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Delineation of a Possible Subsurface Ridge in Onshore Palar Basin based on Morphotectonic Studies and its Implications

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Summary

The Palar basin represents a virgin area in terms of exploration with a poor seismic coverage limited to only the NELP area of ONGC and a no well control. In this context, a morphotectonic analysis of Palar area had been attempted mainly on basis of prevalent drainage data to delineate the tectonic elements of the area. Based on the morphotectonic analysis, a centrally placed E-W trending ridge had been hypothesized that acts as tectonic divide between the northern and southern parts of the basin. This ridge is considered to be a a result of Post Cretaceous post rift compression in contrast to the other ridges that were formed due to Early Cretaceous rifting episode. A number of geomorphic highs had been delineated in this ridge that are probably culminations and can be considered exploration targets

Keywords: *Palar, ridge, morphotectonics, trends*

Introduction

Palar basin is an intracratonic rift basin with its rift axes oriented in an N to NNE located in Tamil Nadu and adjoining Andhra Pradesh with its northern part extending into offshore. The basin is separated from adjacent Pennar Basin in the North by a basement high called Nayudupeta High whereas in the south it is separated from the Cauvery Basin by, the Chingelput High (Fig 1).

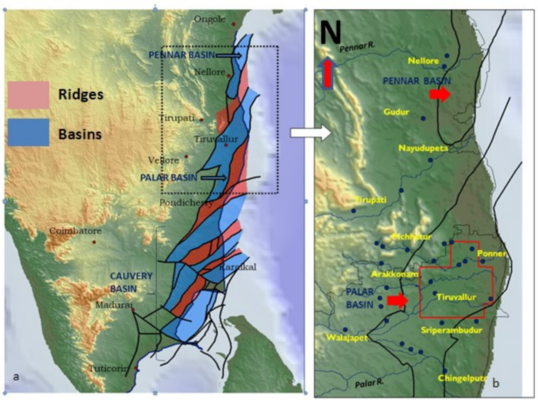

Figure 1. General tectonic & geographical set up of East Coast showing different basins and their dividing ridges with the basins marked in blue and dividing ridges in red (1a.) Geographical and basin outline of Palar and Pennar Basin (1b.)

The tectonic initiation of the Palar Basin however occurred in Lower Permian in N-S oriented linear troughs found in the southern part of the Palar basin. This led to the deposition of Ongur Formation in a fluvio-glacial environment with a marine influence directly over the Precambrian crystalline rocks. Subsequently, the initiation of rifting leading to the continental separation between India and Antarctica in Upper Jurassic resulted in formation of genetically related pull apart rift systems of Cauvery, Palar, Pennar & KG ultimately forming a series of horst and graben features. This formation of horsts and grabens led to deposition of synsedimentary Sriperambudur Formation in a restricted basinal setup in lacustrine environment. In Lower Cretaceous transpression along the junction between Antarctica and Sri Lanka-India led to development of a NNW-SSE led to the uplift of the Nayudupeta High which eventually demarcates the Palar basin from the Pennar Basin. Continued rifting of Palar Basin also led to a final tectonic deepening of the latest stage of rifting and led to the deposition of a transgressive Satyavedu Formation consisting of ferrugeneous sandstone with plant fossils (Fig 2a). Palar Rifting probably terminated in Early Cretaceous after which the area suffered wide spread positive movements in Late Cretaceous (Rangaraju et al, 1993). This led to the uplift and erosion of the area with no

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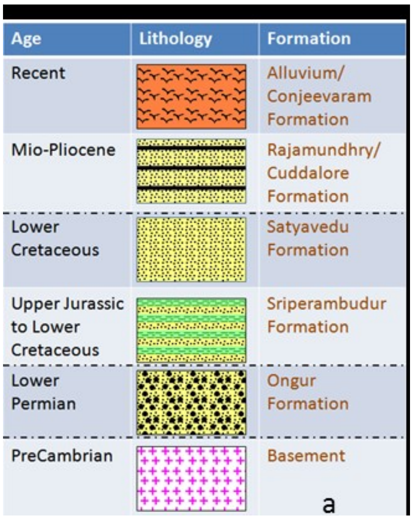
surface development of any Post Rift sediment. Presently, the Palar Basin shows evidences of neotectonics (Ramasamy et al, 2011, Narasimhan, 1990) implying the area is still tectonically active though it overlies a stable South Indian shield. Fault plane solutions indicate thrust faulting along with strike slip component along an E-W striking nodal plane which defines the present day or the post-rift state of stress in the region (Murty, 2002)



