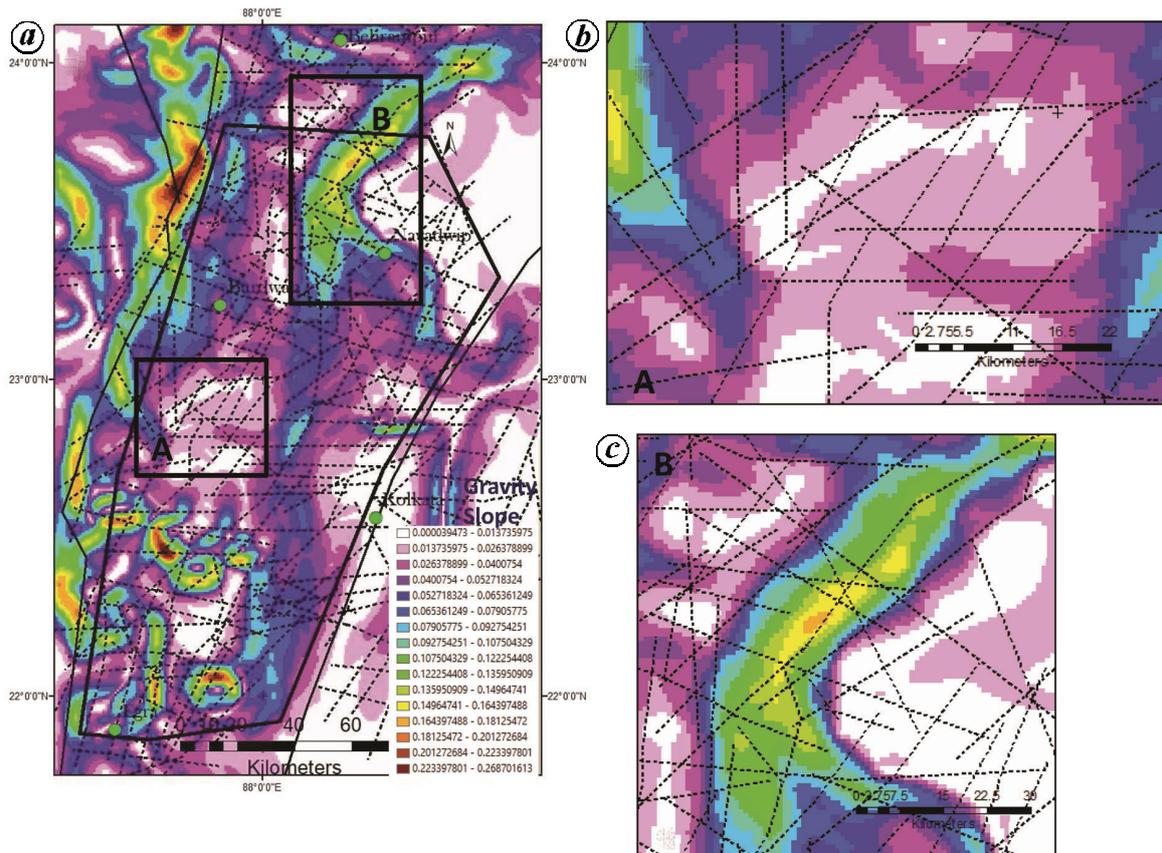


Figure 8. *a*, Gravity slope map prepared from regional gravity data overlain with faults delineated from surface geomorphic data. Slope breaks marked in colour scale have been correlated with faults. *b*, *c*, Areas *A* and *B* in (*a*) showing good correlation between gravity slope breaks and faults derived from minor faults (marked as dotted lines).

geomorphic faults, shows that in most cases, the depth of focus is found to be greater than 30 km. This again reiterates that the deep-seated faults have some associations with the surface faults, where reactivation of these deep-seated basement faults has probably resulted in the formation of surface faults.

