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# Evidence from Remote Sensing and Field Work Observations of Tectonic Features in Pouma Area, Littoral-Cameroon

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INFORMATION

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ABSTRACT

The Pan-African mobile belt in Pouma, Littoral-Cameroon, offers a unique geological context for studying tectonic features from the Neoproterozoic era. This study utilizes remote sensing techniques and field observations to investigate the complex geological structures within the study area. The location, relief, and geology of the region are initially described to provide the necessary background. Lineament analysis, identification of structural elements, and orientation measurements form the primary methodology employed. The results obtained from the lineament analysis and structural observations demonstrate the presence of multiple lineament directions, indicating a diverse range of geological structures in Pouma. Such lineaments are commonly associated with tectonic stresses and can signify the existence of faults or fractures. Additionally, the dominant NE-SW orientation of the lineaments aligns with previous studies, identifying a significant tectonic corridor in the area. The interpretation of findings reveals anomalies and confirms the presence of the Kribi-Campo fault, extending from Pouma in the Northeast to Campo in the Southwest. Furthermore, the observation of post-metamorphic fractures intersecting inclined folds provides additional support for the regional tectonic history described in related studies. In conclusion, this study provides compelling evidence of the tectonic features in the Pan-African mobile belt of Pouma, Cameroon. The combination of remote sensing and field observations enhances our understanding of the region's geological evolution. The observed complex structures, lineament orientations, and fault systems have broader implications for tectonic studies not only in Cameroon but also in similar geological contexts worldwide.

## 1. Introduction

The Pan-African mobile belt in Pouma, Littoral-Cameroon, represents a unique geological setting that offers a wealth of information about the tectonic events that unfolded during the Neoproterozoic era (Toteu et al., 1994; Yonta-Ngoune et al., 2010).

The region is part of a larger tectonic domain characterized by the collision and amalgamation of crustal blocks, resulting in the formation of extensive tectonic zones and structures. Understanding the tectonic features within the Pouma Area is crucial for unraveling the complex interplay of geological forces that shaped the landscape and influenced the distribution of mineral resources. The geological significance of the Pouma Area lies not only in its contribution to the broader tectonic framework but also in its potential for valuable mineral deposits. The tectonic processes that occurred in this region can give important clues about the formation and distribution of economically significant minerals. By studying the tectonic features present in Pouma, such as faults, fractures, and folds, researchers can gain insights into the structural controls that influenced the localization of mineral deposits. This knowledge is of great interest to both the scientific community and the mining industry.

The relief and geology of the Pouma Area further enhance its geological importance. The diverse topography is a testament to the complex interplay of erosional and tectonic processes that have shaped the landscape over millions of years. From rugged mountain ranges to deep valleys and broad plains, the Pouma Area offers a range of geological environments that reflect the tectonic events that occurred throughout its history. By studying the distinct geological formations, researchers can decipher the sequence of tectonic events, reconstruct ancient paleoenvironments, and gain insights into the tectonic forces that influenced the evolution of the region.

The methodology employed in this study combines the use of remote sensing techniques and field observations, providing a comprehensive approach to analyzing the tectonic features in Pouma. Remote sensing data, such as satellite imagery and aerial photographs, offer a bird's-eye view of the study area, allowing researchers to identify and map lineaments, or linear features, that may represent faults or fractures. These lineaments serve as valuable indicators of tectonic activity and provide insights into the overall tectonic fabric of the region. Fieldwork, on the other hand, involves conducting detailed geological surveys, collecting rock samples, and accurately measuring the orientations and dips of various geological structures.

By integrating the data obtained from remote sensing and field observations, a holistic understanding of the tectonic features within the Pouma area can be achieved. This multi-faceted approach ensures the reliability and accuracy of the findings, enabling robust interpretations of the geological evolution of the Pan-African mobile belt in Pouma. By addressing the problematic areas of limited understanding regarding the tectonic features and geological structures, this study fills a significant knowledge gap in the scientific community. The findings provide compelling evidence and interpretations that contribute to our broader understanding of tectonic processes, both within the Pouma area and in similar geological contexts worldwide. The research outcomes have practical implications as well, aiding in the assessment of natural hazards, resource exploration, and land-use planning in the region.

The study of the tectonic features within the Pan-African mobile belt in Pouma, Littoral-Cameroon, presents a valuable opportunity to investigate the geological history and tectonic processes of the region. Through a combination of remote sensing techniques and field observations, this research aims to enhance our understanding of the complex interplay of geological forces and the geological evolution of the Pouma area. The outcomes of this study will contribute to the broader scientific knowledge base, providing a foundation for future research and facilitating better-informed decision-making in matters related to geology, resources and land management.

