Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Magnetometric delineation of sub-basins, understanding their allochthonous/autochthonous origin in the basin development - A case study from Proterozoic Cuddapah Basin, India

Prasanthi Lakshmi Mallipeddi

prasantimp.ngri@csir.res.in

National Geophysical Research Institute

Parveen Begum Shaik

National Geophysical Research Institute

Research Article

Keywords: Cuddapah basin, NFB, tectonic development, modeling of magnetic anomalies, oroclinal bending, block rotation

Posted Date: November 2nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-7080548/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Magnetometric delineation of sub-basins, understanding their allochthonous/autochthonous origin in the basin development - A case study from Proterozoic Cuddapah Basin, India

M. Prasanthi Lakshmi* and S. Parveen Begum
CSIR-National Geophysical Research Institute, Hyderabad – 500007
**Corresponding author. Email: prasanti_mp@ngri.res.in*

Abstract

Cuddapah basin, situated in the southeastern part of India, is a major Proterozoic basin formed as an amalgamation of five sub-basins with fold and thrust belts located in its eastern part. Many researchers opined that these fold and thrust belts were formed in the collision process of the Prince Charles Mountains-Rayner complex of Antarctica with this part of south India during the formation of the Rodinia Supercontinent. Amalgamations involved significant tectonic events that caused temporal changes in the structural patterns of fold and thrust belts. Debates are widespread on whether the Nallamalai Fold Belt (NFB) is a part of Antarctica that got accreted to the Indian shield. The Qualitative appraisal of the aeromagnetic data revealed that Total Magnetic Intensity (TMI) anomaly distribution is constrained by basement configuration within various sub-basins, which in turn is controlled by newly inferred faults systems. Probable block rotation events related to the compressional tectonics (that acted during collisional events) caused the present shape of the basin's eastern margin, which is parallel to the continental rift margin of India at this location. From the interpretation of aeromagnetic data, we identified substantial clues on the rotation of the northern and southern halves of the NFB to develop a possible model of tectonic development of the Cuddapah basin (and its sub-basins). Our inferences suggest that NFB was always a part of the Cuddapah basin. The proposed tectonic model establishes the interlink between the NFB and western sub-basins throughout the evolution of the Cuddapah basin. Modeling results of magnetic data indicate geophysical evidence of significant thrusting along the western margin of the NFB.

Keywords: Cuddapah basin, NFB, tectonic development, modeling of magnetic anomalies, oroclinal bending, block rotation

1. Introduction

Paleo- to the Mesoproterozoic period in Earth's evolutionary history is characterized by the initiation of several intra-cratonic basins around the world. The Indian subcontinent was no exception, containing several Proterozoic basins with thick sedimentary succession that almost occupy 20% of the Indian Precambrian terrain. The sediments in these basins are largely un-metamorphosed and tectonically least disturbed and at most places overlie the granitic-gneissic basement.

The crescent shaped and concave westward Cuddapah basin (CB) located in the eastern part of Dharwar craton (EDC) in south India is one of them, which occupies an area of around 44,000 sq. km. It is bounded by granite-greenstone terrain to its west, north, and south. The eastern margin is bounded by Nellore Schist Belt (NSB) and the Eastern Ghats Mobile Belt (EGMB), representing a Proterozoic collisional boundary. This basin is known for the base metals, the world's largest Baryte deposits, diamond-bearing conglomerates and lamproites, and unconformity type uranium mineralization. The simple sketch of the Cuddapah basin with sub-basins and adjoining terrains is shown in figure 1.

Geotectonically, this basin can be considered as a mosaic of different crustal blocks/sub-basins linked to each other, which experienced different rates of subsidence and upliftment along the preexisting faults during its entire geological history. The Papaghni sub-basin (PNSB) in the southwestern corner, the Kurnool sub-basin (KSB) in the northwestern region, the Srisailam sub-basin (SSB) in the north, and the Palnad sub-basin (PSB) in the northeast, all of them bounded by Nallamalai fold belt (NFB) or the Nallamalai sub-basin in the eastern part. The Nallamalai thrust and the Veligonda thrust define the western and eastern margins of NFB, respectively. It is believed that NFB is separated structurally from western sub-basins by the Nallamalai thrust.

Several authors (Narayanaswami, 1966; Kaila et al., 1979, 1987; Murthy et al., 1981; Meijerink et al., 1984; Venkatakrishnan & Dotiwalla, 1987; Babu Rao et al., 1987; Nagaraja Rao et al., 1987; Sarma et al., 1991; Ram Babu, 1993; Chetty, 2011; Mukherjee et al., 2018; Tripathy et al., 2019; Kale et al., 2020 and references therein) have postulated various theories on the tectonic development of Cuddapah basin. Mall et al., 2008; Chandrakala et al., 2010; Pandey et al., 2018, emphasized on the possibility of thermal triggering and reactivation of the existing faults at the southwestern corner, initiating the basin evolution through the sinking of the crustal blocks along the faults (Nagaraja Rao et al., 1987). Anand et al. (2003) suggested lithospheric stretching and mantle melting (passive rifting) beneath the CB. Extensional tectonics with intermittent phases of compression related to collisional events and associated transpressional tectonics in the eastern margin played a crucial role in the evolution of the basin (Chetty, 2011; Kale et al., 2020) during the Proterozoic period.

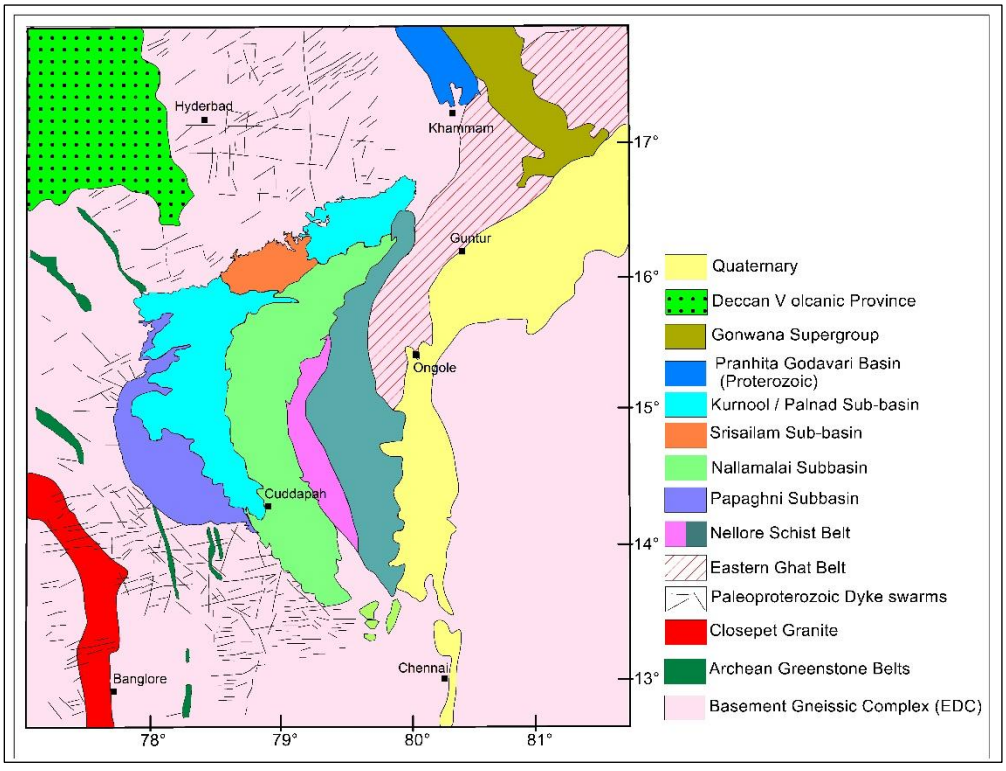


Figure 1: Geological map of Cuddapah basin and its surroundings (modified after Kale et al., 2020)

The most agreeable opinion of the recent workers is that the sub-basins are independent terrains/depositional sub-basins, that are tectonically connected.

There are two broadly categorized hypotheses on the evolution of the Cuddapah basin. There is a general agreement between the two hypotheses on how individual western sub-basins are opened up and matured in due course. The main disagreement is due to whether the NFB, on the whole, is always a part of CB during its evolution or it is a separate entity moved closer in due course and accreted to western sub-basins (Chetty, 2001; Collins et al., 2015; Chandrakala et al., 2015; Saha, 2004, Saha & Sain, 2019). Tripathy et al. (2019) conclude the allochthonous nature of the Nallamalai group of sediments within NFB. However, there are still debates on the equivalence of some of the formations of the Cuddapah supergroup and Nallamalai group (Meijerink et al., 1984, Tripathy et al., 2019; Saha & Tripathy, 2012; Patranabis-Deb et al., 2012).

Matin (2014) says CFTB-Cuddapah-Fold-Thrust-Belts forms a frontal most part of larger FTB that has split and attached to different parts of Gondwana land, wherein CFTB includes NFB lying between two thrusts and western Cuddapah representing undeformed foreland. He infers that the western part of CB, NFB, NSB, and EGMB are all fragments and together form a frontal portion of the main FTB (along the present eastern coast of India, amalgamated during Neoproterozoic), the remnant of which is now in Antarctica.

Saha and Sain (2019) suggest Kandra ophiolitic complex situated over the Veligonda thrust (representing the oceanic subduction zone) were originated at a distance away from the eastern margin of EDC and are found at its present location due to the tectonic transfer during Paleoproterozoic subduction, collision, and continued convergence east of CB. Intrusive granites and alkalines also indicate partial melting of the crust during the collision between southeastern India and Antarctica. No such indicatives found along the western margin of NFB. They suggest that the NFB, NSB, and EGMB collage was accreted to the eastern margin of EDC (Papaghni basin and Kurnoo basins being open to ocean till then) only during Neoproterozoic, and henceforth claiming that the

NFB was an alien terrain to Cuddapah basin until the amalgamation of the Rodinia supercontinent.

However, the repetitive collision of Antarctica block and the Indian subcontinent due to E-W convergence was established. The effect of the collision between India and Antarctica, E-W convergence, and rifting on the present shape of the NFB is indisputable. Nevertheless, the timing of the events is yet to be established definitively.

In this work, magnetic data is examined to correlate the models developed with these two schools of thought on whether NFB is an alien terrain or was always a part of CB/EDC.

2. Role of aeromagnetic data in the CB: Geophysical data, especially magnetic data, is widely used in understanding the structural framework of the basin. Age correlation of various structural features derived from magnetic data is possible by studying the offset relationships indirectly, giving some clues on the evolution of the multiple sub-basins.

There are extensive gravity studies on this basin (Balakrishan et al., 1967; Mishra et al., 1987; Krishna Brahmam, 1989; Ramakrishna, 1991; Ram Babu, 1993; Singh & Mishra, 2002; Singh et al., 2004) for evaluating the basement structure. The primo factor of utilizing magnetic data is the data density. The other concern is that Cuddapah sediments, being denser, contribute to the gravity anomaly. In contrast, the sediments are completely nonmagnetic in nature and hence transparent, giving ways to look at the basement picture. One of the significant contributions from the aeromagnetic data over the Cuddapah basin and the surroundings is that very long linear magnetic anomalies representing the fault fracture pattern and episodic dyke intrusions forming rhombic patterns were identified. These were originated from the adjoining granite gneissic terrain (exposed to the west of the basin) extending into the basin, inferring their role in basin initiation & development.

Most of the work on magnetic data was carried out in the Papaghni sub-basin. Several researchers worked on depth estimates inferring the basement depths (Prasanthi Lakshmi & Ram Babu, 2002), depths to basic intrusions representing episodic igneous activity at different times, aiding to decipher the stratigraphic thickness of formations within the basin. (Babu Rao et al., 1987), inferring intra-crustal horizons (Rama Rao et al., 2011), etc. Babu Rao (1995) inferred the block-faulted nature of the basement from their work on the Werner de-convolution.