Correlation of structural trends

Based on the above correlations, an overlay analysis has been carried out for the faults and structural trends extracted from gravity data and other seismic datasets pertaining to different time-based layers (Figure 9). These have been correlated upwards to understand the timewise variation of trends. Among them, the gravity surface broadly representing subsurface structure of the Pre-Cambrian basement rocks on a regional scale depicts a broad N–S trend and a subtle E–W trend. The Gondwana surface pertaining to Permo-Triassic shows a dominant N–S trend that appears to be affected with an offset in E–W orientation. A lower Cretaceous surface correlating with the top of Rajmahal Trap exhibits predominantly N–S trending faults. Palaeocene surface is found to

represent a NE–SW and NW–SE trend with a marked absence of N–S trends. The surface above representing present-day topographic surface shows all the above trends with a marked increase in E–W trend. This implies that the N–S or NNE–SSW and E–W trends are the oldest represented ones. This is followed by the NE–SW and NW–SE trends. The sudden increase in the E–W trends as well as representations of the other trends on the surface implies a major Post-Paleocene tectonic event associated with E–W trends that define the present-day state of stress. One such event that fits the above observations is the intense tectonic activity during Late Miocene along the Dauki Fault that forms the northern boundary of the Bengal Basin (Figure 1). The Dauki Fault forms a major E–W reverse fault and accommodates about 25% of the stress due to Indian plate movement²³ resulting from N–S shortening between Indian craton and the Shillong block²⁴. This N–S compression is probably transmitted as present-day regional state of stress ($\sigma_{H_{max}}$) oriented in a N–S to NNE–SSW direction, as computed from fault plane solutions of earthquakes affecting the study area^{25–27} and maximum stress direction indicated in the *World Stress Map*²⁸. In such a case, faults aligned E–W will display maximum effects of reactivation. However, these

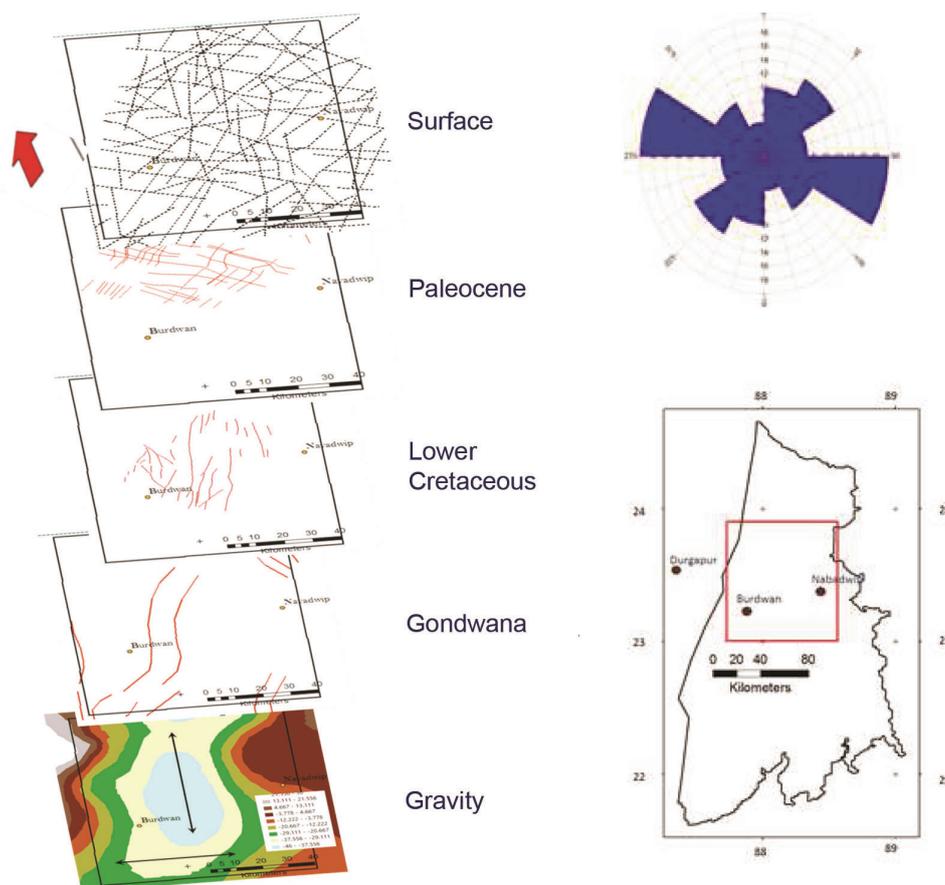


Figure 9. An overlay analysis of fault trends mapped from gravity (representing basement), faults mapped using seismic data on top surfaces of Gondwana, Lower Cretaceous and Paleocene and faults that have been mapped on topographic surface from morphotectonics. (Inset) Part of the study area that is represented. The rose diagram represents surface trends of the faults where the most dominant trend is found to be WNW–ESE.

