J. Ind. Geophys. Union, 28(6) (2024), 430-438

Insights into neotectonic behaviour of the Southern Granulite Terrane and Dharwar Craton: A study based on lineament analysis and seismic activity

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ABSTRACT

The study sheds light on the neotectonic behaviour of the Southern Granulite Terrane and Dharwar Craton through comprehensive lineament analysis and seismicity assessment. Lineaments were meticulously identified in the study area using visual interpretation techniques in ArcMap GIS software. These features, observed through satellite imagery and shaded relief maps, were discerned based on criteria such as tonal contrast, terrain alignment, vegetation patterns, and drainage characteristics. Rose diagrams were generated to understand the distribution of lineaments across different domains, bounded by the major shear zones, categorizing them into major and minor categories based on their length. Distinct structural trends are revealed, with ENE-WSW, N-S, and NW-SE trends dominating in Domains A, B, and C of the southern Dharwar Craton, influenced by shear zones. In Domain D of the SGT, the NNE-SSW lineament trend aligns with the Gangavalli Shear Zone (GSZ), indicating ongoing tectonic reactivation. Seismicity in the southern Dharwar Craton reaches magnitudes up to 4.4, concentrated near major shear zones, while the northern SGT exhibits lower-magnitude seismic events, primarily at shear zone intersections. The correlation between lineament density and seismicity suggests that high density of lineament is indicative of neotectonic activity. The study highlights the significant role of ancient Proterozoic shear zones in shaping the current tectonic landscape. It emphasizes the need for further geophysical and seismological investigations to fully understand the tectonic dynamics of the region and assess potential seismic hazards

Keywords: Southern Granulite Terrane, Dharwar Craton, Remote sensing, Seismicity, Neotectonic activity.

INTRODUCTION

Shear zones, faults and lineaments are the manifestations at the earth’s surface of the deep geological structures and crustal tectonic units. Such features mark significant tectonic units within the crust and often serve as zones of favourable mineralization, while they also influence groundwater distribution. The displacement along these faults and lineaments is one of the primary causes of intraplate earthquakes.

Faults and lineaments can be delineated using geological, geophysical and remote sensing techniques. Remote sensing, in particular, has proven effective in identifying linear structures by highlighting surface features that correspond to underlying tectonic activity. Shear zones, which may range in thickness from less than a meter to several hundred meters, display planar to curvi-planar geometries, reflecting zones of heterogeneous deformation. These zones, as described by Ramsay (1980a,b), Ramsay and Huber (1987), Jiang and White (1995) and Fossen and Cavalcante (2017), often show evidence of complex overprinting or poly-phase deformations, with both ductile and brittle components preserved in their structure. This combination of deformation styles is indicative of the tectonic processes that shaped them over time. The ability of remote sensing technologies to offer panoramic views of large areas, makes it an invaluable tool in structural mapping. It is especially useful for examining inaccessible or remote regions, allowing researchers to analyse geological features at a broader scale. Shear zones and faults create discontinuities in the Earth's surface, which become even more pronounced in Digital Elevation Models (DEMs). These models, when combined with shaded relief maps, enhance the visibility of these structural features, providing rich visual representations that aid in interpretation. Seismicity data, often associated with these structural features, offers critical insights into tectonic boundaries and ongoing neotectonic activity. The identification of active faults, lineaments, and shear zones not only helps in understanding past geological events but also plays a key role in assessing earthquake hazards and mineral exploration.

The study area, located in southern India, covers the southern part of the Dharwar Craton and the northern portion of the Southern Granulite Terrain (SGT), two geologically important regions. It extends from 10° 30' to 13° N and 77° to 79° 15' E, encompassing approximately 66,000 km². The Dharwar Craton, one of the Earth's oldest crustal blocks, is composed of Archean rocks, while the SGT contains high-grade metamorphic rocks that have undergone multiple tectonic events from the Archean to the Neo-Proterozoic eras. The study area (Figure 1) is traversed by several major shear zones, including the N-S trending Mettur-Kolar Shear Zone (MKSZ), NNE-SSW trending Nallamalai Shear Zone (NSZ) and east-west trending Palghat-Cauvery Shear Zone (PCSZ). Other significant shear zones within the region include the Moyar Bhavani Shear Zone (MBSZ), the Cauvery Shear Zone (CaSZ), and the Salem-Attur Shear Zone (SASZ), which follow E-W, NW-SE, and E-W orientations, respectively. These shear zones intersect the hill ranges of Biligirirangan Hills, Shevroy Hills, Kalrayan Hills, and Kolli Hills, forming structural corridors within the terrain.