The most striking is the shape of the Cuddapah, especially its eastern margin on which several papers are available in the literature. However, still, the parallelism of the eastern margin with the continental rift margin remained anonymous.

Aeromagnetic coverage of the basin: Geological Survey of India (GSI) and CSIR-National Geophysical Research Institute contributed in collecting the aeromagnetic data over the entire CB (Fig. 2). In the year 1967, as a part of the 'Operation Hard Rock' (OHR) program, the Airborne Mineral Surveys and Exploration (AMSE) group of the Geological Survey of India (GSI) had started multi-parameter airborne geophysical surveys over CB in the eastern part. They covered about 25,000 sq. km of the area over NFB and a part of the adjoining NSB to the east of CB (GSI, 1981) (pink in color in Fig. 2). The flights were flown at 130 m height with line spacing of 1 Km in two different line directions N600W-S600E and N800E-S800W, over the northern and southern half, respectively. Diurnal and heading corrections were applied, and the final Total Magnetic Intensity (TMI) map in different scales with a contour interval of 10 gammas was prepared (GSI, 1981). These contour maps were digitized to obtain the digital data.

The National Geophysical Research Institute (NGRI) of the Council of Scientific and Industrial Research (CSIR), in collaboration with GSI, as a part of 'Diamond Exploration', carried out airborne magnetic surveys in the years 1980-1982 in three field seasons. Aeromagnetic data covering an area of about 60,000 line-km over the northeastern, northern, western, and southern parts of CB and adjoining metamorphic crystalline terrain was acquired (purple colored area in Fig. 2) over N-S flight lines. The

flight height was maintained at 150 m with line spacing of l km over the basin and 500 m over the crystalline terrain west of the basin to cover Kimberlite fields with high resolution. The TMI maps were prepared on 1:63,360 scale with a contour interval of 10 gammas. The drafted magnetic sheets were prepared with the actual flight path drawn on a particular scale and anomaly value marked over the flight line for the manual contouring purpose. Diurnal and heading corrections were applied prior to drafting the data on sheets. Instead of digitizing already available manually drawn contour maps to avoid manual bias, the aeromagnetic data available on drafted magnetic sheets were read and fed into a database.

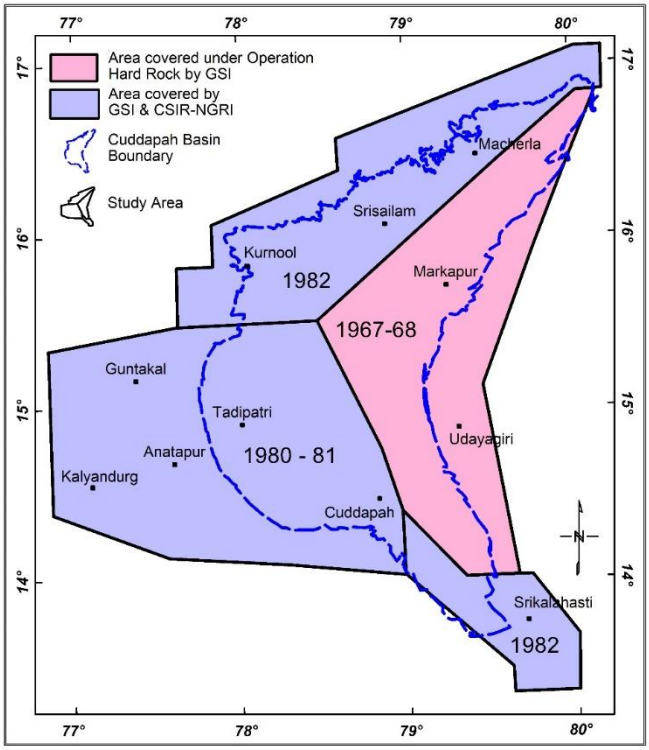


Figure 2: Image showing the survey blocks

Both the data sets were brought to a common height of 150 m, IGRF correction was applied. The entire data set was levelled for herringbone errors generated due to the leftover flight line bias in the data. The total magnetic intensity anomaly (TMI) image generated by gridding this data with a cell size of 200 m, is shown in figure 3a & b. High

amplitudes are represented by pink to red colors, while deep blue on the image represents the lowest values.

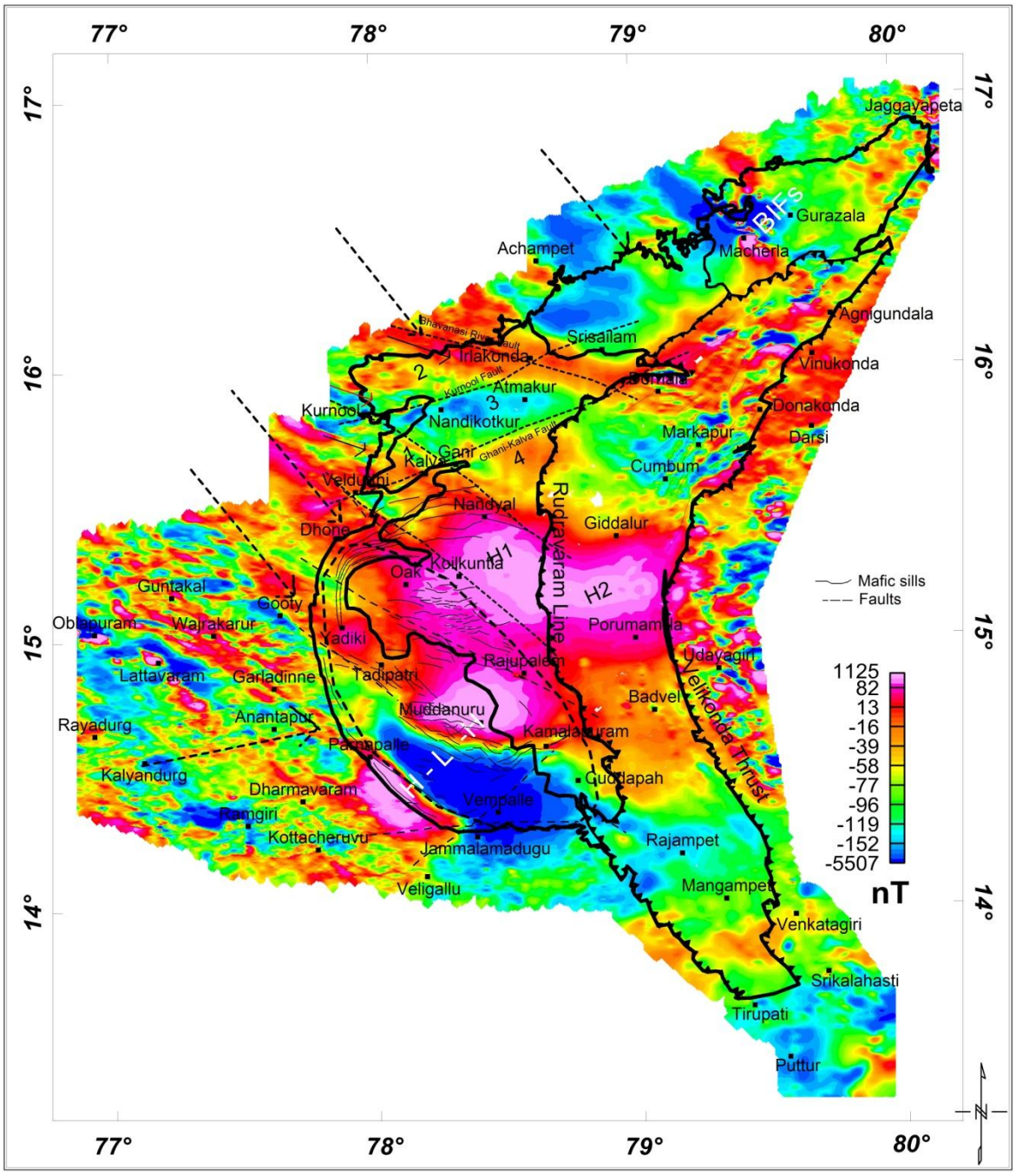


Figure 3a: TMI anomaly image of Cuddapah basin and adjoining terrain

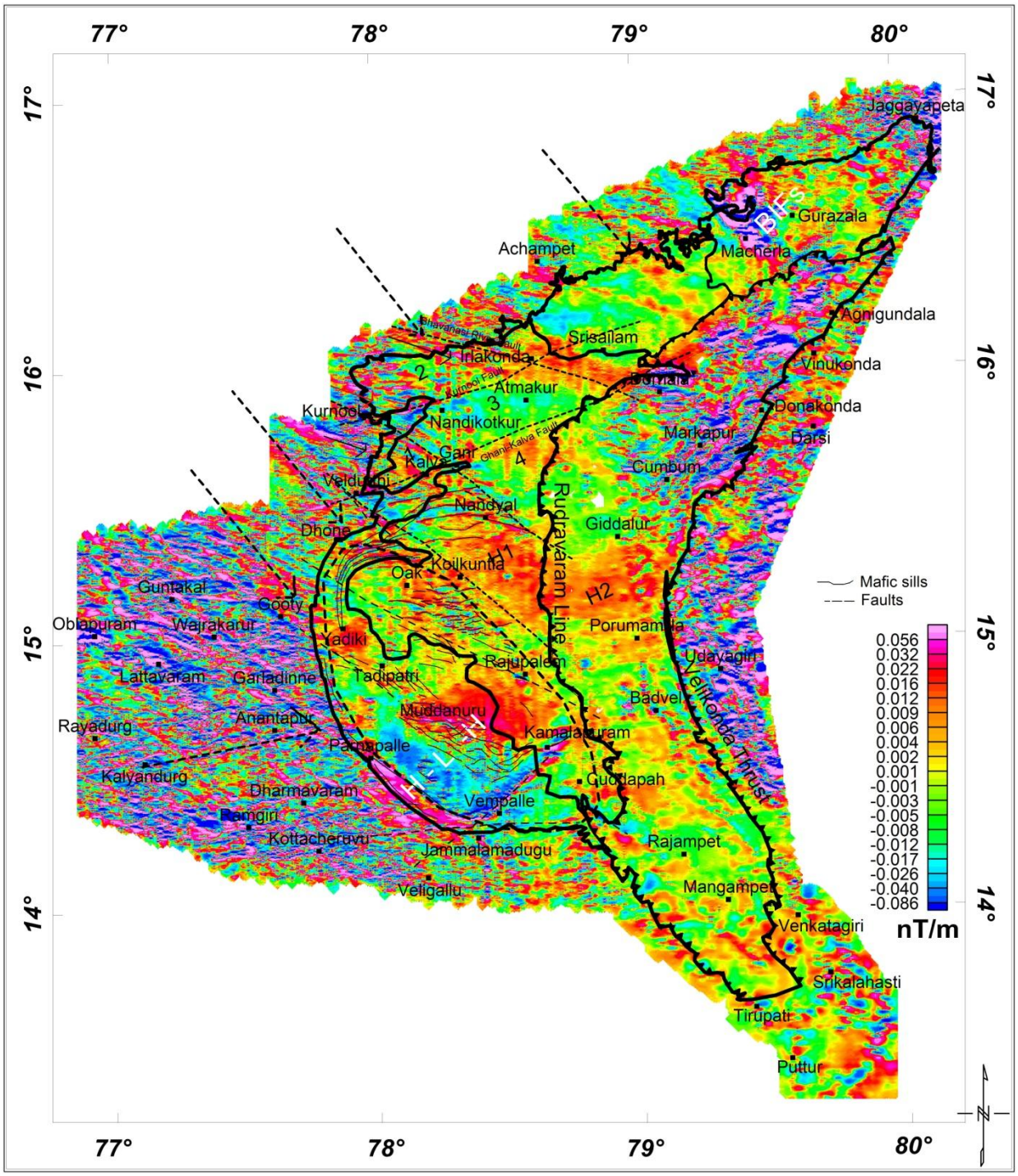


Figure 3b: FVD (of TMI) image of Cuddapah basin and adjoining terrain

3. Methodology

The primary objective of our study on the Cuddapah basin is to present the significance of magnetic anomalies, decipher the basement configuration and the derived structural features that could explain significant stages in the basin development.