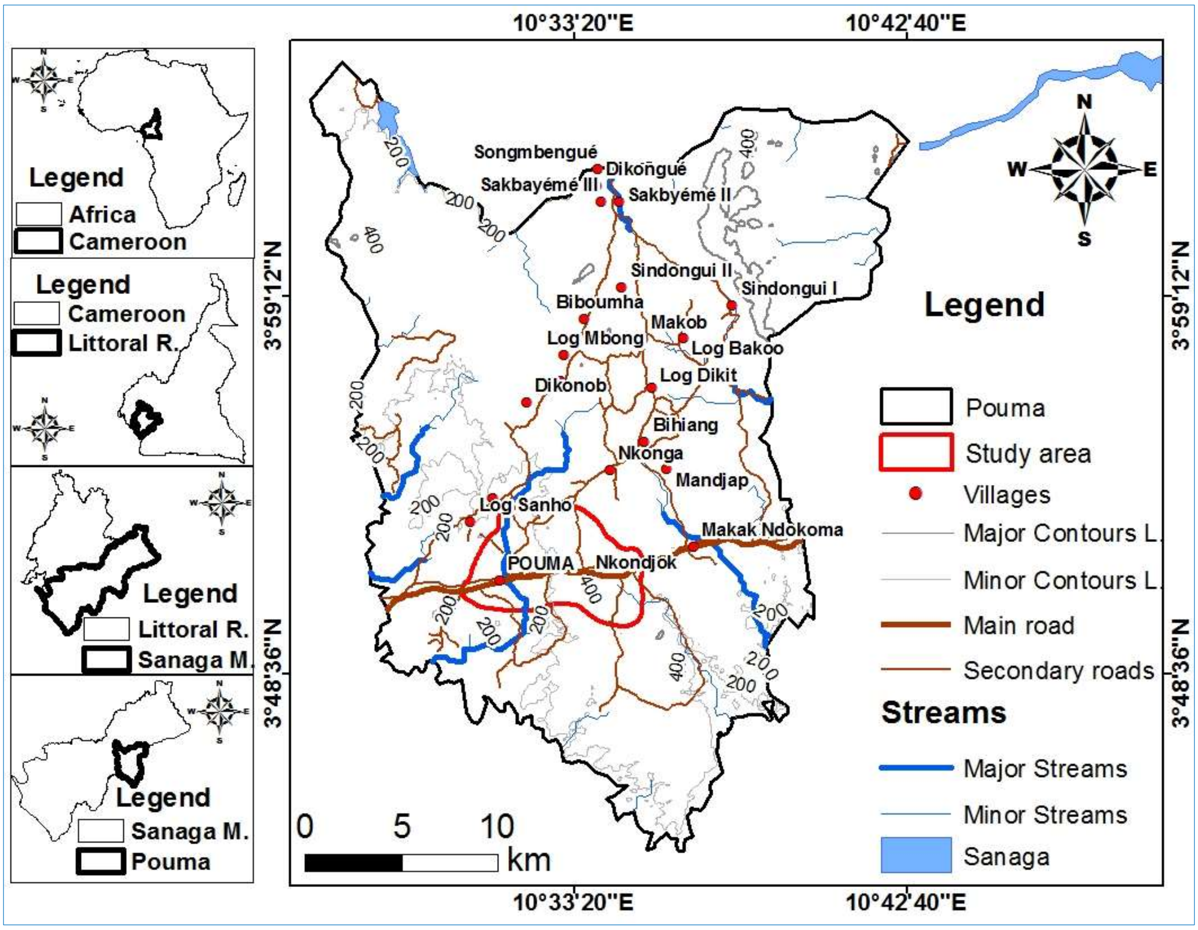



Fig. 1. Location map of the study area

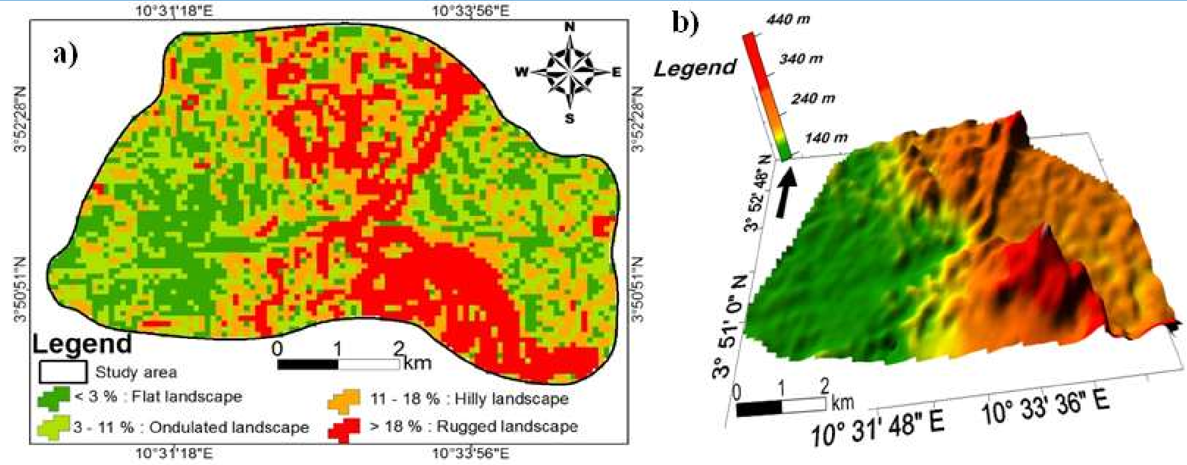


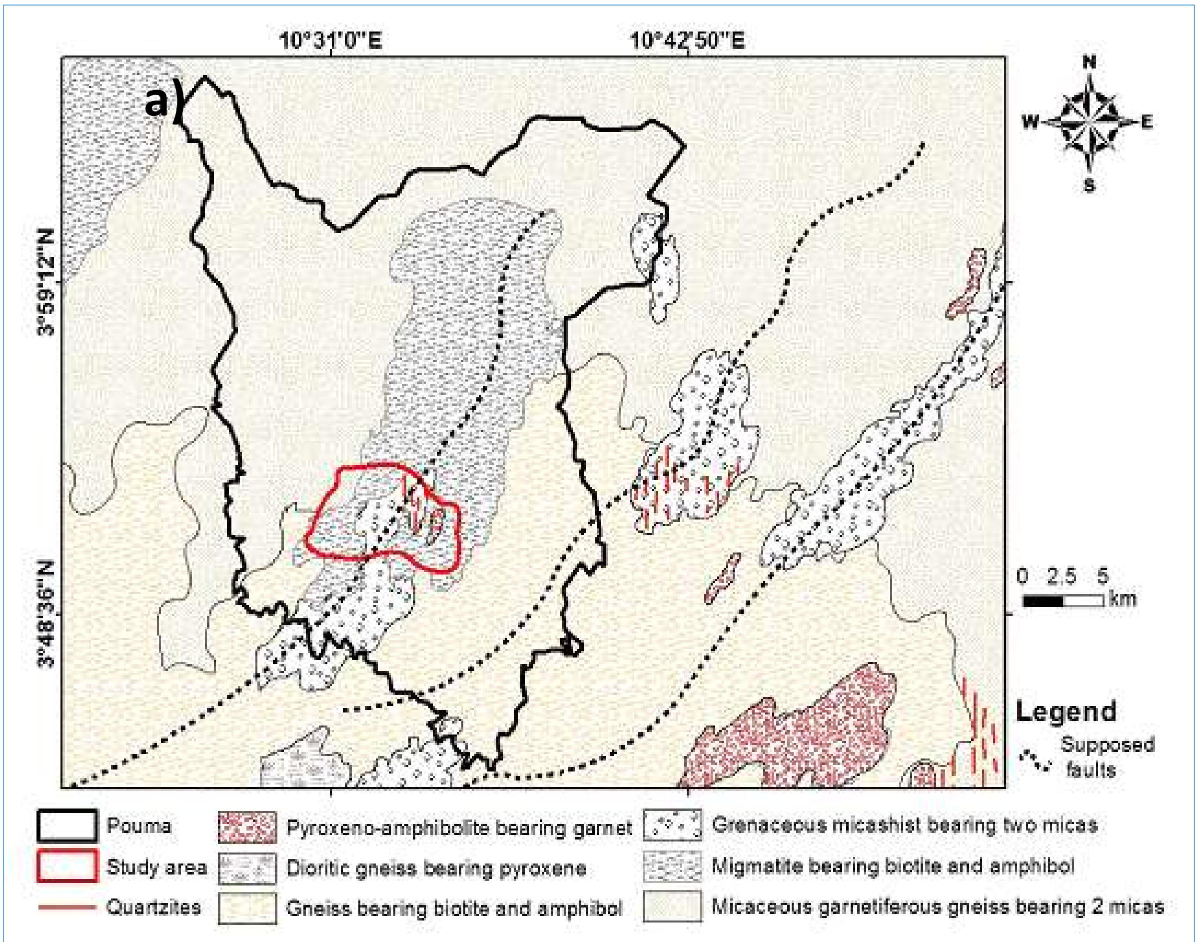

Fig. 2. Relief: a) slopes; b) geomorphology

## 2. Location of the Study Area

The study area is situated within the picturesque town of Pouma, nestled in the captivating Littoral region of Cameroon (Fig. 1). Pouma finds its place in the Division of Sanaga-Maritime, boasting an expansive land area of 701 km², which encompasses a total of 24 vibrant villages (PCD Pouma, 2011). Serving as the chief town of the district, Pouma is strategically positioned at geographic coordinates that portray its natural splendour: altitudes ranging from 100 to 157 meters; latitude spanning from 3°43'18 "N to 4°5'30 "N; and longitude extending from 10°25'52 "E to 10°42'42 "E.