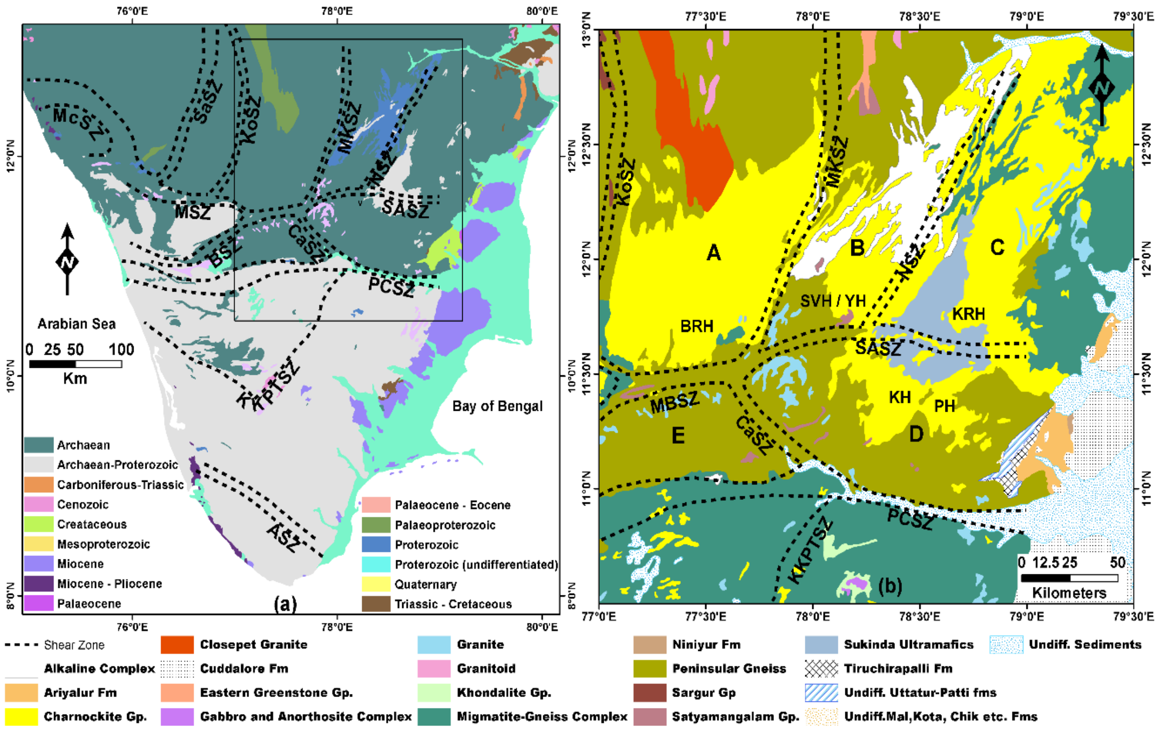

Figure 1. **(a)** Geochronological map of the Southern Granulite Terrain (SGT) and Southern Dharwar Craton created using data from the GSI-Bhukosh Database. The shear zones have been modified based on Kumar et al. (2013). The black rectangle inset represents the study area. Major shear zones depicted include: MSZ - Moyar Shear Zone; BSZ - Bhavani Shear Zone; SASZ - Salem-Attur Shear Zone; CaSZ - Cauvery Shear Zone; PCSZ - Palghat-Cauvery Shear Zone; KKPTSZ - Karur-Kambum-Painavu-Trichur Shear Zone; ASZ - Achankovil Shear Zone; ChSZ - Chitradurga Shear Zone; CoSZ - Coorg Shear Zone; NSZ - Nallamalai Shear Zone; MKSZ - Mettur-Kolar Shear Zone; and KoSZ - Kollegal Shear Zone. **(b)** Geological map of the study area, divided into five domains based on the orientation of major shear zones: A - Region between KoSZ, MBSZ, and MKSZ; B - Region between MKSZ, SASZ and NSZ; C - Region between NSZ and SASZ; D - Region between SASZ, CaSZ and PCSZ; E - Region between MBSZ, CaSZ and PCSZ. The map also highlights key hills: BRH - Biligiri Rangan Hills; SVH/YH - Shevaroy Hills/Yercaud Hills; KRH - Kalrayan Hills; KH - Kolli Hills and PH - Pachamalai Hills. The legend for the map is provided at the bottom.

This study has focused on mapping morpho-tectonic lineaments in these terrains using remote sensing techniques, integrating Digital Elevation Models (DEMs) with Landsat 8 OLI satellite imagery. This approach enhances the ability to identify and map linear structures such as faults and shear zones. The present analysis is significant for understanding the tectonic framework of the region, which marks the zones of weakness where seismic stress can accumulate and be released, contributing to intraplate earthquakes. Furthermore, the study examines the spatial correlation between lineament density and seismicity, offering insights into the neo-tectonic characteristics of the area. By comparing morphometric data derived from DEMs and remote sensing imagery, the study confirms the structural complexity of the region.