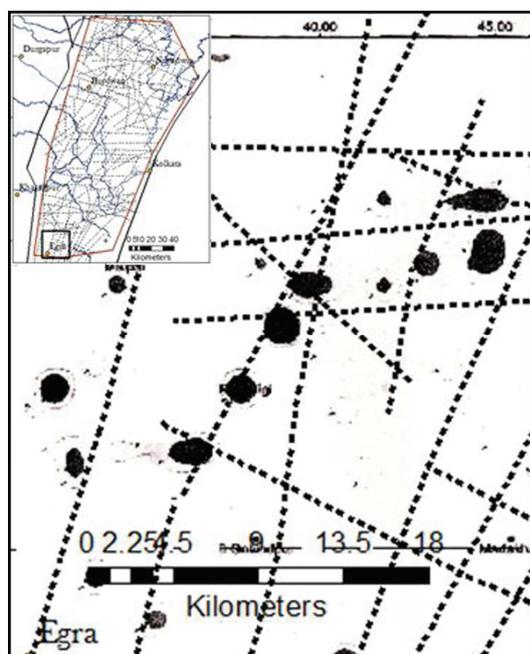


Figure 10. Adsorbed gas anomalies of pentane in Contai area (area marked in inset map) are found to correlate with NNE–SSW-oriented morphotectonic faults³⁵. This corroborates the premise that NNE–SSW faults act as conduits of remigration.

reactivations result in a very low amount of displacement associated with the E–W faults that are often found to be beyond seismic resolution and hence not discernible in seismic data. These reactivations also result in down-thrown horizons in earlier extensional faults to be uplifted in a compressive tectonic regime, thus displaying structural inversion of some horizons compared to the general trend across the fault (e.g. Ghatal formation in Figure 5 b).

Remigration and accumulation in study area

In any basin, faults bounding a structural prospect act as entrapments or seals preventing any further migration of hydrocarbons and creating primary hydrocarbon pools or accumulation. Due to neotectonic reactivation in the area, the earlier faults acting as barriers may be reactivated. As a result, earlier structures that served as primary hydrocarbon pools could be breached eventually leading to the destruction of the primary reservoir and redistribution of its hydrocarbon content²⁹. Segments of faults, earlier acting as barriers, serve as hydrocarbon flow paths in the post-reactivation scenario causing vertical remigration of

hydrocarbon³⁰. Continuing phases of active tectonics also lead to the formation of new structural highs at a shallower level that act as new locales of accumulation to the remigrated hydrocarbon³¹. These reactivated faults and structural highs are smaller and shallower than the primary structures. The reactivated faults are more open in the direction parallel to the maximum horizontal stress (σH_{\max}). As a result, most fractures within the fault zone are open and conducive to hydrocarbon migration. Conversely, faults oriented perpendicular or at a high angle to σH_{\max} become closed and help in the entrapment of hydrocarbons^{29,32}. Effects of such reactivated prospects are found in Bozhong Depression, Zhu 2 depression and Yinggehai Basin in China, that have created a new petroleum system with new structural traps, migration routes and source kitchens³¹. In the Bohai Sea Basin in China, young and sometimes shallow folding is important for petroleum occurrence. As the age of maturation and migration is known to be before Pliocene in the deep southern part of the Bohai Sea Basin, it can further be inferred that hydrocarbons have migrated from previous existing reservoirs to traps formed in Late Neogene and Quaternary. According to Xu *et al.*³³, neotectonic movement controlled the accumulation of oil and gas in the later period in the Bohai Bay. Similarly, we surmise that active tectonics might have led to the formation of shallow reactivated structures in the Bengal Basin, which might serve as locales of hydrocarbon entrapment. Shallow boreholes in the study area on either side of the morphostructurally interpreted faults show a displacement of 45–20 m. Similarly, at shallower levels, displacement of equivalent stratigraphic layers (Figure 5 *b*) is found to vary from 35 m to 55 m. Considering a regional dip in the shelf area amounting to maximum of 2° (ref. 10), this separation in adjacent wells may be due to neotectonic reactivation of older faults that may have created associated structural highs.