Qualitative analysis of the anomalies: Aeromagnetic data extensively aids in the mapping of geological features, the structural framework of the terrains defined by faults/fracture patterns, folds, dykes that are often concealed under sedimentary cover, also in narrowing down the search for mineralized zones, etc. (Grauch et al., 2003; Betts et al., 2003; Wennerstrom & Airo, 1998; Nabighian et al., 2005). The aeromagnetic anomaly patterns widely represent the dyke, fault/fracture/shear systems, along with the patterns of greenstone belts. Structural features like faults, fractures, and other lineaments are identified based on the trend of aeromagnetic anomalies with their linearity, abrupt truncation of the anomaly trends along a line, flexures in the contour pattern, alignment of sets in the continuity of anomaly patterns, offsets in the linear magnetic features, alignment of highs/lows or their termination abruptly along a line, etc. It also helps in deriving basement configuration, mapping faults that control the basin's development, thereby unraveling the tectonic development.

Quantitative interpretation: 2.5 D modelling: 2.5 D modelling is carried out to decipher the basement structure using GM-SYS (GEOSOFT, 2004) package, an interactive computer programming software. The magnetic response is computed based on the algorithms of Talwani et al. (1959), Talwani & Heirtzler (1964), Won & Bevis (1987) for an infinitely long prismatic body. Later, The GM-Sys package was developed using integrating algorithms developed by Shuey & Pasqulae (1973) for 2.5 D profile modelling with a finite strike length.

4. Geological setup of the basin

CB (shown in Fig. 1) is an amalgamation of five sub-basins: the Papaghni in the southwestern part, the Kurnool sub-basin extending from northwest to south of southeast, the Srisailam sub-basin in the north, the Palnad sub-basin in the northeast corner, and the Nallamalai sub-basin all along the east. The four sub-basins, Papaghni, Kurnool, Srisailam, and Palnad, together are denoted as western sub-basins.

The CB sediments rest over the Archean granite-greenstone terrain with an unconformity known as Eparchaean unconformity. The Archaean granite-greenstone terrain exposed to the west of the basin comprises N-S to NW-SE trending steeply dipping greenstone belts, intruded by Neoarchean granite batholiths, with several episodes of volcanic activity, dyke emplacements traversing the terrain in various directions. The dykes predominantly trend in NE-SW, NW-SE, and ENE-WSW directions. The Paleoproterozoic mafic intrusives are inferred to be related to mantle plumes (Pandey & Chalapathi Rao, 2019). At times emplaced by quartz reefs, the long NW trending shear zones are also prevalent in the exposed basement. Rama Rao et al. (1991, 1993), Ramesh Babu et al. (2012) worked on magnetic data to identify possible extensions of greenstone belts.

Sediments of the Cuddapah supergroup and Kurnool group of sediments occupy the basin. Stratigraphically, the Cuddapah supergroup is divided into Papaghni, Chitravathi, Nallamalai, and Srisailam groups. While Paleo-Mesoproterozic sediments of the Cuddapah Supergroup occupy the Papaghni and Srisailam sub-basins, the Palnad and Kurnool sub-basins are filled with the Neoproterozoic sediments of the Kurnool group. Here we give brief stratigraphic details sub-basin-wise, while the stratigraphic sequence is given in Table 1.

Our present study area comprises a part of NSB in the eastern extremes. The tectonostratigraphic volcano-sedimentary sequence (intruded by granitic plutons, anorthosites, carbonatites, and ophiolites) constitutes the NSB. This schist belt thrust

KURNOOL GROUP (200-450)	Kundair Subgroup (75-150)	Nandyal Shale (50-100)	Shale, partly calcareous
		Koilkuntla Limestone (15-50)	Siliceous, shaly limestone with quartzite interbeds
		Paniam Quartzite (10-35)	Massive and pinnacled quartzite, siliceous shale, basal pebble bed
	--x—x—x—x--Paraconformity--x—x—x—x--		
	Jammalamadugu Subgroup (120-260)	Auk Shale (10-15)	Laminated shale, mostly ochreous with siltstone interbeds
		Narji Limestone (100-200)	Flaggy grey limestone, glauconitic sandstone interbeds
		Banganapalle Quartzite (10-50)	Oligomict conglomerate, ‘girt’, quartzite, shale
		Srisailam Quartzite (300)	Glauconitic ferruginous quartzite with shale
--x—x—x—x--Unconformity--x—x—x—x--			
	Nallamalai Group (3500-6000)	Cumbum Formation	Mainly slate and phyllite, chert, dolomite
		Pullampet Formation	Shale, felsic tuff, barytes, dolomite, quartzite
		Bairenkonda Quartzite (1500/	Quartzite, quartzite wacke, shale
		Nagari Quartzite (4000)	Quartzite, quartzite wacke, shale, basal conglomerate
--x—x—x—x--Angular Unconformity--x—x—x—x--			
CUDDAPAH SUPER GROUP	Chitravati Group (4900-5000)	Gandikota Quartzite (300)	Shale- quartzite alternations, glauconitic quartzite interbeds
		Tadpatri Formation (4600)	Shale, felsic tuff, basic sills and flows, chert, stromatolitic dolomite, quartzite
		Pulivendla Quartzite (1 – 75)	Quartzite and conglomerate
	Papaghni Group (2100)	Vempalle Formation (1900) with Kuppalapalle Volcanics	Stromatolitic dolomite, chert, quartzite, basic sills and flows
		Gulcheru Quartzite (30-210)	Basal conglomerate, arkose, quartzite with shale interbeds
--x—x—x—x--Unconformity--x—x—x—x--			
Archean Gneiss / Crystalline Basement of Dharwar Craton			

* Numbers in Parenthesis indicate thickness in meters

Table 1: Stratigraphy of CB

over the sediments of the Nallamalai group along the Vellikonda thrust. The Kanigiri Ophiolitic complex in the north and Kandra Ophiolitic complex in the south indicate that this belt is an accretionary terrain associated with Paleoproterozoic subduction.

The western margin of the EGMB is regarded as the suture zone due to the association of ophiolites, anorthosites, carbonatites, and shear zones (Chetty & Murthy, 1993). EGMB is a zone of maximum tectonic disturbance, and it comes into contact with the northeastern part of the CB, which is a zone of maximum tectonic disturbance.

Significance of NFB: The arcuate-shaped NFB runs over nearly 400 km in the easternmost part of the CB. It is convex westward and bordered by NSB in the east, and it is filled with quartzites, dolomites, and phyllites. NFB is characterized by fold-fault structures and bounded by thrust margins on either side. Several granitic bodies were intruded into the northern part of NFB and adjoining NSB (during 1400-1550 ma). While the Nallamalai rocks are highly deformed, the western sub-basin formations show no or slight deformation. The formation and evolution of NFB play a crucial role in the completeness of the present shape of the Cuddapah basin. The age of the sediments is limited by 1400 ma as indicated by the 1400 ma granites, and Chelima lamproites intruded the folded Nallamalai sediments.

Narayanaswami, 1966; Nagaraja Rao et al., 1987; Ramam & Murthy, 1997 and several others proposed models on the tectonic evolution of the NFB. Several geological (Saha, 2004; Matin, 2014; Saha & Sain, 2019; Kale et al., 2020; Mukherjee et al., 2018 and references therein) and geophysical studies (Mall et al., 2008; Chandrakala et al., 2010; Pandey et al., 2018 and references therein) were carried out in recent years on how it is attached to its surrounding terrains. Venkatakrishnan & Dotiwalla (1987) named the fold-thrust belt as Cuddapah salient. They inferred a dextral sense (clockwise) of shear to the ENE-WSW trending Veldurti-Guntur lateral ramp (extension of Gani-Kalva fault) in the northern NSB and sinistral (anticlockwise) sense of shear to the Cuddapah-Nellore transverse fault. Naqvi & Rogers (1987) inferred extension of tectonic

convergence between Antarctica and India towards the foreland caused the deformation in eastern Cuddapah.

5. Qualitative analysis of regional magnetic anomalies within the subbasins

The sediments, being essentially nonmagnetic, are entirely transparent to magnetic anomalies due to the basement and are not bound to show high frequency high amplitude anomalies unless there are some associated mafic intrusives. The long wavelength component essentially represents the basin configuration and/or variations in magnetization of the basement.

Three types of wavelength characteristics can be easily differentiated with visual inspection when we look at the magnetic anomalies over the basin (i) NW-SE and WNW trending high frequency components continuing from the exposed basement into the basin across most of the western and northern margins of the basin, indicating gradational basin margin with gradually deepening basement – indicated by broken arrows in figure 3a & b (ii) curvilinear high frequency anomalies due to mafic sills in PNSB (indicated by black linears in Fig. 3a & b) and high amplitude bipolar anomalies due to magnetite bearing units in the northern part of NFB between Markapur-Dornala-Agnigundala triangular region (iii) the long wavelength anomaly component occupying large areal extent representing regional basement picture. Among these long wavelength anomalies, high-low-high anomaly in the southwestern corner of the basin (between Parnapalle-Muddanuru-Vempalle indicated with H-L-H in Fig. 3a) due to a lopololithic intrusive and the very high amplitude anomaly (of more than 13500 nT) due to Banded Iron Formations (BIF) near Macherla in the northern extreme are the most distinctive anomalies. The remaining regional anomalies are either independent highs or independent lows; bipolar regional anomalies are found to be uncommon in the basin. At this magnetic inclination, a general rule of thumb is that a TMI high represents a basement low and vice versa.

Here we analyzed the magnetic anomalies that might represent the basement configuration to differentiate between various sub-basins within CB.

5.1 Western sub-basins

PNSB: Five episodes of extensive igneous activity in different geological times are recorded in this sub-basin, holding the oldest of sediments. This basin is associated with a huge magnetic anomaly of high-low-high type (between Parnapalle and Muddanuru region in Fig. 3a, c & d). Modelling and inversions of this anomaly led to the conclusion that there is a cupola-lopolith kind of mafic body ascended due to the mantle plume activity, which is also responsible for triggering the basin initiation and further upliftment (Mishra & Tiwari, 1995; Mishra & Ravi Kumar et al., 2014; Seshu et al., 2020). This anomaly is so wide that it covers the entire sub-basin and obscures the anomaly due to basement configuration. More so, the strike of the anomaly can be stated to be in the NW-SE direction in coherency with the general trend of Dharwars. Arcuate bands of high frequency anomalies paralleling the southwestern basin boundary (associated with mafic sills and flows of Vempalli and Tadpatri formations (drawn as thin linears in Fig. 3b, c & d) and another band of arcuate-shaped high frequency anomalies on the opposite side of the axis of the sub-basin between Rajupalem and Koilkuntla (coved by Kurnool sediments) define the elliptical shape of the major basement low extending in NW-SE direction (indicated by a broken ellipse in Fig. 3a-d).

KSB: Further north and east of PNSB, the KSB is filled with Cuddapah supergroup and younger Kurnool group of sediments. TMI anomaly map clearly displays a pronounced high (denoted as H1 in Fig. 3a, b, e & f) extending in NW-SE direction in the middle of KSB starting from Nandyal, Koilkuntla region and then taking a curvilinear shape extending into the NFB (denoted by H2). The northern part of the KSB appears shallower (as evidenced by the continuation of the trends from the exposed basement into the basin) than its southern part (with a regional magnetic high H1). A geologically well-known prominent fault called the Gani-Kalva fault divides these two parts.