GEOLOGICAL SETTING OF THE STUDY AREA

Low-grade greenstone and granites are the major litho-units of the Dharwar craton whereas, high grade granulites, charnockites, gneisses and alkaline intrusives are the major litho units of the northern part of the SGT. From the Dharwar Craton to SGT, there is a noticeable increase in metamorphic grade, transitioning from greenschist facies to granulite facies and this change in metamorphic facies is traced by an orthopyroxene isograd or Fermor line. P-T conditions in the region range from 4 kb/450°C in the north to 8 kb/800°C in the south (Raith et al., 1982). The area between the Dharwar Craton and SGT, is intersected by large crustal-scale shear zones, ranging from meters to tens of kilometers in length. The SGT is often viewed as a mosaic of crustal blocks or highland massifs, separated by low-lying shear zones that extend in various directions such as NE-SW, E-W, and NW-SE (Rajendraprasad et al., 2006). These shear zones form tectonic boundaries, distinguishing the different tectonic origins of the SGT and the Dharwar Craton.

Prominent shear zones in this area include the Moyar Shear Zone (MSZ), Bhavani Shear Zone (BSZ), Salem-Attur Shear Zone (SASZ), Cauvery Shear Zone (CaSZ), Palghat-Cauvery Shear Zone (PCSZ), Karur-Kambum-Painavu-Trichur Shear Zone (KKPTSZ), Achankovil Shear Zone (ASZ), Chitradurga Shear Zone (ChSZ), Coorg Shear Zone (CoSZ), Mettur-Kolar Shear Zone (MKSZ), and Nallamalai Shear Zone (NSZ). Notable massifs such as the Biligirirangan Hills (BRH), Shevroy Hills (SVH), Kolli Hills (KH), Nilagiri Hills (NGH), Palani Hills (PLH), and Kalrayan Hills (KRH) are situated between these shear zones (Ghosh et al., 2004; Kumar et al., 2013).

Geologically, this region is primarily composed of Precambrian acid to intermediate charnockites, hornblende-biotite gneisses, quarzo-feldspathic gneisses, granites, alkaline complexes, and tertiary deposits. Charnockites predominantly form the hill massifs separating the major shear zones. The study area is divided into five segments (A, B, C, D, and E) based on the orientation of the shear zones. The southern part of the area, located below the Moyar Bhavani Shear Zone, has a low-relief landscape with minimal traceable lineaments. In contrast, domains A, B, C, and D feature high-relief geomorphic hills with prominent large-scale lineaments.

DATA AND METHODOLOGY

Satellite remote sensing data from (Landsat 8 Operational Land Imager, OLI) and Advanced Spaceborne Thermal Emission and Reflection Radiometer (Aster) Digital Elevation Model (DEM) were used for lineament mapping. The Landsat 8 images contain 11 spectral bands, of which band 1-9 are acquired in Visible-Near Infrared-Shortwave infrared region, band 10 and 12 are acquired in thermal bands. Landsat-8 OLI, an American Earth observation satellite launched on February 11, 2013, consists of nine spectral bands with a spatial resolution of 30 m for bands 1 to 7 and 9, except for its panchromatic band (spatial resolution of 15 m), and two thermal bands with a resolution of 100 m Landsat-8 OLI, an American Earth observation satellite launched on February 11, 2013, consists of nine spectral bands with a spatial resolution of 30 m for bands 1 to 7 and 9, except for its panchromatic band (spatial resolution of 15 m), and two thermal bands with a resolution of 100 m.

All the bands have spatial resolution of 30 m, except band10, 11 (100 m) and Panchromatic band 8 (15 m). The Terrain corrected version (L1T) of Landsat OLI image is geometrically corrected to UTM co-ordinate system (Zone 43N), WGS84 datum. The ASTER Global Digital Elevation Model (GDEM) Version 3 (ASTGTM), provides a global DEM of Earth's land surface at a spatial resolution of 1 arc second (30 meter). The DEM is projected to the same reference frame as that of Landsat 8 OLI image and provided as Geotiff images. Both the data can be downloaded freely from the USGS website (https://earthexplorer.usgs.gov). The cloud free, L1T Landsat 8 OLI data (path:143 & 144; row:51, 52 & 53) acquired on 31.03.2014, 24.04.2017, 23.02.2015 and 17.04.2017 and ASTER GDEM covering the study area were downloaded from the USGS website. The image analysis was carried out in ENVI 4.8 software and lineament mapping was carried out in ArcGIS software. Earthquake data between 1976 and 2010 are compiled from the seismic observatory of Gauribindanur, Bhabha Atomic Research Centre (BARC), Karnataka.