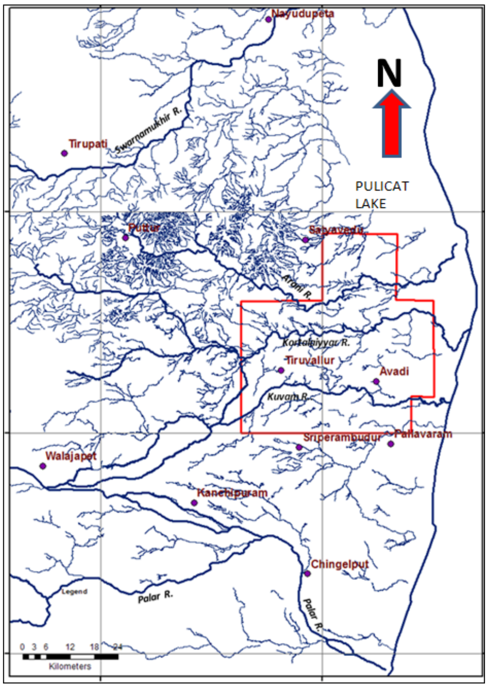


Figure2. a. Generalized stratigraphy (with unconformities marked in dotted line) after Vairavan, 1993 and (2b.) drainage nap of Palar Basin

Morphotectonic Studies in Palar Basin

The Palar basin represents a virgin area in terms of exploration with a poor seismic coverage limited to only the NELP area of ONGC and a no well control. In this context, a morphotectonic analysis of Palar area had been attempted mainly on basis of prevalent drainage data to delineate the tectonic elements of the area. The major drainages in the area are found to define a Parallel pattern flowing from west to east suggesting that the regional drainage in the area is governed be the regional slope of the terrain (Fig 2b). However, based on structurally induced local drainage anomalies like rectangular drainage, drainage offset, rectilinear drainage etc. as discussed in Mazumder et al, 2012, microlinears were delineated and joined as per their trend and continuity to define probable regional faults (Fig 3a)that were subsequently validated by a field check in selective traverses (Fig 3c). In a similar way, geomorphic highs had been delineated based on radial and peripheral drainage as discussed in Mazumder et al, 2012 which can be considered to be surface expressions of subsurface geomorphic highs (Fig 3b). These geomorphic interpretations had been correlated with collateral data like seismic data (Fig 3d) , earthquake epicentres, gravity and magnetic wherever available to validate them as well as to delineate their subsurface continuities. The delineated morphotectonic features had also been overlain with bathymetry (Fig 3e) , gravity and magnetic data in the offshore part (Subrahmanyam, et al, 1995 and Murthy et al, 1995) and also found to be correlating and continuous in both aspects-disposition and trend.

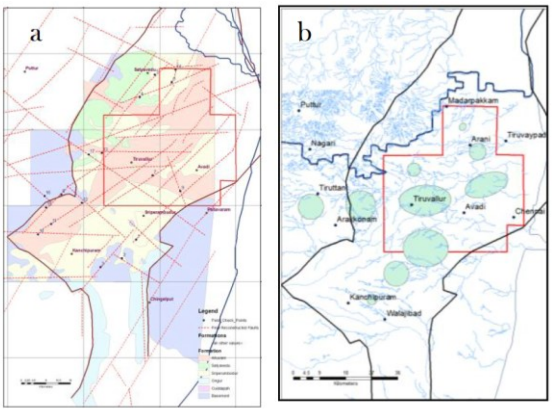


Figure 3 a. Fault network delineated from drainage anomalies in Palar Basin overlain on the geological map b. Geomorphic highs interpreted from drainage data .