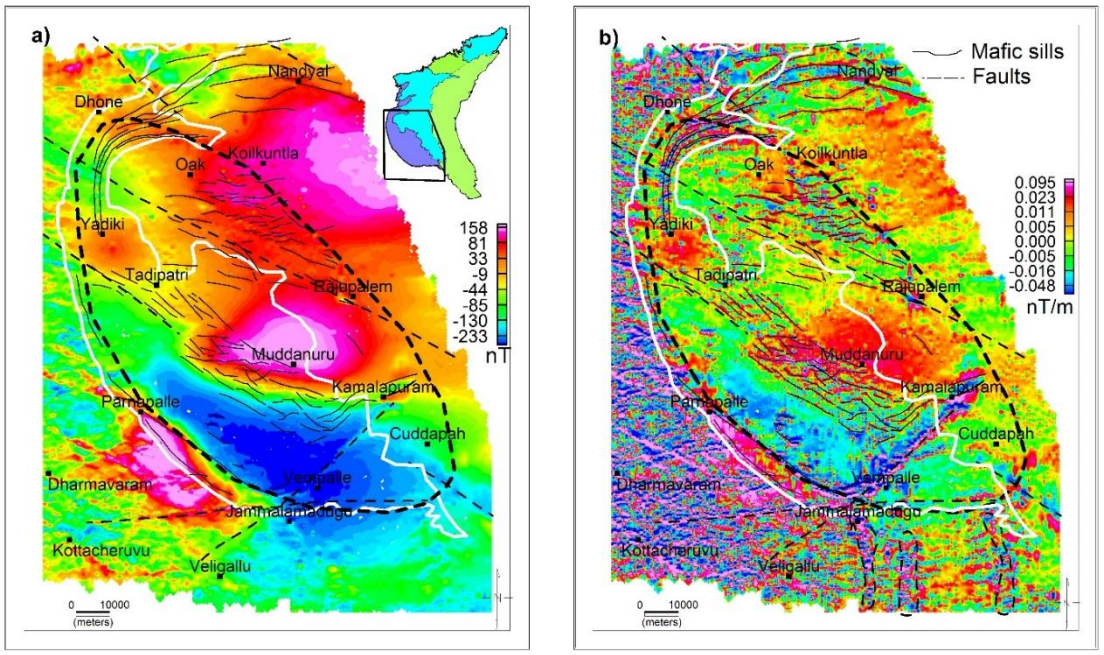


Figure 3: c) TMI image over a part Papaghni sub-basin
d) First vertical derivative image over a part Papaghni sub-basin

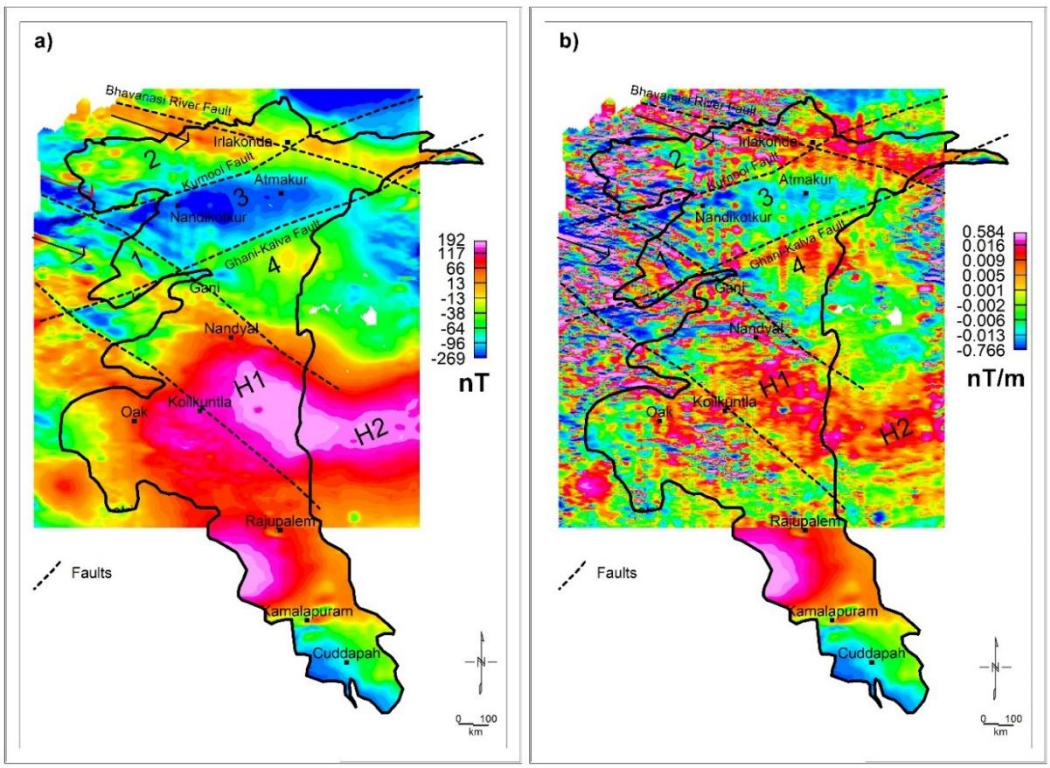


Figure 3: e) TMI image over a part Kurnool sub-basin
f) First vertical derivative image over a part Kurnool sub-basin

SSB: TMI image over SSB, PSB, and the northern part of NFB is presented as a separate map (Fig. 4a) to clearly showcase the continuity of features from one sub-basin to another. However, due to the very high amplitude (13,500 nT) anomaly of BIFs, the significance of the other anomalies in this region is diminished. For this reason, we applied a high pass filter to highlight the anomalies of interest judicially. High-pass filtered TMI is shown in figure 4b. SSB is characterized by a broad TMI low (near Srisailam) that portrays a shallower basement. It is clear from the manifestation of magnetic anomalies that the Srisailam plateau with an elevated basement in SSB is bounded to its east and west (along its contact with PSB and KSB, respectively) by NW trending narrow depressions of the basement. These have possible extensions into the NFB.

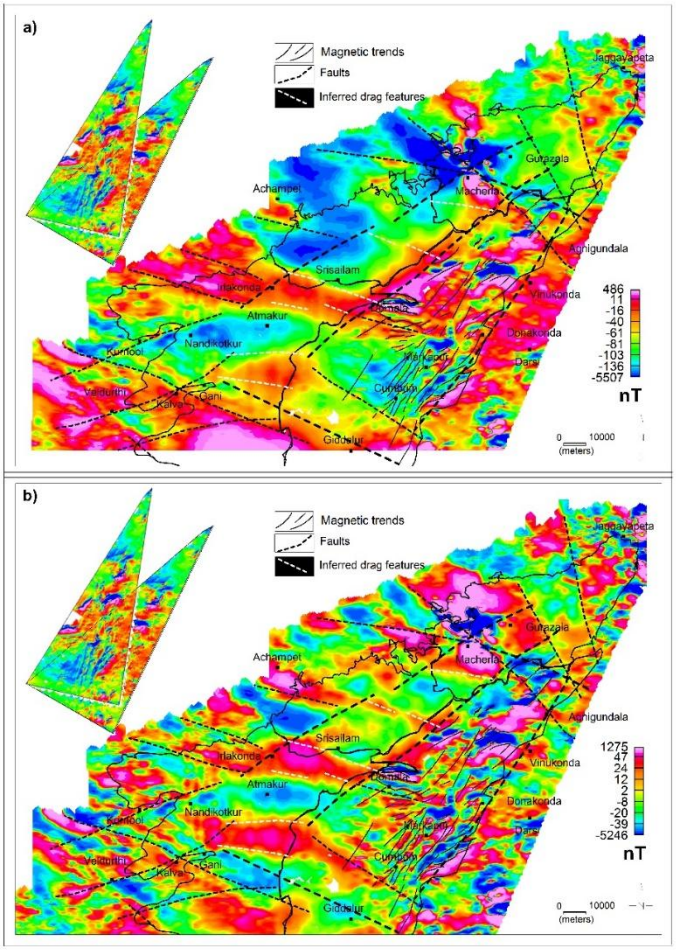


Figure 4: a) TMI image over northeastern part of Cuddapah Basin
b) High-pass image over northeastern part of Cuddapah Basin

PSB: Highly intense (13,500 nT) long wavelength anomaly zone with NW-SE elongation along the western edge of PSB is related to BIFs (marked in figure 4a, near Macherla) of the Peddavuru greenstone belt (Rama Rao et al., 1991). A high amplitude high frequency anomalous zone may represent the possible extension of NSB underneath the Kurnool group of rocks.

5.2 NFB

There is a striking difference in the magnetic character of the southern and northern parts of the NFB. The NNE-SSW trending linear anomalies (through Cumbum, Markapur in Fig. 4) and several high amplitude short wavelength anomalies of the E-W trend (between Dornala and Agnigundala) are dominant in the northern/northeastern part of NFB to the north of H2 (please note H2 in Figure 3a). The southeast extension of the Peddavuru greenstone belt (Rama Rao et al., 1991) is inferred by Tripathy et al. (2019). This anomalous zone is quite prominently associated with a fault zone (Gundlakamma fault marked in Fig. 4a), which seems to be extending into the present-day NFB and also limiting the E-W to ENE trending high amplitude bipolar anomalies to its west.

Towards the south of H2, NFB is relatively quiet, characterized by arcuate convex (west) bands of high frequency anomalies paralleling the eastern boundary/thrust (shown by thin linears drawn in the TMI image of the entire NFB shown separately in Fig. 5). These anomalies could be due to sills present in the Nallamalai group that could have folded. Though it is believed from the earlier works that the basic igneous activity is confined to southwestern, there is evidence from our analysis for the widespread availability of basic units even in the Nallamalai basin in the form of sills and tuffs. On the other hand, Neelakantam (1987); Sesha Sai et al. (2017) showed the presence of sills within Nallamalai sediments.