Further, the lineaments within the structurally complex Archean to Neoproterozoic terrane were delineated using processed Landsat 8 OLI satellite imagery and shaded relief Digital Elevation Models (DEMs). The data were pre-processed using ENVI 4.8 software prior to lineament mapping. Linear features were mapped at two reference scales (below 50,000 m and above 50,000 m ground scale) and validated by overlaying them on Google Earth imagery and Survey of India toposheets. Lineament density and rose diagrams were analysed to assess the orientation and distribution of the lineaments. Subsequently, a seismicity map was generated, and the results from the lineament analysis were integrated with the seismicity data to better understand the neo-tectonic activities in the study area.

REMOTE SENSING AND DEM ANALYSIS

We utilized six bands (bands 2-7) from the Landsat 8 OLI sensor, which were layer-stacked for analysis. Since the data was terrain-corrected, no geometric correction was required. However, radiometric calibration and atmospheric correction were applied. The radiance data was converted to reflectance values using the Fast Line-of-Sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) atmospheric correction model in ENVI. This processed data was used to create colour composites, including natural colour composite (NCC, RGB band combination: 4-3-2) and false colour composite (FCC) using various band combinations, followed by image enhancement through contrast stretching. The 5-4-3 colour infrared band combination proved effective in distinguishing land features and highlighting linear discontinuities. Additionally, directional filters were applied to the colour composites to further highlight the lineaments.

The Shaded relief maps are commonly used for mapping lineaments from DEMs (Abdullah et al., 2010; Mallast et al., 2011; Martial et al., 2013; ElGhrabawy et al., 2019). These maps are generated by projecting the DEM at different sun azimuth angles, allowing the visualization of topographic discontinuities in different angles. For the study area, the shaded relief map was created using a sun azimuth angle of

315 degrees, which enhances geomorphic variations and highlights elevation changes across the landscape, making structural features more discernible.

RESULTS

Lineament mapping

Lineaments were manually extracted through visual interpretation and "heads-up" digitization using ArcMAP GIS software from processed satellite imagery and shaded relief maps. Lineaments include linear to curvilinear features visible in satellite images, excluding anthropogenic elements such as roads, railway tracks etc. These features were identified by analysing tonal contrasts, hill alignments, linear vegetation patterns, elongated drainage stretches, sudden deflections in drainage courses, and characteristic eye-shaped drainage patterns. Lineaments were interpreted separately from natural colour composites (NCC, RGB band combination: 4-3-2), false color composites (FCC, RGB band combination: 5-4-3), and filtered images. A shaded relief map (Figure 2), generated using Aster DEM, highlights the topography of the study area, where elevations range from 20 m to 1,620 m. The shaded relief map, created at a 315° sun azimuth angle, accentuates the geomorphic variations. Prominent lineaments observed include those oriented along E-W, NE-SW, and NW-SE directions, indicating large-scale structural trends. After identifying lineaments using different methods, the interpreted lineaments were consolidated into a final lineament map (Figure 3), ensuring the removal of duplicates. Anthropogenic features were carefully excluded by cross-referencing topographic maps and high-resolution Google Earth images. Further, rose diagrams were generated for lineaments across five distinct domains (A to E), each fully or partially bounded by major shear zones (Figure 4). These diagrams were created using GEOrient software, taking into account both the length and orientation of lineaments. The lineaments were categorized as major (> 50 km in length) or minor (<50 km in length) for each domain. Additionally, a lineament density map was generated using spatial interpolation techniques (Figure 5), offering valuable insight into the concentration and distribution of lineaments throughout the region.

Domain A, characterized by its large aerial extent, includes highly elevated hill ranges such as the Biligirirangan Hills and Male Mahadeshwara Hills. Prominent N-S and E-W trending major lineaments are clearly observed across these hills. The Mettur-Kolar Shear Zone (MKSZ) forms the boundary between Domains A and B. Shevaroy (SVH) or the Yercaud hills (YH) are the main high relief feature of Domain B. This domain is marked by visible N-S and NW-SE trending lineaments. East of the Nallamalai Shear Zone (NSZ), the Jawadhu Hills and Kalrayan Hills represent the major elevated relief features. The NSZ runs between the Shevaroy and Kalrayan Hills, differentiating Domains B and C, where E-W, NE-SW, and NW-SE are the predominant lineament trends. Domains D and E are separated from the northern Dharwar Craton by the E-W trending Moyar Bhavani Shear Zone (MBSZ) and Salem-Attur Shear Zone (SASZ). The Cauvery Shear Zone (CaSZ) demarcates the boundary between Domains D and E. Domain D includes the Kolli Hills and Palani Hills, both of which are highly elevated, whereas Domain E lacks any significant relief features. NE-SW is the primary lineament trend visible in Domain D, while lineaments of Domain E are largely derived from drainage patterns and vegetation.