## 3. Relief

The slopes are very rugged at the north and the south of the study area. There are steep hills that are difficult to walk on and deep, drained valleys. There are also low plateaus in the Eastern and western sectors.



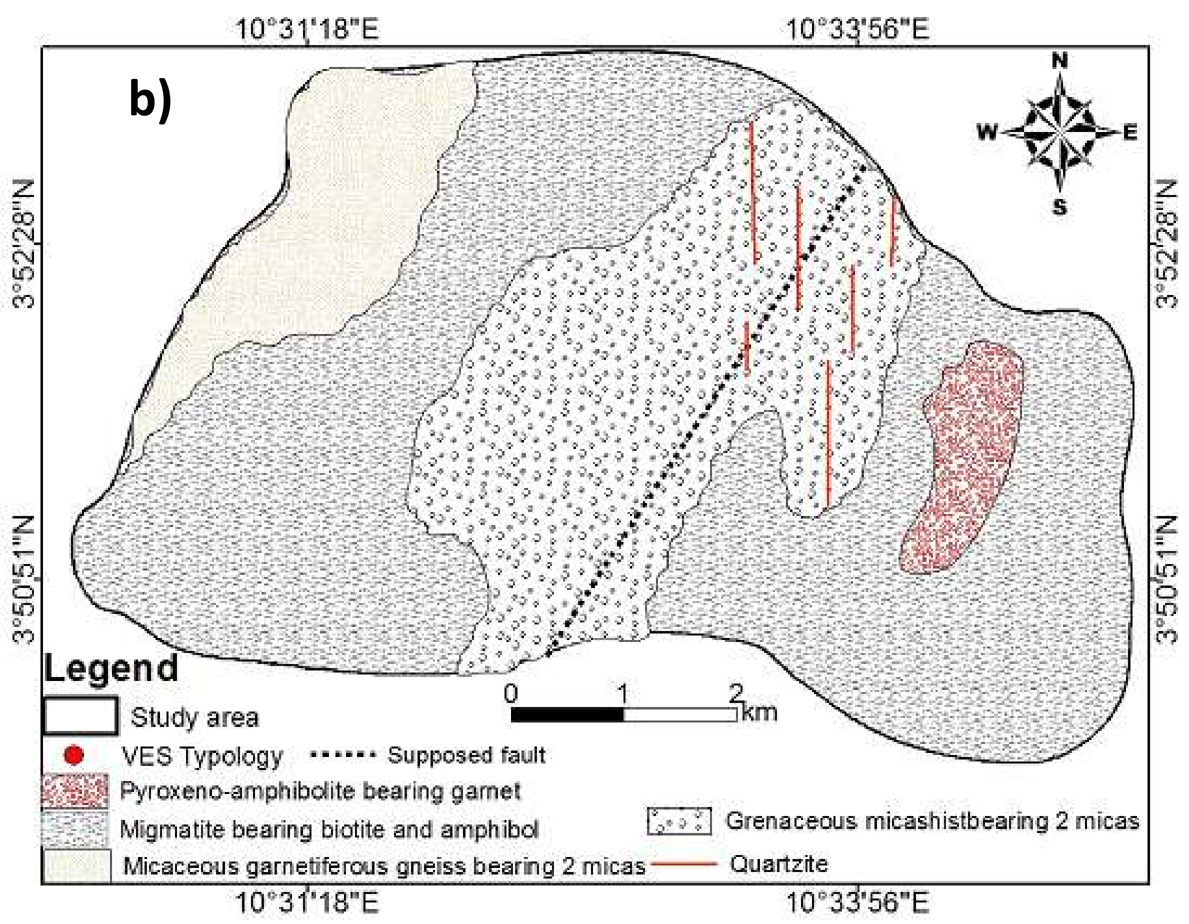



Fig. 3. Geological map (Modified from Champetier de ribes, 1958): a) of Pouma; b) of the study area

The North, South and South-East of the study area are characterized by a predominance of steep to hilly landscapes. The Eastern and western sectors are characterized by an abundance of undulating landscapes accompanied by varying amounts of rolling landscapes in the East, and flat landscapes in the West (fig. 2a). Elevations in the study area range from 150 m to 450 m, with a peak in the South of the South-East and low values predominating in the Western part (fig. 2b). The quartzites domain which stretches from the central North to the central South, presents structural and erosional landforms put in place respectively by tectonic movements and by the removal of eroded surface materials by water and gravity. This is being empowered by its hilly to rugged slopes.