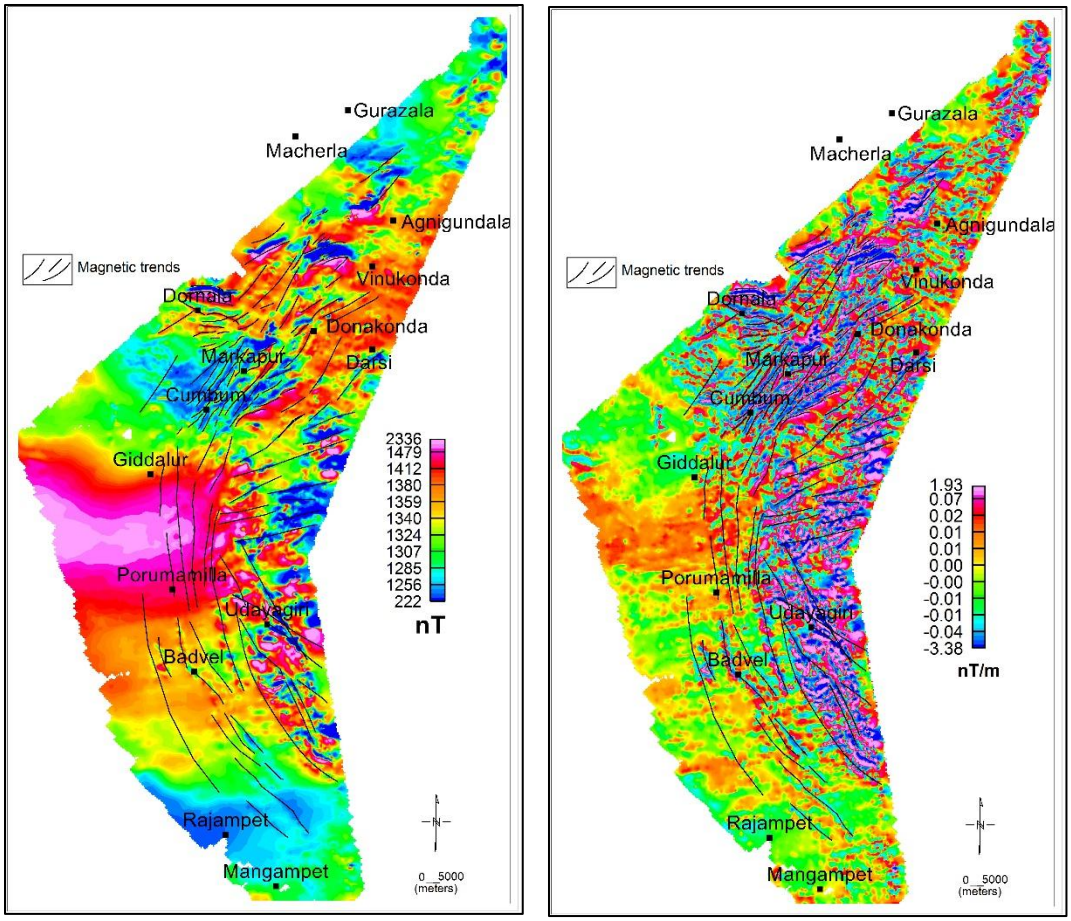


Figure 5: TMI and First vertical derivative images over Nallamalai sub-basin

These bands are closely spaced towards the east, reaching the basin margin, and become widely spaced with diminishing amplitudes towards the west. We assign this behavior to the open folded nature of formations towards the Rudravaram line/Maidukuru thrust (Meznerink et al., 1984). These bands also gradually diminish in amplitude towards the center of NFB, cease to appear when they reach H2, indicating a deeper nature. These high frequency trends correlate with the topographic anticlinal trends, exhibiting parallelism.

6. Characterization of the H1 and H2 anomalies:

2.5 D modeling: To confirm the assumed deeper basement over the regional anomalous high, we modeled the TMI anomaly over two profiles running across this high, one in

KSB to the left of the Rudravaram line (Maidukuru thrust) and another profile in N-S direction, cutting across the NFB. Profile locations are shown in figure 3a. Sarma et al. (1991) gave a glimpse of the basement configuration in the central part of the basin over H2. They inferred a graben-like basement structure through modeling. This anomaly is a broad linear high of amplitude 180 nT running over a strike length of approximately 100 km and occupies a large area in the central part of the basin running from KSB into the NFB through the Maidukuru thrust zone. Only a huge magnetic body with a strong remanence component could explain the amplitude of the anomaly at this magnetic latitude. Sarma et al. (1991) acknowledged that a huge body with a uniform remanent magnetization throughout its length is impossible. In the other case, it could be due to the basement structure of the basin. They suggested removing regional component for a better fit in the modeling. They showed that gravity data supports their model - a regional gravity low indicating a basement low.

We considered removing the regional from the TMI anomaly profile to obtain a better picture of the basement because the influence of high-low-high anomaly influences the anomaly shape. We have chosen a low pass filter of 200 km wavelength iteratively and considered removing the regional from the TMI anomaly over the profiles. We took two profiles for modeling, one from the west of Maidukuru thrust over H1 and another to the east over H2 (profiles 1 & 2 shown in Fig. 3a). The fitted models inferring the basement configuration are shown in figures 6 a-b, respectively. Along with these two profiles, we modeled several profiles with an approximate spacing of 5 km to obtain the complete basement picture covering H1 & H2 regions through the thrust zone. These results are discussed in later sections.

Our model in the Kurnool sub-basin over H1 (Fig. 6) infers a 12 km deep syncline with a sub-vertical faulted boundary along its northern side. In contrast, the southern side sloping basement is not as steep as the other northern fault. This basement low is shouldered by basement highs to its south and north. The northern high is shallower than the southern shoulder; the southern one might represent the transition between PNSB and KSB.

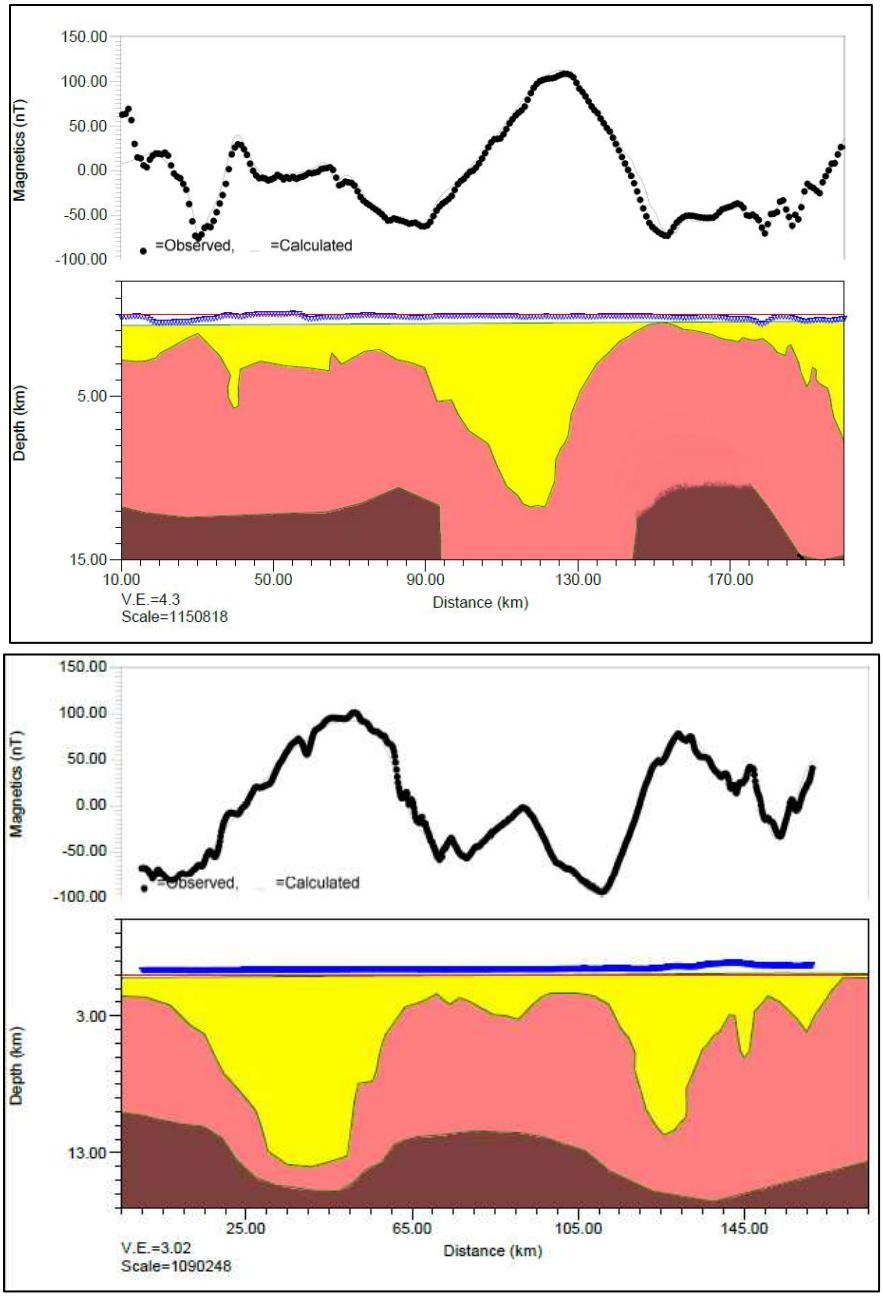


Figure 6: 2.5 D model over profile P1 and profile P2

The Maidukuru Shear/ Nallamalai fault dissects the NW-SE trending TMI high (basement low) in an NS direction. We have chosen a longer profile (profile 2) over NFB to understand the basement topography over NFB from the southern end till it reaches the assumed graben structure in the central part of NFB. In this model, we noticed that

basement has been gradually deepening from the south and deciphers the steepest basement low in the central region of NFB over H2. The basement reached a depth of around 11 km over the H2. Kaila & Tiwari (1985) inferred a maximum thickness of 10 km in the easternmost part of the basin.

7. Discussions

In a nutshell, we discussed the magnetic anomaly patterns qualitatively in a broader sense, how these are related to the basement character and structures within various sub-basins. The major basement topographic configurations within the Papaghni and Kurnool sub-basins and/or the basement topographic divides between the western sub-basins seems to be strongly influenced/controlled by NW-SE to WNW-ESE Dharwar trends. Among these, we tried to identify the magnetic impression of structures extending past/across the sub-basin boundaries (inter-sub basinal) to understand the interrelationships between the sub-basins that may indirectly help understand tectonics related to the basin development from magnetic data alone.

The PNSB formed due to the subsidence in elliptical form bounded by NW trending faults, with an NW trending axis is limited up to Nallamalai thrust in the east. The regional HLH TMI anomaly also indicates its confinement within the sub-basin.

The KSB extends over a length from south to north of CB, sandwiched between Papaghni sub-basin (PSB) and NFB as a narrow belt, but extends wide in its northern part. Most of the KSB exhibits regional Dharwar strike in its basement configuration, whether shallow or deeper.

Among all the inter-sub basinal features/anomalies identified, the most prominent and predominant is the wide NW-SE trending high (H1) in KSB, extending further into the NFB in the E-W direction as H2. Only a few works are available in the literature (Sarma et al., 1991; Babu Rao, 1995) over this region. They modeled this anomaly in the eastern part of NFB and achieved a rough fit with a graben-like model. Sarma et al. (1991) emphasized this anomaly, saying that understanding this anomaly may help

understand the evolution and origin of CB. We tried to throw light on this anomaly with a closer look as we observed the curvature/bend in this anomaly in close proximity to the Rudravaram line/Nallamalai/Maidukuru Thrust. The anomaly runs over a length of 100 km with a change in strike halfway precisely where it passes across the sub-basin boundaries/Rudravaram line. The 2.5 D model infers the same kind of basement structure over this anomaly, to the west and east of the Rudravaram line/Maidukuru thrust.

The structures in the northern part of NFB (to the north of H2) inferred from magnetic anomaly patterns are not comparable with those in the southern part, but a good agreement with the known surface geological structures is found. The prime factor is that there is a change in the trend of linears (Fig. 4a inset and Fig. 4a & b) from North to NE in the central part of NFB, suggesting an oroclinal bend as was inferred by Tripathy et al. (2019). This is also noticed from the bend in WNW-ESE features extending into NFB (Fig. 4b) and appear to be dragged from WNW-ESE to NW-SE direction in response to the rotation of the northern part of the NFB from the NNE direction (paleo position marked with red dashed triangle in inset) to NE (present-day position-black solid triangle) in the clockwise direction. The anomalous dragged features are marked with white broken lines in figure 4b. The possible extension of these features into the NFB is identified. The decrease in their amplitude is inferred from the increasing depth in NFB. According to our assumption, if northern NFB is rotated back to its paleo-position (Fig. 4a inset), these anomalies form a contiguous N-S belt typical of NFB prior to rotation and attaining the present arcuate shape.

On a closer look into the HI & H2, the curvature/bend in this anomaly is observed in close proximity to the Rudravaram line/Nallamalai/Maidukuru Thrust (Fig. 5). The 2.5 D modeling also infers the same basement structure over this anomaly, to the west and east of the Rudravaram line/Maidukuru thrust. A triangular region/space is noticed (Fig. 7a). If we presume that H2 is rotated from its original NW-SE along the Maidukuru thrust, this is in close approximation to the block rotation model given in figure 7a inset. The triangular space in the anomaly must represent a probable zone of expansion in

wedge shape, created due to rotation exactly to the east of the Rudravaram line (Fig. 7a).