The major charnockitic hill ranges - Biligirirangan Hills, Male Mahadeshwara Hills, Yercaud Hills, Jawadhu Hills, Kalrayan Hills and Kolli Hills are distinctly divided by major shear zones, indicating their role in the geomorphic evolution of the region. The wide valleys between the Shevaroy-Kalrayan Hills and Kolli-Palani Hills, marked by the SASZ, and between the Shevaroy and Kalrayan Hills, marked by the NSZ, reflect the significant impact of these shear zones on the landscape. The southern and eastern valleys of the Biligirirangan Hills are defined by the MBSZ and Mettur Shear Zone respectively. These variations in relief are likely due to differences in the rates of denudation, where the more resistant charnockitic hills persisted while the shear zones, being weaker and more fragile, were subjected to extensive denudational processes, resulting in wide valleys amidst the high-relief charnockitic massifs.

The rose diagram for Domain A (Figure 4) shows that the dominant lineament trends are ENE-WSW, followed by N-S and WNW-ESE. In Domains B and C, Kalrayan Hills and the northwest of Shevaroy/Yercaud Hills exhibit high to moderate lineament density. A broad linear high density is observed over Biligirirangan Hills in south of domain A and over Male Mahadeshwara Hills. The Salem-Attur valley, a low-relief zone, separates the high-density lineaments of Domain D to the south from those of Domain C to the north. Domain E and the southwest part of Domain D, which have very low relief, show minimal lineament density, since lineaments primarily traced through enhanced vegetation patterns.

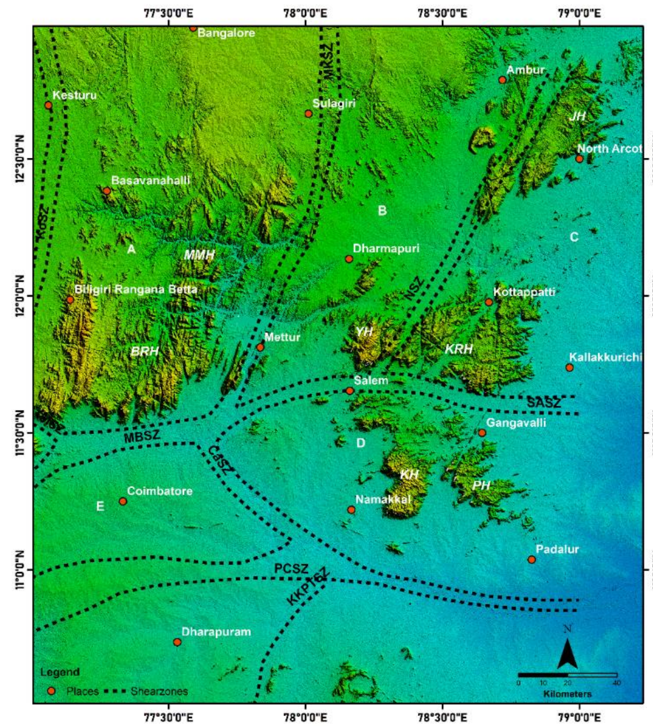

Figure 2. Shaded relief map of the study area generated using a Digital Elevation Model (DEM) overlaid with major shear zones. The map highlights the following hills: MMH - Male Mahadeshwara Hills; BRH - Biligiri Rangan Hills; YH - Yercaud Hills/Shevaroy Hills; JH - Jawadhu Hills; KRH - Kalrayan Hills; KH - Kolli Hills and PH - Pachamalai Hills.

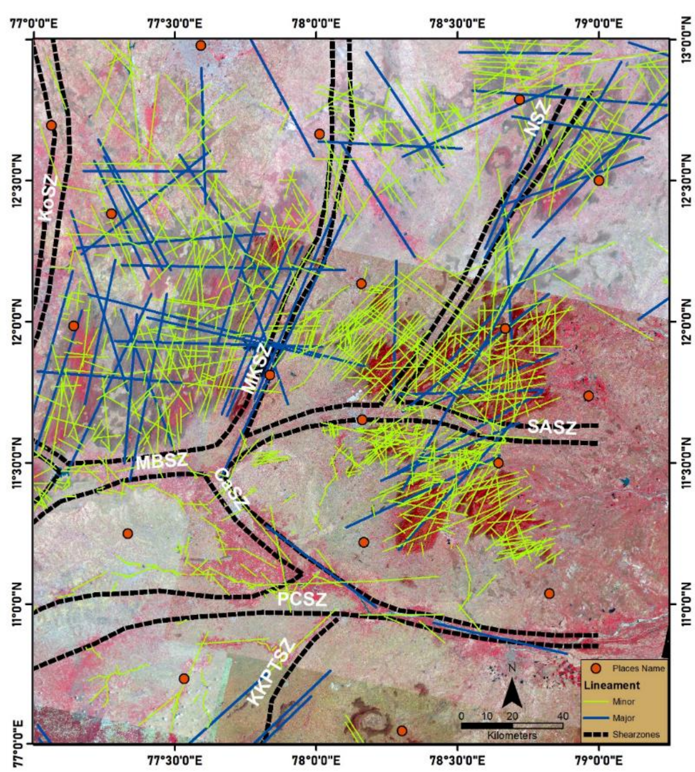

Figure 3. Landsat 8 OLI false-color composite image of the study area. Major and minor lineaments are depicted as light green and blue lines, respectively. Red dots indicate key locations, with place names corresponding to those marked in Figure 2.