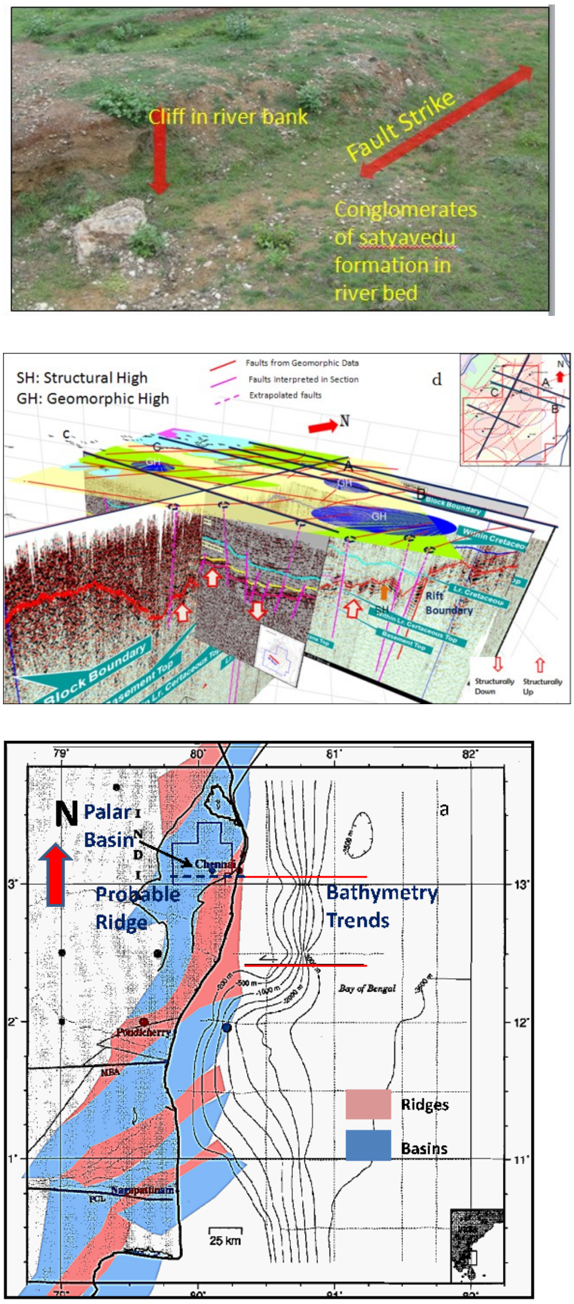


Figure 3 c.Validation of Morphotectonic interpretations by field checks(at pt. 5 near Satyavedu). d. Correlation of morphotectonic interpretations with interpreted seismic data for validation as well as to delineate subsurface extent. e.Correlation with offshore bathymetry trend (after Murthy et al, 1995)with surface faults from geomorphic data suggesting regional lateral continuity

Analysis of Morphotectonic interpretations

A trend analysis of faults interpreted on basis of drainage in the Palar Basin shows a dominant NE-SW trend along with subsidiary NW-SE and E-W trends (Fig 4 a). The E-W trending faults had been extracted as a separate theme and then a density analysis had been carried out on them.