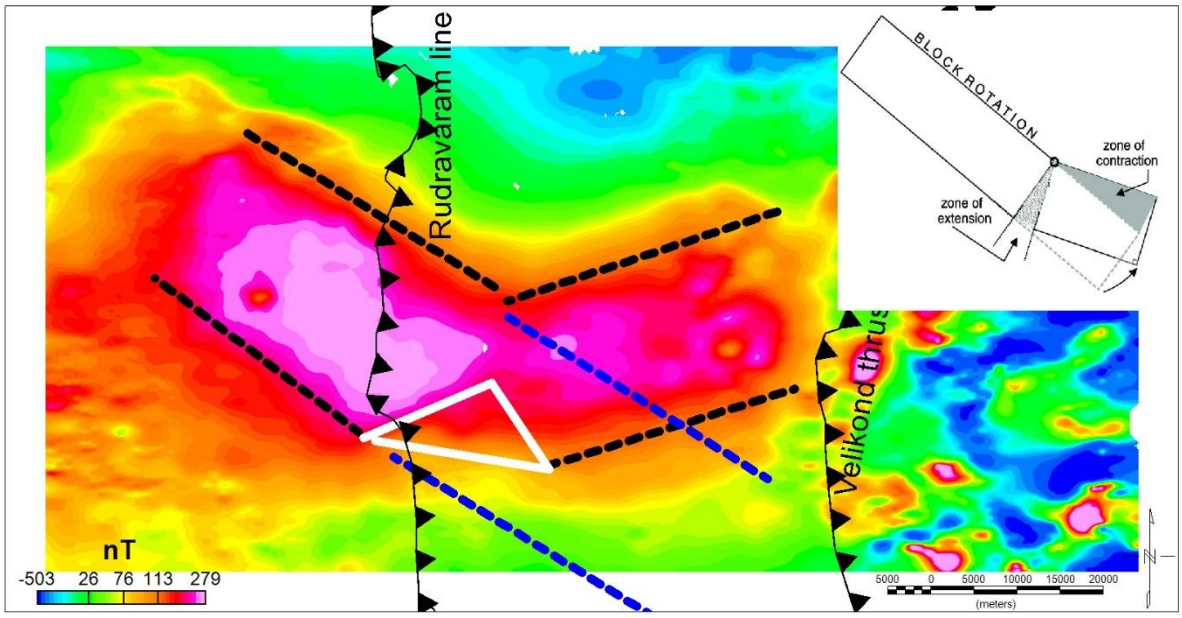


Figure 7a: TMI image over central part of Cuddapah Basin

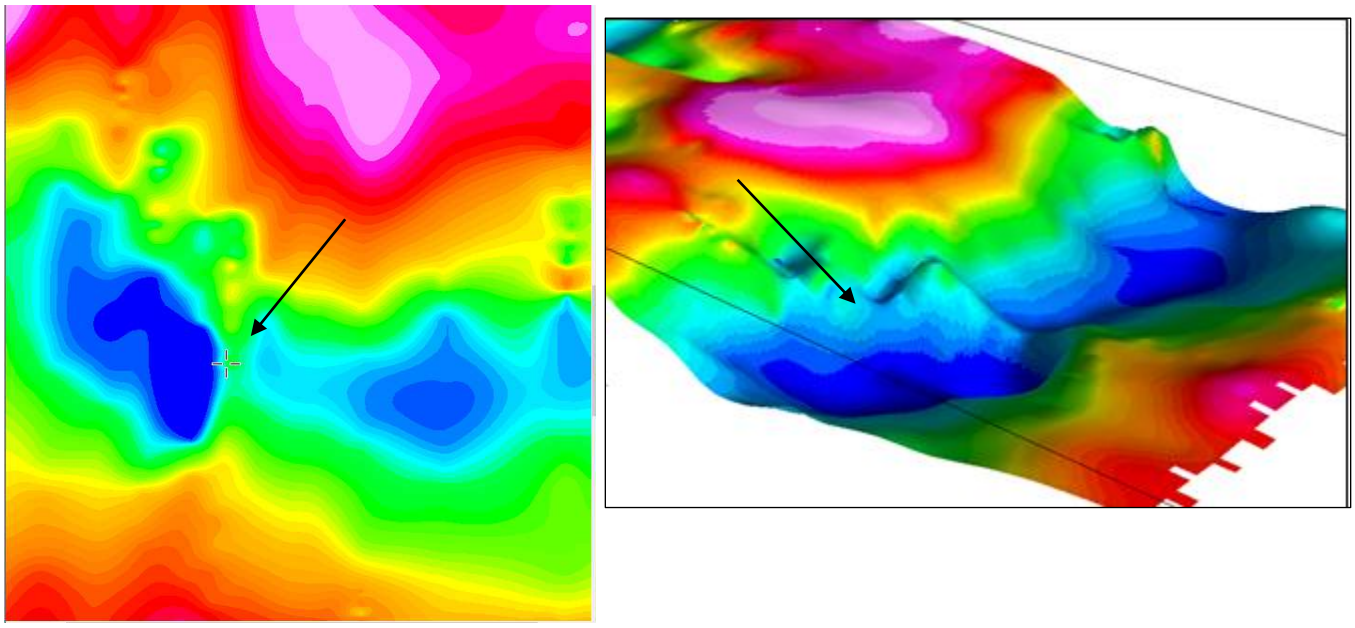


Figure 7: (b) Basement configuration over H1-H2 through Maidukuru thrust zone; (c) the same in 3d view. Arrow indicates thrusting along the Rudravaram line.

We considered several N-S trending profiles to the east and west of the Rudravaram line and over this triangular zone to get a detailed picture of the basement through modelling to ascertain whether this triangular zone of expansion exists in the basement. The basement configuration from all the profiles is clubbed to map the basement over the region shown in figure 7b (in plan) and figure 7c (in 3d). It is fascinating to notice the up-thrusting of the basement from NFB over the basement of KSB along the Rudravaram line (indicated with an arrow). In addition to the upthrusting, the derived basement picture clearly shows the wedge-shaped zone of expansion (Fig. 7b) at 12 km and below in the sub-crustal levels involving the basement. It is interesting to note that the length of the E-W (rotated to) segment fits exactly within the width of the NFB at this point, where the basin width is maximum and is located at the focal point of convexity. Therefore, the source of H1 and H2 is not a magnetic body. It is just a basement depression caused due to faulting, which produced this high magnetic anomaly at the present location.

At this point of conjecture, we propose that the southern part of the block in NFB is rotated counterclockwise (over 400) about both vertical and horizontal axes along the Maidukuru fault (at the cross-section of Maidukuru and NW fault (denote it) (Fig 7a).

A basement depth of about 12 km is obtained in the deepest part of NFB, where the fault-controlled northwest trending block is inferred as rotated. The presence of low-angle detachment faults in the lower crustal levels might have facilitated the rotation of shallow crustal blocks. Chetty (2011) inferred the coincidence of the detachment fault with the magnetic marker at 12 km depth.

Possible factors responsible for block rotation

Two possible processes that support the rotation model in this region are

(i) in the exposed granite gneissic terrain west of Cuddapah, several NW-SE trending shears were traversed by several transverse faults in NE-SW to ENE directions

(sometimes emplaced by dykes). They formed a mosaic of rigid blocks of various dimensions depending on the continuity and spacing between faults forming the blocks. Chetty (2011) explained the rotation of these blocks about vertical axes due to the strike sense of displacement along the bounding faults. With continued deformation through prolonged periods, the blocks tend to rotate (Nur et al., 1986). Similarly, the same granite gneissic terrain that formed the basement to Cuddapah sediments, might also have experienced block rotation.

(ii) CB experienced tectonic activity due to the Eastern Ghats orogeny, and NFB originated as a foreland basin facilitated by bounding N-S faults and the orogeny. Qualitative analysis of the aeromagnetic anomalies inferred certain basement features, which extend from western sub-basins into NFB. Due to multiple compressions related to continental collisional tectonics, these experienced tectonic disturbances at the Maidukuru thrust boundary and further east.

Generally, the continental rift margins are followed by oroclinal/fold belts globally that exhibit oroclinal bending parallel to the rift boundaries.

NFB by itself is an orogeny that manifests arcuate shape with internal fold/structural trends, more or less matching with the fabric of NSB & EGMB on either side of the dividing line between northern NFB and southern NFB. The trends within the southern part of NSB appear to be extending in NW-SE. In contrast, in the northern half of the NSB, these are in the NE-SW direction, exactly matching the orientation of northern and southern NFB, respectively. We noticed a few E-W trending magnetic linears extending from within the basin to the east of the basin, crossing the boundary into NSB. Saha (2001) inferred that the neighboring NSB rocks are also affected by the deformation of Nallamalai sediments. Chetty, 2001; Collins et al., 2015, Chandrakala et al., 2015 proposed a close link in crustal nature, structural setup, and temporal relationship between NSB and NFB. The same characteristic nature of the EGMB is inferred by Chetty (2011). The direction of anomaly trends is similar in EGMB (Rambabu & Prasanthi, 2005). Based on the structural trends, EGMB is divided into different domains/blocks, which are rotated. While the primary trend of the EGMB varies from

NNW between 14° and 15° N to approximately ENE between 17° to 18° N, several cross trends could be observed within the terrain. The cross trends within the EGMB, oriented E-W between latitudes 14° and 16° N, change to ENE between 17° and 19° N. Crustal shortening due to E-W compressional tectonics could be the reason for fault and block rotations. The same process could also be responsible for the block rotations within NFB facilitated by a conjugate system of faults.

8. Tectonic Model:

Northwest-southeast trending basement faults and NNE trending Nallamalai boundary faults formed a conjugate system (Fig. 7a). There could be a possible dip slip during the initialization of the formation of NFB along its boundary faults. Moreover, NFB boundary faults (Maidukuru and Vellikonda faults) being younger than NW-SE trending faults (black in color in Fig. 7a), the southern half of the initially inferred graben (blue lines in Fig. 7a) could also have been experienced the slip along the western boundary fault of NFB. Then, Nallamalai sediments might have undergone a folding process due to E-W compressional tectonics related to one of the continental collisional events. After this event, rotation of the northern and southern parts of the NFB could have taken place, which derived the crescent shape of the NFB. In this process, rotation of the southern part of NW-SE high (H2) falling in NFB must have rotated to attain E-W trend. Deposition of the Kurnool group of sediments could have been initiated after the rotational event. Thrusting of the NFB sediments over the Kurnool group of sediments along the Rudravaram line could be the latest event.

On the whole, inferences drawn from the aeromagnetic data interpretation to view the development of CB are given in an illustrative way in figure 8.

- The dominant crustal fabric/trends in EDC are NW-SE. The presently proposed NW-SE trending fault-bound feature (H1 & H2) identified from aeromagnetic data interpretation was the longest NW-SE trending feature in the EDC. It is

noteworthy to observe that this feature is very much parallel to NW-SE trending Godavari graben (Fig. 1) running along the northern boundary of EDC.

- Initiation of CB through rifting and formation of PSB due to a mantle plume in Paleoproterozoic period (~2500-1900 Ma).