In the study area, the prospects explored till now mostly occur as deep-seated fault-related closures or structural closures. These deep-seated structures of Cretaceous to Miocene constitute the primary areas of accumulation. These primary hydrocarbon accumulations have been probed by a number of deep wells. However in each case, no producible content of hydrocarbon has been encountered on testing¹. Neotectonic reactivation results in breaching of these primary traps and vertical upward remigration of the accumulated hydrocarbon, and eventually in the destruction of the primary reservoir. The remigrated hydrocarbons may accumulate in the secondary structural highs at a shallower level in the Upper Miocene or Pliocene, forming new areas of exploratory interest. These shallow and subtle structural highs formed due to neotectonic reactivation are manifested as geomorphic highs. Similarly, the faults delineated by morphostructural analysis are surface manifestations of the neotectonically reactivated faults. The present-day stress orientation resulting in these neotectonic deforma-

tions is assumed to be similar to that existing during hydrocarbon migration of Paleocene to Late Miocene petroleum system, i.e. 42–2 Ma (ref. 8). Considering the direction of maximum horizontal stress (σH_{\max}) prevailing during that time to be similar to that at present, the morphotectonically interpreted NNE–SSW faults act as conduits of vertical remigration, whereas the E–W-oriented faults act as sealing faults for trapping. The shallow and subtle structural highs deciphered from geomorphic highs help to form structural traps for secondary accumulation. Some of the remigrated hydrocarbons may remain untrapped and escape to the surface through the faults where the light gaseous hydrocarbons are adsorbed by the soil matrix³⁴. A high adsorbed gas concentration along the NNE–SSW faults corroborates the premise that such faults act as migration conduits (Figure 10).

An association of all these three elements, i.e. NNE–SSW faults, E–W faults and geomorphic highs satisfies the pre-requisites of formation of new pools of hydrocarbon resulting in a separate petroleum system (Figure 11 *a*). These hydrocarbon accumulations may occur as small pools in sandstone of Lower Pliocene or Upper Miocene age. Thick clays deposited in the Upper Pliocene may act as an effective cap rock to the hydrocarbon deposits. Areas of such association defined on the basis of the morphotectonic interpretations are demarcated in the study area. These areas may serve as the new targets of hydrocarbon exploration. The new hydrocarbon pools are smaller and shallower than the deeper primary pools. In addition, since the geomorphic highs are manifestations of subsurface structural highs, all layers underneath the geomorphic highs exhibit some sort of antiformal structure that may act as an area of accumulation for hydrocarbons. In such a case, if associated with an E–W-oriented sealing fault, there is a probability of encountering undiscovered multistoried stacked pools in the different reservoir units from Pliocene to Gondwana (Figure 11 *b*). Though the deeper pools may be in various stages of depletion whereas the shallower pools may be subtle, such a sequence of stacked hydrocarbon accumulation may be interesting. The multistoried sequence of pools could be exploited by the same well system that may be economical for exploration.

Hydrocarbon shows have been reported during drilling at a shallow level in ONGC well GP1 (at 1876 m in the Upper Miocene), occurring within the delineated areas correlating with pentane anomalies on the surface. This also reiterates the thermogenic nature of the petroleum system vis-à-vis shallow-level biogenic gas. Gas shows have also been observed at a shallow depth of 1469 m in well RN1 near the hinge zone. Though these intervals have not been tested for producibility, the occurrence of hydrocarbons at such a shallow depth in stratigraphically younger formations within the delineated areas supports the above concept and consequent interpretations.