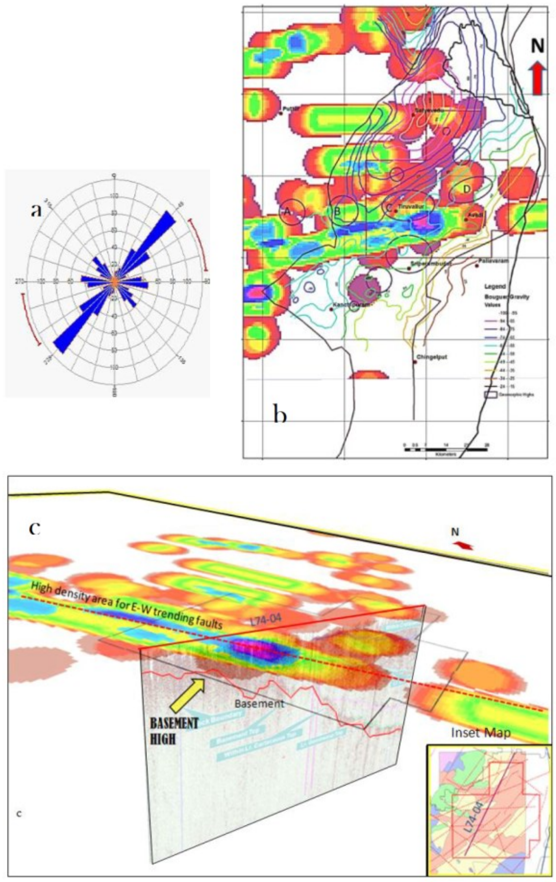


Figure 4.a) Rose diagram of faults delineated in Palar Basin showing a dominant NE-SW trend along with subsidiary NW-SE and E-W trends (b) Overlay of density map of E-W trending faults (purple: highest to blue: lowest) with the regional gravity map of Palar Basin shows that the area of higher density E-W faults (marked in blue) more or less coincides with the area of gravity high also coincident with the trend of interpreted geomorphic highs (A, B, C & D) (c) Correlation with interpreted seismic section shows basement high correlating with area of higher density E-W faults and trend of geomorphic highs

The results of the analysis show that most of the E-W trending faults are concentrated on the central part of the basin (Fig 4 b). A correlation of the density map of E-W trending faults with the regional gravity map of Palar Basin shows that the area of higher density E-W faults in central part of Palar Basin more or less coincides with the area of gravity high (Fig 4 c) that bounds the northern depression towards its south. This high is also evident from interpreted seismic lines where traces of another low are also observed further south of this high. An overlay of the interpreted geomorphic highs with all of the above features indicate that the highs in the central part of Palar Basin form an alignment which coincides to a reasonable degree to the earlier mentioned area of high density E-W faults

The above zone of coincident higher density E-W faults, E-W trending geomorphic highs and region of basement high in the central part of Palar basin can be said to define a subsurface ridge (Fig 5 a) that differentiates the Palar Basin into a north and a southern part. A separate trend analysis had been carried out for each part based on faults identified from morphotectonic analysis as well as lineaments derived from a regional analysis. The analysis shows that though the imprint of the NE-SW trend is fairly evenly distributed in both the parts of the basin, the northern part shows a very subtly developed N-S (Fig 5 b) trend where as in the southern part it occurs as an appreciable component of the trends (Fig 5 c). This implies that the E-W trending basement ridge in the central part of Palar Basin dividing it into north and south probably also acts as a tectonic divide. The dominant NE-SW is probably attributed to the main rifting phase between India and Antarctica that was instrumental in creating most of the east coast basins. The E-W trend instrumental in creating the hypothesized centrally placed ridge is the result of the post rift phase that is continuous even today. The present state of stress in this region as discussed earlier is an N-S or NNW-SSE compressive regime that is associated with a sinistral strike slip component.

The area of high density E-W trending faults in the central part of Palar basin coinciding with a basement high and gravity high is also a probable result of the N-S compressive stress. This E-W trending zone is found to correlate in disposition and alignment with a Pre Cambrian shear zone in the south Indian Shield (Fig 6 a and b). Since these shear zones are associated with deep seated faults (Harinarayana et al, 2006, Kumar et al, 2009) and occur almost perpendicular to the present day maximum stress direction, they might act as zones of prominent reactivation. Now, as this E-W trend is associated with thrust faulting, it might have caused an uplift of the region resulting in a basement high or gravity high thus delimiting the northern part from the south. The geomorphic highs A, B, C & D aligned along this EW trend probably signify culminations within the intrabasinal high.