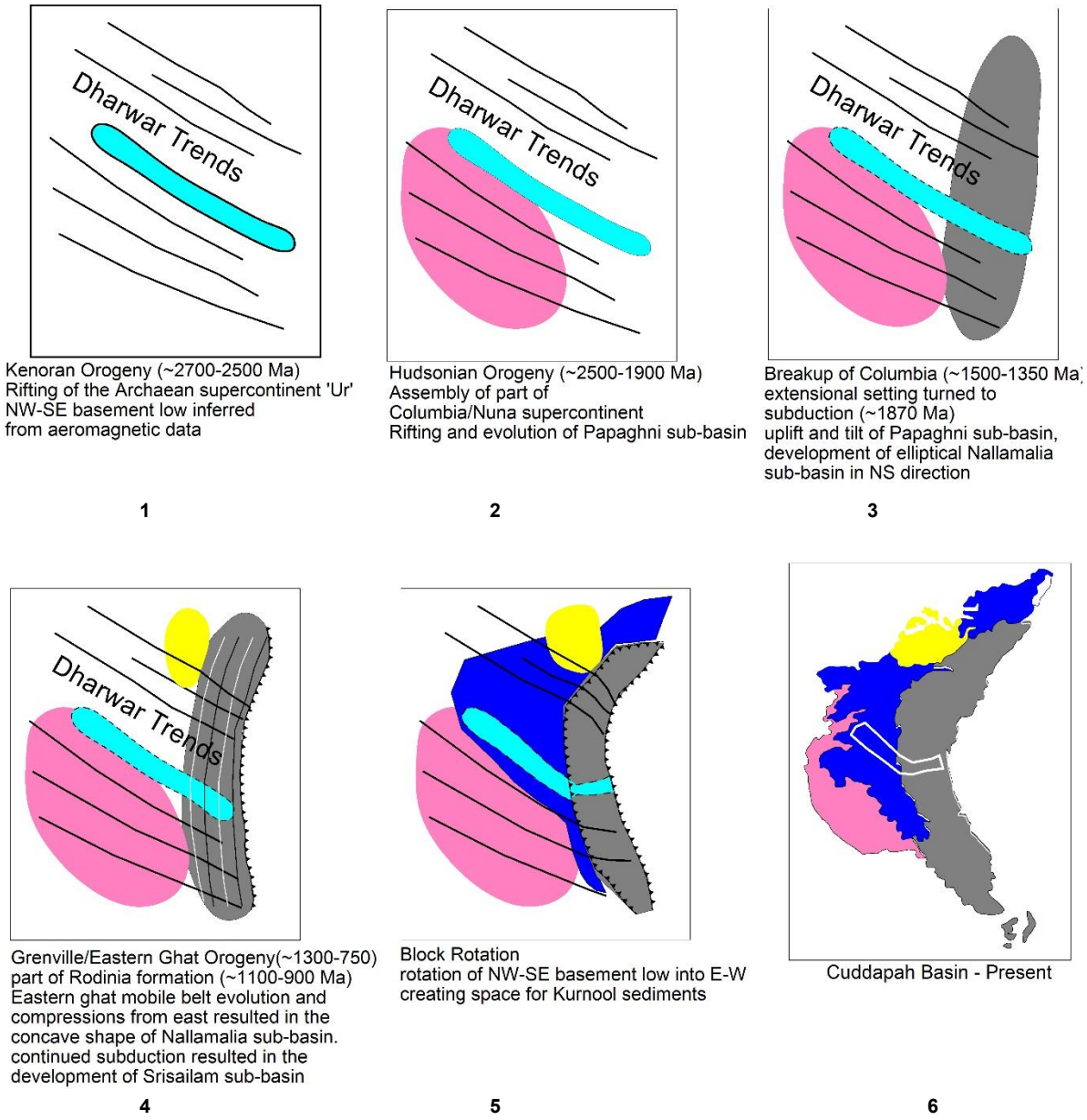


Figure 8: Schematic representation of our inferences on basin development

- Extensional setting turned to subduction (~1870 Ma) uplift and tilt of Papaghni sub-basin, development of elliptical Nallamalai sub-basin between two major N-S faults, and deposition of Nallamalai group of sediments during Mesoproterozoic.
- EGMB evolution and compressions from the east resulted in the Nallamalai fold belt. Development of Srisailam sub-basin.

- Crustal shortening due to convergence caused displacement in the thrust and fold belt of NFB along with adjoining terrains.

- This process resulted in the rotation of fault-bounded blocks within NFB. The clockwise rotation of the northern NFB and counterclockwise rotation of the southern NFB attributed the crescent shape to NFB. This process also has created space for deposition of the Kurnool group of sediments in the southern part between PNSB and southern NFB. Further thrusting has taken place along the western boundary of NFB, i.e., the Rudravaram line.

9. Conclusions

There are two schools of thought on how and when the NFB is associated in time with another part of the CB, i.e., western sub-basins. One school debate on the point that Nallamalai Basin NB is always a part of CB. Another supports the proposition that it formed elsewhere and accreted/converged/joined to the western basin over time. We tried here two identify if any magnetic signatures exist that prove one of the schools, i.e., either to support the origin of NFB at a distant place joining CB in due course or the existence of NFB at its place of origin.

The structures identified through qualitative analysis of magnetic data primarily support and establish that the structural framework of NFB is incomparable to that of the remaining part of the basin. However, through our present study, we identified a few strong magnetic features that continue into NFB from the western sub-basins. Modeling of the magnetic date over these features indicated similar basement characteristics on

either side of the Maidukuru thrust. As evidenced from the structures continuing from western subbasins into NFB and from modeling results, the western boundary of NFB is inferred to be just a thrust contact, not a continental collisional boundary any time in the past. Hence, it indicates that NFB is always a part of CB, just as other subbasins that underwent temporal tectonic changes locally. The upper crust is much the same for all the subbasins, with tectonic breaks between the western subbasins, NFB, and Nellore schist belt.

Basement configuration obtained from modeling of closely spaced profiles indicated thrusting very clearly along the thrust. In this way, our work provides strong geophysical evidence for thrusting along the western margin of NFB.

Change in the belt's orientation, from near N-S to NE to E in its northern part and SE in its southern part, can be related to the oroclinal bending facilitated by block rotation. The similar orientation of the NFB and EGMB suggests that NFB rotation can be linked to EGMB orogeny and it's bending simultaneously/contemporaneously. The inferred anomalies from our study undergone tectonic disturbance indicated clues to the rotation that might represent the thick-skinned oroclinal bending as it involved the deeper basement.

Authors contribution:

Prasanthi Lakshmi: Conceptualization, Manuscript writing, and overall supervision. **Parveen Begum:** Modeling and maps.

Acknowledgements: The authors are thankful to the Director, CSIR-NGRI for permitting to publish this work. Reference number NGRI/Lib/2025/Pub-41.

REFERENCES

1. Anand, M., Gibson, S.A., Subba Rao, K.V., Kelley, S.P., & Dickin, A.P. (2003). Early Proterozoic melt generation processes beneath the intracratonic Cuddapah basin, Southern India. *Journal of Petrology*, 44, 2139–2171.

2. Babu Rao, V. (1995). Aeromagnetic studies in relation to geology and structure of the Proterozoic Cuddapah Basin, South India. *Proceedings Annual Convention of Geological Society of India, Department of Geology, University of Tirupati, Tirupati,* 42-66.

3. Babu Rao, V., Atchuta Rao, D., Rama Rao, Ch., Sarma, B. S. P., Bhaskara Rao, D.S., Veeraswamy, K., & Sarma, M.R.L. (1987). Some salient results of interpretation of aeromagnetic data over Cuddapah basin and adjoining terrain, South India. *In: B.P. Radhakrishna (Editor), Purana Basins of Peninsular India, Geological Society of India, Memoir*, 6, 295-312.

4. Balakrishan, S., Chistopher, G., & Ramana Rao, A.V. (1967). Regional magnetic and gravity studies over Cuddapah basin. *Proceedings Symposia Upper Mantle Project, National Geophysical Research Institute, Hyderabad, publication,* 8, 303-319.

5. Betts, P.G., Valenta, R.K., & Finlay, J. (2003). Evolution of the Mount Woods Inlier, northern Gawler Craton, southern Australia: an integrated structural and aeromagnetic analysis. *Tectonophysics,* 366, 83-111.

6. Chakraborti, S., & Saha, D. (2006). Tectonic stresses and thin-skinned tectonics in a Proterozoic fold-and-thrust belt read from calcite mylonites in the Cuddapah basin, south India. *Indian Journal of Geology,* 78, 37–54.

7. Chandrakala, K., Pandey, O.P., Mall, D.M., & Sarkar, D. (2010). Seismic signatures of a Proterozoic thermal plume below southwestern part of the Cuddapah Basin, Dharwar craton, India. *Journal of Geological Society of India,* 76, 565–572.

8. Chandrakala, K., Pandey, O.P., Prasad, A.S.S.S.R.S., & Sain, K. (2015). Seismic imaging across the Eastern Ghats Belt-Cuddapah Basin collisional zone, southern Indian Shield and possible geodynamic implications. *Precambrian Research,* 271, 56–64.

9. Chetty, T.R.K. (2001). The Eastern Ghats Mobile Belt, India: A Collage of Juxtaposed Terranes (?). *Gondwana Research,* 4(3), 319-328.

10. Chetty, T.R.K. (2011). Tectonics of Proterozoic Cuddapah Basin, Southern India: A Conceptual Model. *Journal of Geological Society of India,* 78, 446-456.

11. Chetty, T.R.K., & Murthy, D.S.N. (1993). LANDSAT Thematic Mapper data applied to structural studies of the Eastern Ghat granulite terrane in part of Andhra Pradesh. *Journal of Geological Society of India,* 42, 373–391.

12. Collins, A.S., Patranabis-Deb, S., Alexander, E., Bertram, C.N., Falster, G.M., Gore, R.J., Mackintosh, J., Dhang, P.C., Saha, D., Payne, J.L., Jourdan, F., Backé, G., Halverson, G.P., & Wade, B.P. (2015). Detrital mineral age, radiogenic isotopic stratigraphy and tectonic significance of the Cuddapah Basin, India. *Gondwana Research*, 28, 1294–1309.

13. GEOSOFT, (2004). OASIS MONTAJ GM-SYS version 7.0 Gravity and magnetic modeling software user guide; *Northwest Geophysical Associates*, Inc.

14. Grauch, V. J. S., Rodriguez, B. D., & Wooden, J. L. (20030. Geophysical and isotopic constraints on crustal structure related to mineral trends in North-Central Nevada and implications for tectonic history. *Economic Geology*, 98, 269-286.

15. GSI, (1981). Geological Survey of India. Explanatory brochures on the Total Intensity Aeromagnetic Map of parts of the Cuddapah Basin and the adjoining crystallines. 1:250,000, First Edition.

16. Kaila, K.L., & Tewari, H.C. (1985). Structural trends in the Cuddapah basin from deep seismic soundings (DSS) and their tectonic implications. *Tectonophysics*, 115, 69-86.

17. Kaila, K.L., Roy Chowdhury, K., Reddy, P.R., Krishna, V.G., Narain, Hari., Subbotin, S.L., Sollogub, V.B., Chekunov, A.V., Kharetchko, G.E., Lazarenko, M.A., & Ilchenko, T.V. (1979). Crustal structure along Kavali-Udipi profile in the Indian peninsular shield from deep seismic sounding. *Journal of Geological Society of India,* 20, 307-333.

18. Kaila, K.L., Tewari, H.C., Roy, K.Chowdhury, Rao, V.K., Sridhar, A.R., & Mall, D.M. (1987). Crustal structure of the northern part of the Proterozoic Cuddapah basin of India from deep seismic soundings and gravity data. *Tectonophysics,* 140, 1-12.

19. Kale, V.S., Saha, D., Patranabis-Deb, S., Sesha Sai, V.V., Tripathy, V., & Pillai, S.P. (2020). Cuddapah basin, India: A collage of Proterozoic sub-basins and Terranes. *Proceedings Indian National Science Academy,* 86(1), 137-166.