**4. Geology**

Pouma is situated in the Littoral region of Cameroon, which is part of the Pan-African mobile belt that formed during the Neoproterozoic era between 1 billion and 550 million years ago, as a result of the collision of the Congo craton and the Sao Francisco craton (Toteu et al., 1994, 2021; Tadjou et al., 2008; Yonta-Ngoune et al., 2010; Poho et al., 2021). Metamorphic rocks (quartzites, micaschists, gneisses) are geological formations crossed by the tributaries that form the Késllé watershed in Pouma-Cameroon (Etamé et al., 2013). In this commune, these rocks are called "Pouma stones" (PCD Pouma, 2011). This is a highly structurally deformed area (exhibiting faults and folds). The structure and lithology are part of the Yaoundé Group (Nzenti, 1987; Maurizot et al., 1996; Stendal et al., 2006; Jean-Lavenir et al., 2023). In Pouma and its surroundings, the geologic formations described by de Ribes (1958), are namely, pyroxeno-amphibolite bearing garnet, dioritic gneiss bearing pyroxene, gneiss bearing biotite and amphibol, granaceous micaschist bearing two micas, migmatite bearing biotite and amphibol, and micaceous garnetiferous gneiss bearing two micas (Fig. 3b). The different geological formations encountered in the study area according to Nsangou de Ribes (1958) (Fig. 3b), are essentially quartzite, micaschist, migmatites and pyroxenites. The area is crossed by supposed faults oriented NE-SW (Fig. 3a) and one of them is crossing the study area following the same NE-SW direction (Fig. 3b).

In Pouma, metamorphic rocks can be found alongside the sedimentary formations. The exact types and extent of metamorphic rocks in the area may vary, as the geological history of the region has led to diverse rock compositions.

Common types of metamorphic rocks that can be found in Pouma include gneiss, schist, marble, and quartzite. Gneiss is a foliated metamorphic rock characterized by its banded appearance, resulting from the rearrangement of mineral grains during metamorphism. Schist is another foliated rock that exhibits a platy texture due to the alignment of minerals. Marble, on the other hand, is a non-foliated metamorphic rock formed from the recrystallization of limestone or dolomite. Quartzite is a hard and durable rock derived from the metamorphism of quartz-rich sandstone.

The presence of metamorphic rocks in Pouma indicates that significant tectonic processes and geological events have affected the region in the past. These rocks provide valuable insights into the geological history, including periods of intense heat and pressure that resulted in their formation.

Overall, the metamorphic rocks of Pouma, Cameroon contribute to the diverse geological landscape of the region, alongside sedimentary formations. They offer clues about the geological processes and events that have shaped the area over millions of years.

**5. Method**

The hill shade method is a commonly used visualization technique for depicting 3D topography using grayscale shading. This method creates the appearance of shadows cast by the hills and mountains. Lighter shades of grey represent raised areas and darker greys represent lower areas. This technique enhances contrast and allows for better visualization of the topography. To extract remote sensing lineaments using the hill shade method, we had to follow the following steps:

- Acquire and process satellite images that have been pre-processed and georeferenced for the study area.
- Generate a hill shade map from the processed satellite image which provides a better visualization of the terrain.
- Manually trace and highlight lineaments visible in the hill shade map that could be geological structures such as, faults and folds, or drainage features such as, rivers and streams that may indicate subsurface mineral deposits or water bodies.
- Analyse the extracted lineaments for trends, consistency, and distribution across the study area using image processing software ArcMap and Rockworks.
- Interpret the extracted lineaments in conjunction with available geological information and field observations to better understand the geological history of the region.