The predominant lineament density patterns align with the trends of Domain A boundary shears- the Moyar Bhavani Shear Zone (MBSZ), KoSZ and Mettur-Kolar Shear Zone (MKSZ) (Figure 5). In Domain B, the rose diagram indicates that NE-SW, followed by N-S lineaments, matching the trends of the MKSZ and Nallamalai Shear Zone (NSZ). It is evident from the rose diagram of Domain C (Figure.4) that that lineaments in Kalrayan and Jawadhu Hills primarily trend E-W, followed by NE-SW and NW-SE, corresponding to the Salem-Attur Shear Zone (SASZ) and NSZ.

In Domain D, the dominant trend is NNE-SSW, followed by N-S and NE-SW, which aligns with the trend of Gangavalli Shear Zone (GSZ). In Domain E, N-S is the primary trend, followed by NE-SW and NW-SE, with the latter trend following the Cauvery Shear Zone (CaSZ), which forms the domain boundary. The trend of major Neoproterozoic shear zones (MBSZ, SASZ, KoSZ etc) in the structural domains correlate well with that of Gabrielsen et al. (2002) who opined that the geographical extent of younger lineaments populations are directly affected by the Neoproterozoic fracture systems. Overall, lineament trends in Domains A, B, and C of the southern Dharwar craton are largely controlled by domain boundary shear zones, whereas the northern SGT domains, show only partial influence. Below the MBSZ-SASZ boundary, N-S to NNE-SSW trends are dominant. The ongoing northward compressional forces in the region, which are considered responsible for the development of neo-tectonic lineaments (Ramasamy et al., 2011).

Seismicity analysis

The integration of lineament density with seismicity data from BARC (Figure 5) provided valuable insights into the neo-tectonic activity of the study area. Earthquakes with magnitudes below 2.0 were excluded to avoid misinterpretations caused by mining or developmental activities, which often generate low-magnitude seismic events. Lineament density is a key indicator of crustal permeability as higher lineament density suggests that the crust is more fractured, allowing fluids and gases to migrate to the surface (Sharifi et al., 2008). Domain D exhibits very high lineament density, encircled by areas of high to moderate density, which may indicate heightened tectonic stress and potential neo-tectonic reactivation.

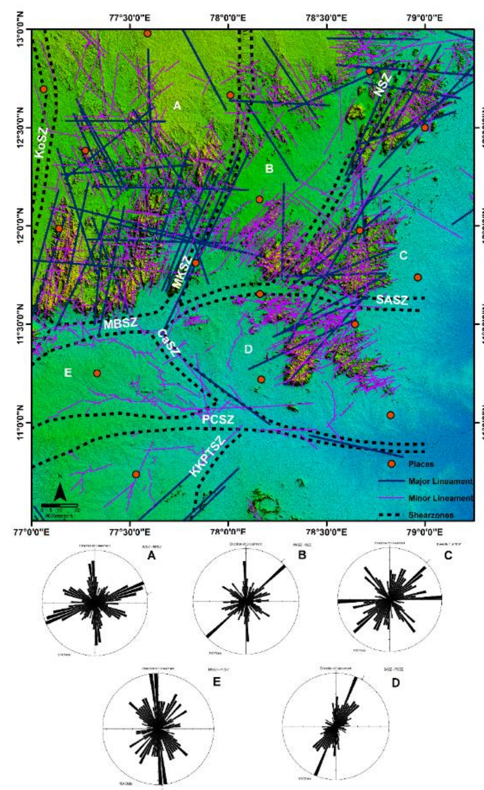

Figure 4. Shaded relief map of the study area generated using Aster DEM. Major and minor lineaments are shown as dark blue and purple lines, respectively. For place names, refer to Figure 2. Below the map, rose diagrams labeled A, B, C, D, and F are created using lineament data from domains A, B, C, D, and E, respectively.