20. Krishna Brahmam, N. (1989). Gravity and seismicity of the Cuddapah basin and surrounding places. *Journal of Geological Society of India,* 34, 373-384.

21. Mall, D. M., Pandey, O. P., Chandrakala, K., & Reddy, P. R. (2008). Imprints of a Proterozoic tectono-thermal anomaly below the 1.1 Ga kimberlitic province of southwest Cuddapah Basin, Dharwar Craton (Southern India). *Geophysics Journal International,* 172, 422–438.

22. Matin, A. (2015). Tectonics of the Cuddapah Basin and a model of its evolution: a review. From: Mazumder, R. & Eriksson, P. G. (eds) 2015. Precambrian Basins of India: Stratigraphic and Tectonic Context. *Geological Society, London, Memoirs,* 43, 231–254.

23. Matin, A. (2014). Tectonics in the Cuddapah fold–thrust belt in the Indian shield, Andhra Pradesh, India and its implication on the crustal amalgamation of India and Rayner craton of Antarctica during Neoproterozoic orogenesis. *International Journal of Earth Science*, 103, 7–22.

24. Meijerink, A.M.J., Rao, D.P., & Rupke, J. (1984). Stratigraphic and structural development of the Precambrian Cuddapah Basin, S.E. India. *Precambrian Research,* 26, 57-104.

25. Mishra, D. C., & Ravi Kumar, M. (2014). Proterozoic orogenic belts and rifting of Indian Cratons: Geophysical constraints. *Geoscience Frontiers,* 5, 25–41.

26. Mishra, D.C., & Tiwari, V.M. (1995). An asymmetrical basic lopolith below sediments in Western Cuddapah Basin - Geophysical Evidence. *Proceedings Annual Convention of Geological Society of India, Department of Geology, University of Tirupati, Tirupati,* 31-41.

27. Mishra, D.C., Babu Rao, V., Laxman, G., Rao, M.B.S.V., & Venkatarayudu, M. (1987). Three dimensional structural model of Cuddapah basin and adjacent eastern part from geophysical studies. *In: B.P. Radhakrishna (Editor), Purana Basins of Peninsular India, Memoir Geological Society of India,* 6, 313-330.

28. Mukherjee, S., Goswami, S., & Mukherjee, A. (2018). Structures and their tectonic implications of the southern part of Cuddapah basin, Andhra Pradesh, India. *Iranian Journal of Science and Technology Transaction Science,* 43, 1-17.

29. Murthy, Y.G.K. (1981). The Cuddapah basin - A review of basin development and basement framework relations. *In fourth workshop on status, problems and programs in Cuddapah basin. Institute of Indian Peninsular Geology, Hyderabad*, 51-73.

30. Nabighian, M. N., Grauch, V. J. S., Hansen, R. O., LaFehr, T. R., Li, Y., Pearson, W. C., Peirce, J. W., Phillips, J. D., & Ruder, M. E. (2005). The historical development of the magnetic method in exploration. *Geophysics,* 70 (6), 33-6170.

31. Nagaraja Rao, B. K., Rajurkar, S.T., Ramalingaswamy, G., & Ravindra Babu, B. (1987). Stratigraphy, structure and evolution of the Cuddapah Basin. In: B.P. Radhakrishna (Eds.), Purana Basins of Peninsular India: Middle to Late Proterozoic. *Memoir of Geological Society of India,* 6, 33-86.

32. Naqvi, S.M., & Rogers, J.J.W. (1987). Precambrian Geology of India. *Oxford Monographs on Geology and Geophysics. Oxford University Press Oxford,* 223.

33. Narayanaswami, S. (1966). Tectonics of the Cuddapah Basin. *Journal of Geological Society of India*, 7, 33-50.

34. Neelakantam, S. (1987). Mangampeta Barites Deposits, Cuddapah District, Andhra Pradesh: Memoir. *Geological Society of India, Memoir,* 6, 429-458.

35. Nur, A., Ron, H., & Scotti, O. (1986). Fault mechanics and the kinematics of block rotations. *Geology,* 14, 746-749.

36. Pandey, A., & Chalapathi Rao, N. V. (2019). Coupled assimilation and fractional crystallization (AFC) and mantle plume source(s) contribution in the generation of Paleoproterozoic mafic dykes of the Eastern Dharwar Craton, Southern India. *Journal of Geological Society of India,* 93, 157-162.

37. Pandey, O. P., Chandrakala, K., Vasanthi, A., & Satish Kumar, K. (2018). Seismically imaged shallow and deep crustal structure and potential field anomalies across the Eastern Dharwar Craton, south Indian shield: Possible geodynamical implications. *Journal of Asian Earth Science,* 157, 302–316.

38. Patranabis-Deb, S., Saha, D., & Tripathy, V. (2012). Basin stratigraphy: sea-level fluctuations and their global tectonic connections evidence from the Proterozoic Cuddapah Basin. *Geology Journal,* 47, 263–283.

39. Prasanti Lakshmi, M., & Ram Babu, H.V. (2002). Basement structure of the southwestern part of the Cuddapah basin from aeromagnetic anomalies. *Current Science*, 82, 1378-1381.

40. Ram Babu, H.V. (1993). Basement structure of the Cuddapah basin from gravity anomalies. *Tectonophysics,* 223, 411-422.

41. Ram Babu, H.V., & Prasanthi Lakshmi, M. (2005). Aeromagnetic image of a part of peninsular India and its relation to geology and structure. *Exploration Geophysics*, 36, 250–258.

42. Rama Rao, Ch., Bhaskara Rao, D.S., & Atchuta Rao, D. (1993). Delineation of possible extension of a schist belt complex in the southwestern part of the Cuddapah basin from regional aeromagnetic anomaly map – A directional spectral approach. *Proceedings of the 28th Annual Convention and the Seminar on "Geophysics for Rural Development", Indian Geophysical Union,* 99-103.

43. Rama Rao, Ch., Chetty, T.R.K., Lingaiah, A., & Babu Rao, V. (1991). Delineation of a greenstone belt using aeromagnetics, Landsat and photogeology - A case study from the South Indian shield. *Geoexploration,* 28, 121-138.

44. Rama Rao, Ch., Kishore, R.K., Pradeep Kumar, V., & Butchi Babu, B. (2011). Delineation of intra crustal horizon in Eastern Dharwar Craton – An aeromagnetic evidence. *Journal of Asian Earth Science,* 40, 534–541.

45. Ramakrishna, T.S. (1991). Cuddapah basin configuration-Another account based on gravity and aeromagnetics. *Journal of Geological Society of India,* 37, 109-118.

46. Ramam, P.K., & Murthy, V.N. (1997). Geology of Andhra Pradesh. *Geological Society of India.*

47. Ramesh Babu, V., Indrajit Patra, Shailesh Tripathi, Raju, B.V.S.N., & Chatrurvedi, A.K. (2012). High resolution heliborne magnetic data – An aid to delineate favourable basement structures for uranium exploration in parts of Palnad and Srisailam sub-basins, Cuddapah Basin, India. *Exploration and research for Atomic minerals*, 22, 141-152.

48. Saha, D. (2001). Deformation of Neoproterozoic succession adjoining the Eastern Ghats India—implications for tectonic convergence associated with Rodinia Gondwana assembly. *Gondwana Research,* 4,759–761.

49. Saha, D., & Sain, A. (2019). Multiple convergences along an Archean craton margin: Clues from Proterozoic ophiolite remnants, granites and granulite domains along the SE margin of India. *Journal of Geodynamics,* 129, 44-58.

50. Saha, D. (2004). Structural asymmetry and Plate tectonic set-up for a Proterozoic Fold and Thrust Belt: Nallamalai fold belt and Adjoining Terrane, South India. In: Roy, A., Jain, S. C.&Chakrabarti, U. (eds) Uniformitarianism Revisited: Comparison Between Ancient and Modern Orogens of India: *Proceedings of the Workshop on IGCP 453. Geological Survey of India, Special Publications,* 84, 101–119.

51. Saha, D., Chakraborty, S., & Tripathy, V. (2010). Intracontinental thrusts and inclined transpression along eastern margin of the Dharwar craton, India. *Journal of Geological Society of India,* 75, 323–337.

52. Saha, D., & Tripathy, V. (2012). Palaeoproterozoic sedimentation in the Cuddapah Basin, south India and regional tectonics a review. In: Mazumder R, Saha D (eds) Paleoproterozoic of India, vol 365. *Geological Society of London Special Publication, London,* 159–182.

53. Sarma, B.S.P., Rao, M.N., & Bosom, E. (1991). A graben like basement structure in the middle of the Cuddapah basin, South India – An aeromagnetic evidence and its tectonic implications. Extended Abstracts of the 1st International Seminar and Exhibition on "Exploration Geophysics in Nineteen Nineties, November 1991). *Association of Exploration Geophysicists,* Hyderabad.

54. Sesha Sai, V.V., Tripathy, V., Bhattacharjee, S., & Khanna, T.C. (2017). Paleoproterozoic magmatism in the Cuddapah basin, India. *Journal of Indian Geophysical Union,* 21, 516–525

55. Seshu, D., Prasanthi Lakshmi, M., Parveen Begum, S., & Manglik, A. (2020). Characterizing the Source of a Prominent Magnetic Anomaly in the Southwestern Part of the Cuddapah Basin. *Journal of Earth System Science,* 129:121.

56. Shuey, R. T., & Pasqulae, A. S. (1973). End corrections in Magnetic Profile Interpretation. *Geophysics,* 38(2), 507–512.

57. Singh, A.P., & Mishra, D.C. (2002). Tectono-sedimentary evolution of Cuddapah basin and Eastern Ghats mobile belt (India) as Proterozoic collision: gravity, seismic and geodynamic constraints. *Journal of Geodynamics,* 33, 249-267.

58. Singh, A.P., Mishra, D.C., Gupta, S.B., & Rao, M.R.K.P. (2004). Crustal structure and domain tectonics of the Dharwar craton (India): insight from new gravity data. *Journal of Asian Earth Science,* 23, 141-152.

59. Talwani, M., & Heirtzler, J. R. (1964). Computation of magnetic anomalies caused by two-dimensional bodies of arbitrary shape. In: PARKS, G. A. (Ed), Computers in the mineral industries, Part 1: *Stanford University Publication, Geological Sciences* 9, 464–480.

60. Talwani, M., Worzel, J. L., & Landisman, M. (1959). Rapid gravity computations for two-dimensional bodies with application to the Mendocino submarine fracture zone. *Journal of Geophysical Research,* 64, 49–59.

61. Tripathy, V., & Saha, D. (2013). Plate margin paleostress variations and intracontinental deformations in the evolution of the Cuddapah basin through Proterozoic. *Precambrian Research,* 235, 107-130

62. Tripathy, V., Satyapal Mitra, S. K., & Sesha Sai, V. V. (2019). Fold-Thrust Belt Architecture and Structural Evolution of the Northern Part of the Nallamalai Fold Belt, Cuddapah Basin, Andhra Pradesh, India. In: *Tectonics and Structural Geology: Indian Context (Ed: Mukherjee S) Springer Geology,* 219-252.

63. Venkatakrishnan, R., & Dotiwalla, F.E. (1987). The Cuddapah Salient: a tectonic model for the Cuddapah Basin, India, based on Landsat image interpretation. *Tectonophysics,* 136, 237-253.

64. Wennerstrom, M., & Airo, M. L. (1998). Magnetic fabric and emplacement of the post-collisional Pomovaara Granitic Complex in northern Fennoscandia. *Lithosphere,* 45, 131-145.

65. Won, I. J., & Bevis, M. (1987). Computing the gravitational and magnetic anomalies due to a polygon. Algorithms and FORTRAN subroutines. *Geophysics,* 52(2), 232–238.