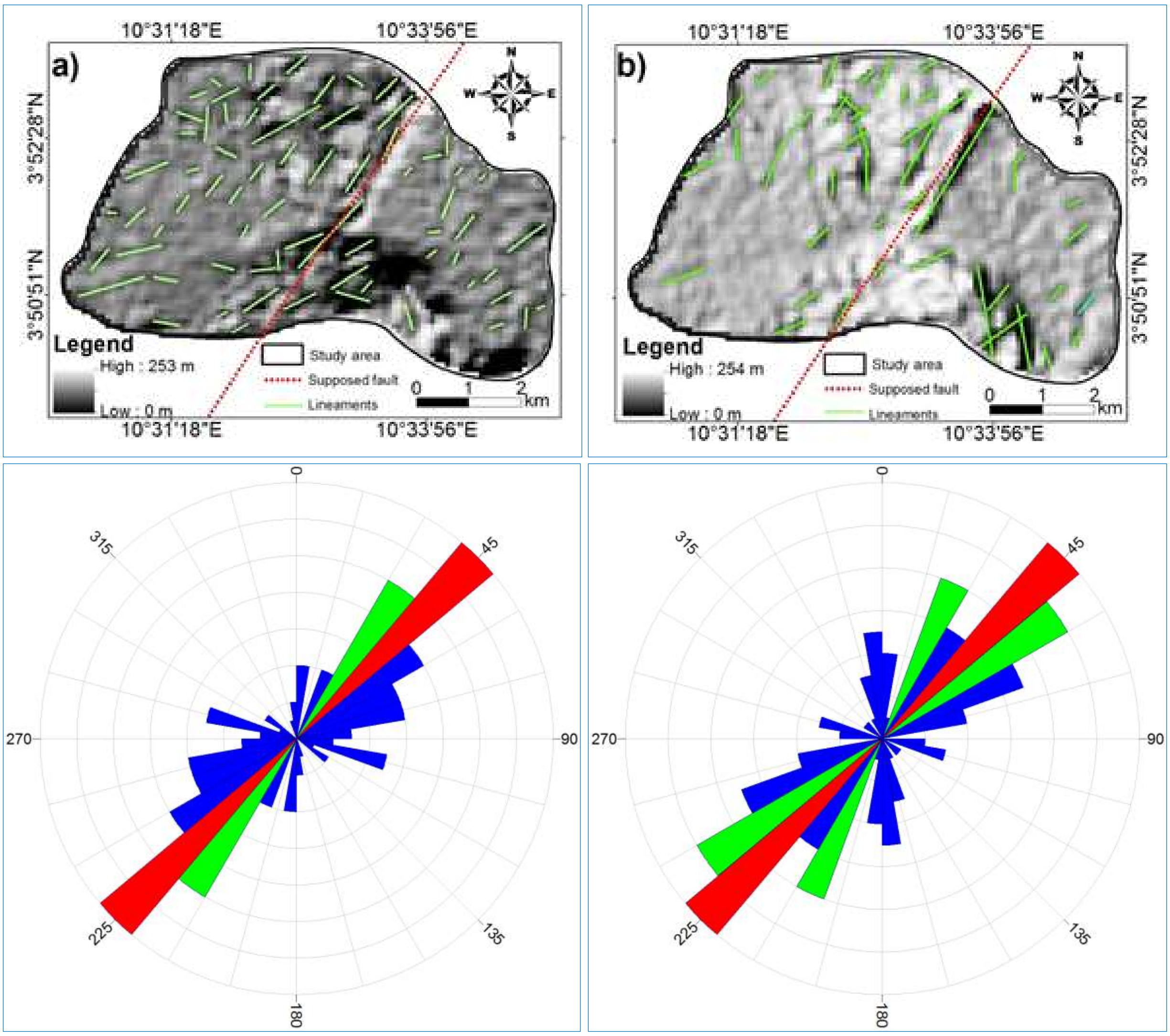



Fig. 4. Lineaments and rose diagram. a) Lineaments with hill shade at Azimuth 350 and Altitude 45; b) Lineaments with hill shade at Azimuth 300 and Altitude 15; c) Rose diagram of lineaments with hill shade at Azimuth 350 and Altitude 45; d) Rose diagram of lineaments with hill shade at Azimuth 300 and Altitude 15