In all the domains except D, a set of lineaments exhibits the Dharwarian NW-SE trend, as noted by Mukhopadhyay (1986) and Chadwick et al. (1989) (Figure 3). The N-S trend is a secondary but common feature observed across the southern Dharwar Craton domains, are likely influenced by the structural trends of KoSZ and Mettur-Kolar Shear Zone (MKSZ). In the southern SGT domains, the N-S trend is prominent, particularly in Domain E, though it is less significant south of the Salem-Attur Shear Zone (SASZ). The prevalence of N-S trending lineaments can be attributed to

In the southern Dharwar Craton, particularly in Domain A, there is a higher frequency of seismic events, with magnitudes reaching up to 4.4. In contrast, the northern SGT experiences lower seismic activity, with earthquake magnitudes up to 3.7 but at a significantly reduced frequency. Seismic activity in the SGT is concentrated at the intersections of key shear zones, such as MKSZ-MBSZ and NSZ-SASZ, and to the west of the Palghat-Cauvery Shear Zone (PCSZ). Notably, the high lineament density near the Kalrayan Hills lacks corresponding seismicity, suggesting that these lineaments may be shallow and aseismic in nature, potentially indicative of more localized deformation rather than deeper, seismogenic faulting. Additionally, small-magnitude earthquakes (2.3 to 2.7) along NNE-SSW trend were reported east of the Gangavalli Shear Zone (GSZ), which correlates with the dominant trend of lineaments and high lineament density in Domain D. This alignment of seismic activity, lineament density, and the NNE-SSW trend of the GSZ suggests that Domain D may be undergoing tectonic reactivation, indicating active deformation along the GSZ. In Domain E, which exhibits minimal lineament density, low seismicity, reinforces the correlation between lineament density and tectonic activity. However, while this study shows a clear connection between lineament density and neo-tectonic activity, further geological and seismological investigations are necessary to fully understand the underlying processes.

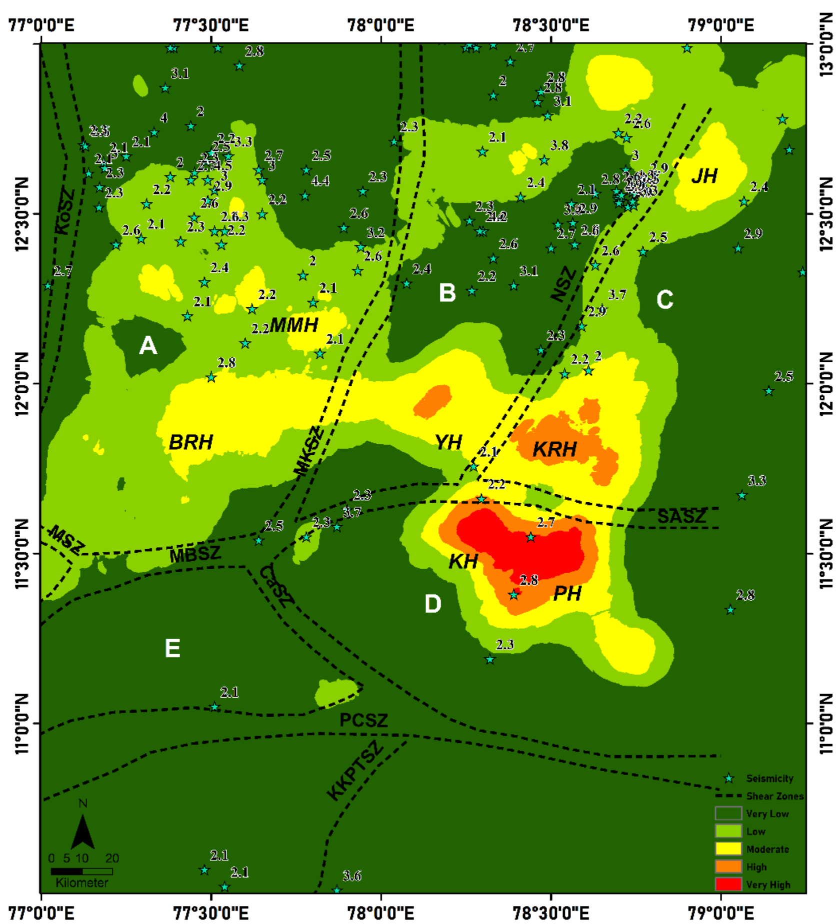

Figure 5. Map showing lineament density overlaid by seismicity data

DISCUSSION

This study provides a comprehensive analysis of lineaments and their relation to the structural and neo-tectonic framework of the southern Dharwar Craton and the northern SGT. Through the integration of satellite imagery, Digital Elevation Models (DEMs), and seismicity data, we have identified tectonic trends that influence the geomorphology and seismicity of the region.

The mapped lineaments, derived from Landsat 8 OLI imagery and shaded relief DEMs, reveal distinct structural patterns across the study area. The major lineament trends in the southern Dharwar Craton (Domains A, B, and C) are largely influenced by prominent shear zones. The rose diagrams for each domain clearly show the dominance of ENE-WSW, N-S, and NW-SE trends in Domain A, while NE-SW and N-S trends prevail in Domains B and C. The alignment of these trends with the domain boundary shear zones suggests that these ancient structures continue to influence tectonic evolution of the region, which aligns with previous studies (Mukhopadhyay, 1986; Chadwick et al., 1989) that document the Dharwarian NW-SE trend.