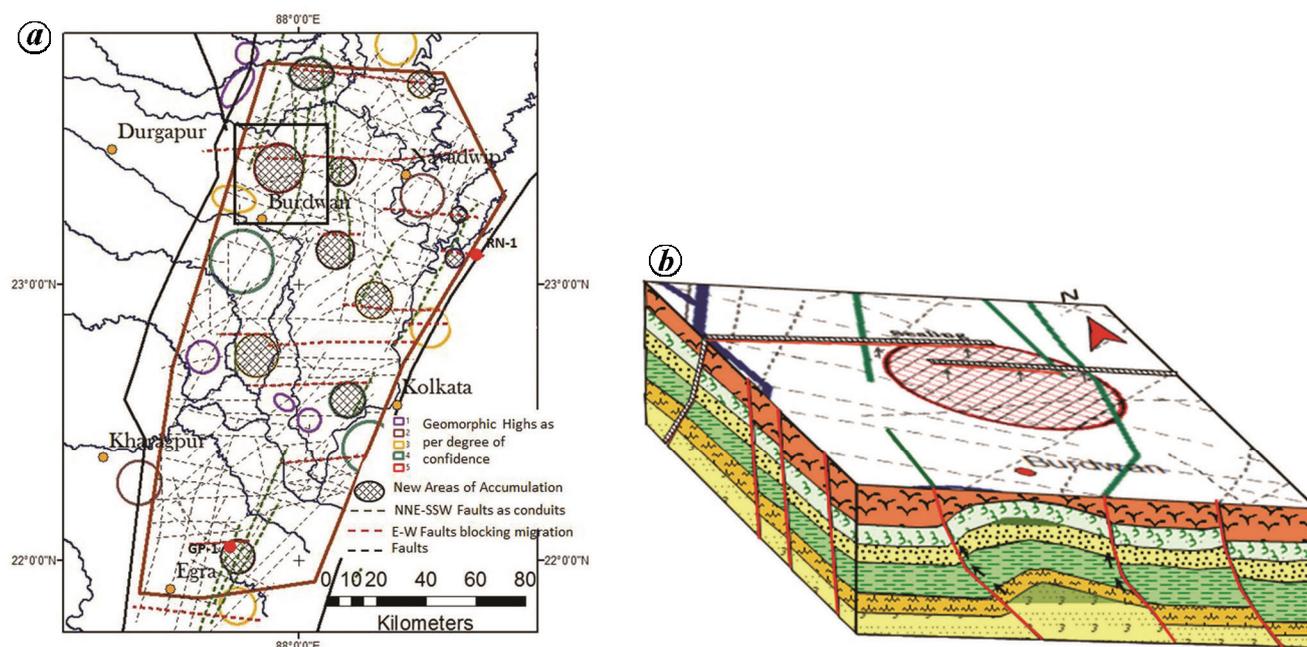


Figure 11. *a*, Morphotectonic map of the study area showing faults and geomorphic highs. Geomorphic highs are classified based on their degree of confidence to represent subsurface structural highs. 1 is the least confident whereas 5 is the most confident. New locales of hydrocarbon accumulation envisaged based on a combination of NNE–SSW faults acting as conduits of vertical migration, E–W faults acting as barriers of further migration and geomorphic highs that are a manifestation of subtle and shallow structural highs. Shallow hydrocarbon shows are reported in well GP1 in the demarcated areas. *b*, 3D model indicating the probable layout of structural elements and mechanism of entrapment in shallow structural highs in Burdwan area. It also indicates the existence of a system of multistoried hydrocarbon pools.

The above concept and methodology may thus help discover commercially viable hydrocarbon basin serving as an alternate and cost-effective hydrocarbon exploration strategy.

Conclusion

In this study we have presented an alternative concept of exploration in shelf part of the Bengal Basin based on neotectonic reactivation of earlier structures that aims to target shallower, subtle structures which are associated with N–S and E–W trending faults. These structures though not resolvable in conventional seismic studies may be delineated in remote sensing and GIS based workflows that act as supplementary data sets to seismic studies and may help in establishing them as promising areas for hydrocarbon exploration. These areas delineated as targets may be recommended for high-resolution seismic and close grid micro-gravity exploration survey. Additionally, this methodology can be adopted in neotectonically active basins with a similar tectonic setting like the Ganga Basin, Purnea Basin and North Bank of Bramhaputra, where existence of petroleum system has been established but commercial success still remains elusive.

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