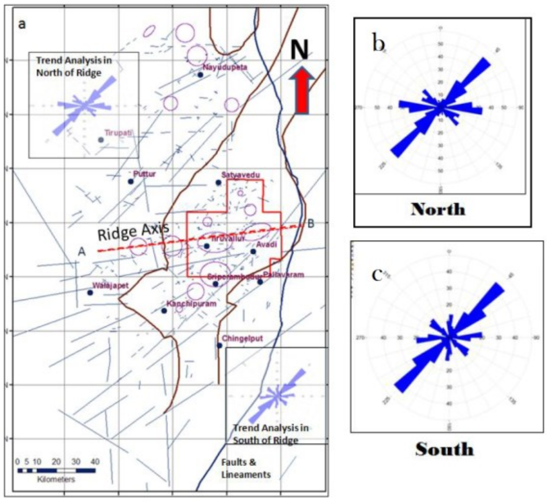


Figure 5a) A trend analysis of faults and lineaments on either side of broadly E-W trending ridge AB that acts as a tectonic divide b) The northern part shows a very subtle N-S trend whereas southern part depicts an appreciable N-S component (c)

Implications in hydrocarbon Exploration

From the above studies, it becomes apparent that in the post rift phase the regional stress direction acting on the area is oriented in a N-S orientation. As such it implies that faults oriented parallel or at low angles to this direction might act as conduits for migration which in this case might be the NE-SW or NNE-SSW oriented faults. Since the deeper part of the basin lies in the north, any primary or secondary migration along faults will be from north to south and might be along these faults. The ridge being at a high angle to these faults will act as tectonic barrier or trap and hence will result in places of accumulation (Fig 7). In such a condition geomorphic highs premised as culminations within the E-W basement high can act as exploratory target.

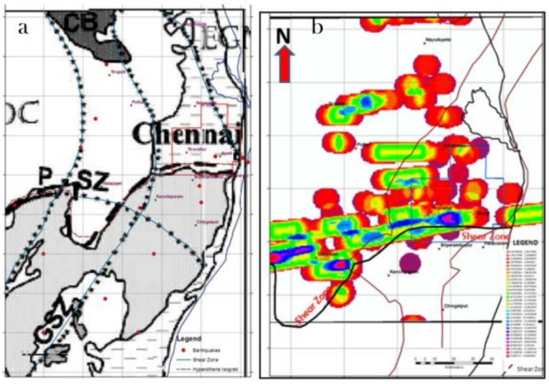


Figure 6a) Pre Cambrian shear zone underlining the Palar Basin associated with earthquake epicenters suggesting that they are seismically active under present stress regime b) Pre Cambrian shear zone correlating with area of maximum E-W trending faults implying that probably the E-W basement ridge is due to reactivation of the shear zone in present stress regime

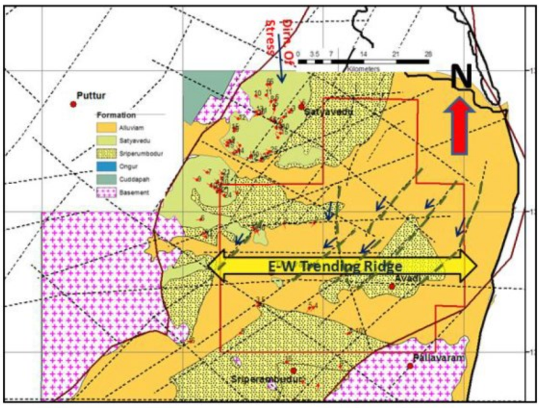


Figure 7) E-W trending ridge acting as a tectonic barrier to the NE and NNE trending faults that probably aid in migration thus helping in creation for locales of accumulation

Conclusions

From the above discussions, it is observed that the Palar Basin is probably dissected into a northern and southern part by a broadly E-W oriented subsurface basement ridge. The E-W ridge also acts as a tectonic divide with the area south of it showing an appreciable N-S tectonic trend that is very subtle in the north. This N-S trend is associated with the Lower Gondwana rifting that probably formed the earliest part of Palar Basin whereas the area north of it is dominated by Late Jurassic-Early Cretaceous India-Antarctica rift related NE-SW trend. Though the entire southern part of eastern coast is constituted of a number of NE-SW oriented basins and sub basins separated by subsurface basement highs, the presently discussed basement ridge differs from them in the aspect that this high is a result of Post Cretaceous post rift compression under the present state of stress whereas the ridges between different basins were formed as a result of Late Jurassic-Early Cretaceous rifting. The geomorphic highs premised as culminations within the basement high might act as probable exploratory target.

The views represented in the paper are those of the authors and not of the organization they represent

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