In contrast, the northern SGT domains (D and E) exhibit a slightly different structural pattern. Domain D is marked by a NNE-SSW trend, which correlates with the Gangavalli Shear Zone (GSZ), suggesting ongoing tectonic activity. The correlation between the high lineament density in Domain D and the seismicity concentrated along the GSZ, further supports the idea of neo-tectonic reactivation in this area. Domain E, characterized by low lineament density and minimal seismic activity, presents a different tectonic regime, potentially reflecting reduced tectonic stress and more stable conditions compared to other domains.

The integration of seismicity data provides additional insights into the active tectonic processes shaping the region. The southern Dharwar Craton, particularly Domain A, exhibits higher seismicity with magnitudes up to 4.4, indicating active tectonic stress along existing fault lines. In the northern SGT, seismic events are less frequent but concentrated at the intersections of major shear zones, such as the MKSZ-MBSZ and NSZ-SASZ, and near the Palghat-Cauvery Shear Zone (PCSZ). Interestingly, areas of high lineament density near the Kalrayan Hills are devoid of significant seismic activity, suggesting that these lineaments may be shallow and aseismic in nature, or that they represent structures less prone to deep tectonic deformation.

The N-S trending lineaments observed throughout the southern Dharwar Craton and the SGT, particularly in Domain E, may be linked to ongoing northward compressional forces, which continue to generate neo-tectonic lineaments (Ramasamy et al., 2011). This is particularly evident in Domains D and E, where the NNE-SSW trending lineaments align with earthquake activity, indicating that these areas are undergoing active tectonic deformation. The connection between lineament density and seismicity supports the hypothesis that areas with higher lineament density are more tectonically active, as they allow for increased fluid migration and stress accumulation, as suggested by Sharifi et al. (2008).

Largely, the study highlights the importance of integrating lineament analysis with seismicity data to better understand the tectonic and neo-tectonic dynamics of complex geological terrains. The structural trends identified in this study align well with previous research, confirming the influence of ancient Proterozoic shear zones on modern tectonic activity. However, further geological and seismological investigations are needed to clarify the extent and nature of these neo-tectonic processes. Detailed GPS-based crustal deformation studies, combined with more comprehensive crustal monitoring, could provide deeper insights into the tectonic evolution of the region and help identify potential seismic hazards.

CONCLUSIONS

The study successfully delineates lineaments across the southern Dharwar Craton and northern SGT using Landsat 8 OLI imagery, DEMs, and seismicity data that reveal significant tectonic patterns. In the southern Dharwar Craton (Domains A, B, C), ENE-WSW, N-S, and NW-SE trends dominate, influenced by key shear zones such as the Mettur-Kolar Shear Zone (MKSZ) and Nallamalai Shear Zone (NSZ). Domain D, characterized by a NNE-SSW lineament trend and high lineament density, correlates with seismicity along the Gangavalli Shear Zone (GSZ), suggesting ongoing tectonic reactivation. The southern Dharwar Craton experiences higher seismicity (up to magnitude 4.4), especially near major shear zones, whereas the northern SGT shows lower seismic activity, concentrated around shear zone intersections. A strong correlation exists between high lineament density and seismic activity, indicating that tectonically active zones align with regions of high lineament density. The study emphasizes the need for further research using GPS-based deformation and enhanced seismic monitoring to understand the ongoing tectonic processes and assess potential seismic hazards.

ACKNOWLEDGEMENT

We appreciate and acknowledge the Department of Earth Sciences, Pondicherry University for providing the support for undertaking this work. The work was financially supported by DST-SERB (Department of Science & Technology – Science and Engineering Research Board, New Delhi) SERB File Number: EMR/2017/001083.The authors thank Dr. K.N. Kusuma for the support provided during the work. Thanks to the Chief Editor Dr. O.P. Pandey and the reviewers for their valuable comments which are instrumental in improving the manuscript.

Author Credit Statement

Akhil S. Suseel: Data acquisition, processing, formal analysis, manuscript writing, data interpretation, editing; S. Lasitha: conceptualization, data interpretation, manuscript writing, supervision, editing, review.

Data availability

The present study uses Landsat 8 OLI satellite imagery and shaded relief DEM. The data was downloaded from https://earthexplorer.usgs.gov. Earthquake data between 1976 and 2010 have been compiled from the seismic observatory of Gauribindanur, Bhabha Atomic Research Centre (BARC), Karnataka.

Compliance with ethical standards

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors adhere to copyright norms.

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Received on: 10-05-2024 ; Revised on: 16-09-2024; Accepted on: 19-09-2024