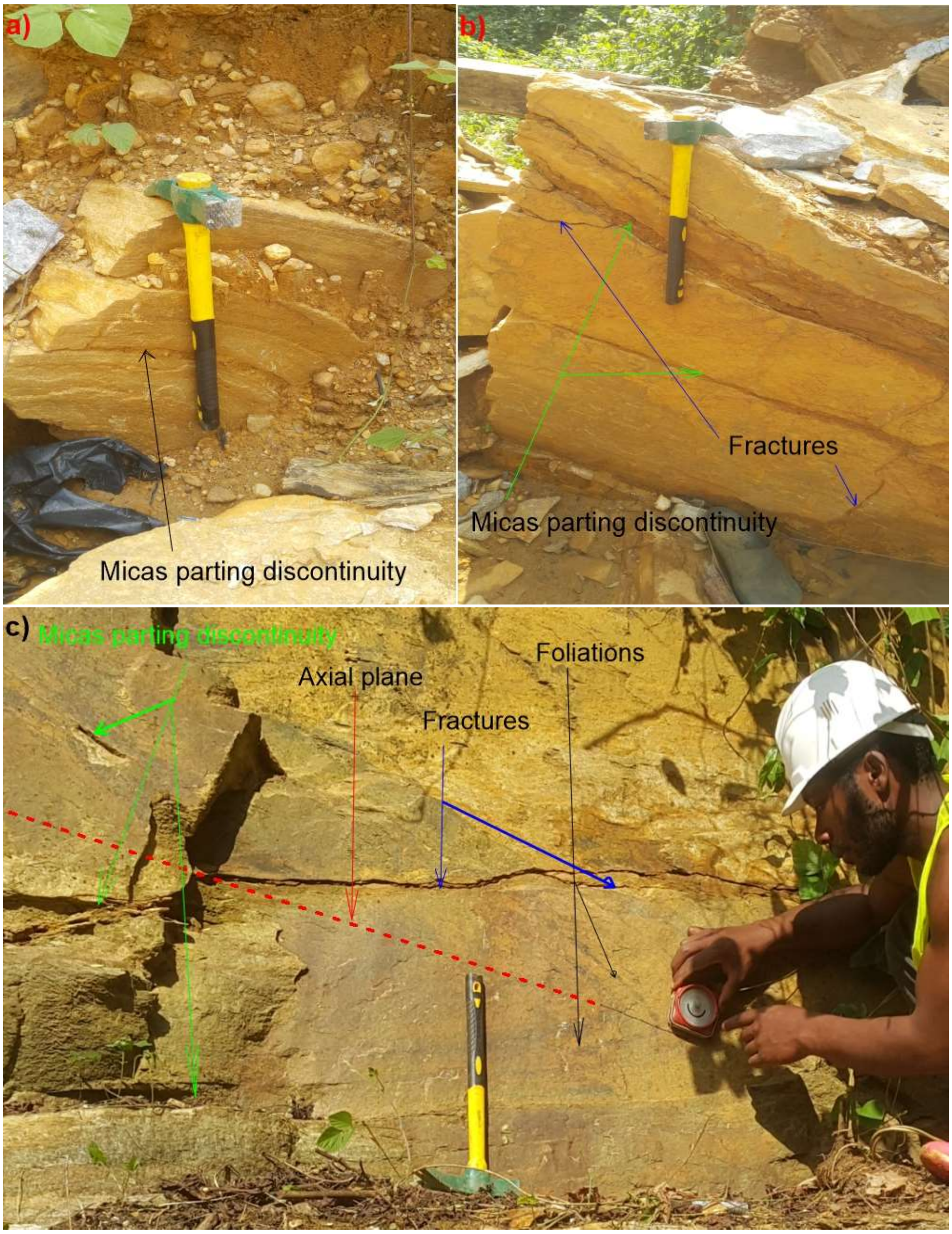



Fig. 5. Structural elements: a) on a partial hinge zone; b) on a Limb; c) measuring axial plane angle

## 6. Results and Discussion

### *6.1. Lineament Analysis*

The remote sensing lineaments are important geological features that appear as linear or curvilinear features on the surface of the Earth. On the Shuttle Radar Topography Mission (SRTM) image, it is possible to observe the remote sensing lineaments (Figs. 4a-b). These lineaments were extracted from the SRTM image of the study area using the hilly shade method. Their distribution is such that they cover almost the entire study area. They are multidirectional and have a major direction; the mean direction is N 45° E (Figs. 4c, d).

The rose diagram in c) and d) shows the distribution and orientation of these lineaments in terms of azimuth (i.e. direction) and frequency. The length of the bars indicates the frequency of lineaments within a particular azimuth range.

### *6.2. Structural Elements*

Field observations show folds, foliations, fractures and micas parting discontinuities in the quartzite formation (Figs. 5a, b, c). Thin soil layers with gravelly sandy-clay composition, are found in the quartzite beds separating each quartzite bench from the other thus, forming a micas parting discontinuity (Figs. 5a, b, c). The cloud of points obtained from the crests of the different folds shows an axial plane inclined by 30° with respect to the horizontal (Fig. 5c). It is also possible to observe some folds whose layers do not show any discontinuity visible at the macroscopic scale, but instead a foliation made up of an alternation of dark and light bands (Fig. 5c).

### *6.3. Direction and Dips*

The mode of outcrop of the quartzite formation (in benches) facilitated the measurement of the different parameters in the field (directions and dips). The direction and dip data collected in the field (Table 1), were used to produce the rose diagram (Fig. 6a), with the relative points density from the 1% Area contouring methodology (Fig. 6b).

The rose diagram has two major directions, one primary from N 21° to N 30° E and the other secondary from N 10° to N 21° E; the vector mean is N 15° E. The rose diagrams obtained from the lineaments (Fig. 4) suggest that, the lineaments are distributed in different directions, indicating that the study area has complex geological structures. Such lineaments are often formed due to tectonic stresses in the Earth's crust, and are commonly associated with faults or fractures such as the recumbent fold (Fig. 5c) (according to the folds grouping presented by Fluety (1964)) present in the study area. According to the stratigraphic principle of cross-cutting, the fractures observed at the quarry (Fig. 5) are post-metamorphic, since they cut the limbs of the inclined folds (which result from ductile deformation). The presence of recumbent folds (Fig. 5) in the study area, confirms the work of Jean-Lavenir et al. (2023) concerning the Cameroon Pan-African fold belt context of the Pouma Area.

Table 1. Directions and dips

| No | Directions (°E) | Dip | Transformed direction | Transformed dip | Dip orientation | Latitude | Longitude | Elevation (m) |
|---|---|---|---|---|---|---|---|---|
| 1 | 29 | 25,0 | 119 | 65 | WNW | 3°51'31,72" | 10°32'59,26" | 2 07 |
| 2 | 25 | 20,0 | 115 | 70 | WNW | 3°51'31,55" | 10°32'59,33" | 207 |
| 3 | 20 | 25,0 | 110 | 65 | WNW | 3°51'335,007" | 10°32'57,606" | 179 |
| 4 | 70 | 22,0 | 160 | 68 | NNW | 3°51'34,57" | 10°32'58,05" | 193 |
| 5 | 26 | 30,0 | 116 | 60 | WNW | 3°51'34,52" | 10°32'58,17" | 192 |
| 6 | 51 | 18,0 | 141 | 72 | NW | 3°51'34,6" | 10°32'57,93" | 191 |
| 7 | 160 | 30,0 | 70 | 60 | WSW | 3°51'33,87" | 10°32'59,76" | 200 |
| 8 | 158 | 20,0 | 68 | 70 | WSW | 3°51'33,86" | 10°32'59,74" | 192 |
| 9 | 10 | 22,0 | 100 | 68 | WNW | 3°51'33,78" | 10°32'59,76" | 194 |
| 10 | 185 | 28,0 | 275 | 62 | WNW | 3°52'3,37" | 10°33'25,22" | 278 |
| 11 | 190 | 44,0 | 280 | 46 | WNW | 3°52'3,37" | 10°33'25,12" | 280 |
| 12 | 192 | 40,0 | 282 | 50 | WNW | 3°52'3,28" | 10°33'25,14" | 279 |

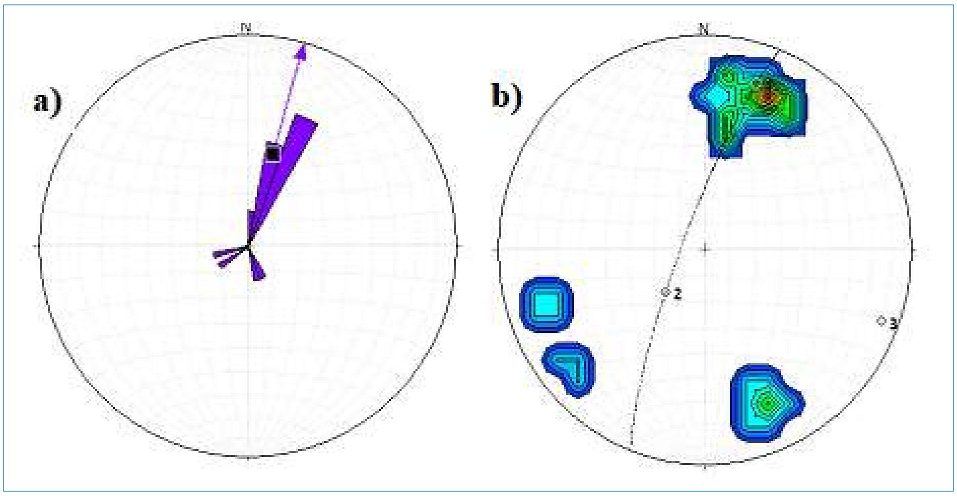



Fig. 6. Stereographic projection. a) Rose diagram; b) Stereogram densities (1% Area contouring)

## 7. Conclusion

In conclusion, the investigation of tectonic features in the Pan-African mobile belt of Pouma, Littoral-Cameroon, through a combination of remote sensing and fieldwork, has provided valuable insights into the geological history and structural complexity of the area. The presence of diverse lineament directions indicates the existence of complex geological structures within the study area. The predominant NE-SW orientation of the lineaments corroborates previous studies, suggesting the presence of a significant tectonic corridor running from Pouma in the Northeast to Campo in the Southwest, known as the Kribi-Campo Fault. Additionally, the identification of post-metamorphic fractures cutting through inclined folds confirms the presence of a Pan-African fold belt in the Pouma Area, aligning with previous research. These findings contribute to our understanding of the Neoproterozoic era and the tectonic processes that shaped the region. The results obtained from this study have important implications for both regional and global tectonic studies. They offer valuable insights into the geological evolution of the Pan-African mobile belt in Cameroon and provide a basis for further investigations in the area. The combination of remote sensing and fieldwork techniques has proven to be effective in characterizing tectonic features, enhancing our understanding of geological complexities and allowing for more accurate interpretations. It is evident that the tectonic history of the Pouma Region is complex and warrants further research and exploration. By continuing to investigate the geological structures and tectonic features of the area, we can gain a deeper understanding of the dynamic processes that have shaped the landscape over time. Overall, this study contributes to the broader field of tectonic studies, particularly in the context of the Pan-African mobile belt and its Neoproterozoic history. The findings emphasize the significance of integrating different methodologies and approaches to unravel the complex geological features of a given region. By building upon these findings, we can continue to expand our knowledge of the geological evolution and tectonic processes that have shaped our planet.

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