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Integrated Mapping of Lineaments in Ago-Iwoye SE, SW Nigeria

Omosanya, K.O[1,2], Mosuro, G.O[1], Akinbodewa A.E[1]
[1]Department of Earth sciences, Olabisi Onabanjo, University, Ago-Iwoye
[2]Cardiff University, School of Earth, Ocean and Planetary Sciences

ABSTRACT

Structural studies of Joints on rock exposures was carried in Ago-Iwoye, NE, SW, Nigeria (N $06^0 56^1$ -$06^0 58^1$ and E 003^0 52^1-003^0 56^1) with the aim of integrating linear structures from outcrop to larger lineament on satellite imageries.

A petrographic study of rocks was done in order to identify the rock types of the study area. Structural measurement such as the attitude (strike and dip), length, and average perpendicular distance was taken on three hundred and twenty six (326) joints while sixty nine (69) lineaments were extracted from Google Earth imageries covering the study area and its surroundings; the lengths and orientations of the lineaments were also determined and plotted on Rosette diagrams and lineament density map.

Slightly foliated granite-gneiss, biotite gneiss, and pegmatites were identified from the petrographic studies. The dominant orientations of Joints are E-W & ENE-WSW suggestive of dominant N-S or NNW-SSE directed stresses, and joint types mapped include systematic, non-systematic, conjugate, T-joints and cross joints with average perpendicular spacing between joints ranging from 4cm - 67cm.

Two dominant structural domains were identified from the lineament map; these are NE-SW & NW-SE with dominant orientation of Lineament being NE-SW, suggestive of NW-SE tectonic (extensional forces), minor ENE-WSW and E-W orientation suggestive of shearing evinced by conjugate joints sets were also recorded. Evidence from the lineament density map suggest that the NE, NW & SW parts of the study area were highly dense while the E-SE part is less dense or near zero relative to lineament concentration; this same trend was earlier observed during the ground mapping.

There is overlap between the minor NW-SE/ENE-WSW orientations in lineaments and joints; this implies that these fractures in both cases were produced by similar tectonic events while other orientations are product of dissimilar tectonic events/regimes.

Keywords: *Mapping, Joints, Lineament, Orientation, Tectonic, Stresses.*

1. INTRODUCTION

Lineaments are lines on satellite imageries that are expression of folds, fractures, or faults in the Subsurface (Sabins, 2000); they are extended mappable linear or curvilinear features of a surface whose parts align in straight or nearly straight relationship. Like the geological structures that they represent these features can be mapped on different scales, from regional (continental), Local (outcrop) to microscopic (Thin sections).

Satellite imagery analysis involves extraction of lineaments from varying wavelength intervals of the electromagnetic spectrum. (Casas et al, 2000). The process of extracting such features from satellite maps involves several enhancement techniques or manual interpretation with the scope of analyzing the density, direction, length, orientation, intersection etc for groundwater modeling, geohazard prediction, and mineral exploration purposes. Conventional statistical techniques applied to lineaments include frequency or length against azimuth histograms (Mostafa and Zakir, 1996), rose-diagrams (Nalbant and Alptekin, 1995) and lineament density maps (Zakir et al., 1999). Lineament density and intersection density of lineaments are also useful for characterizing the spatial patterns of lineaments (Kumar and Reddy, 1991). Other workers worthy of note include Leech et al. (2003), Ferre et al. (2002), Wang and Howarth (1990), Won-In and Charusiri (2003) and Kocal et al., (2002)

A better understanding of geological structures could be achieved by integration of result from different scales and disciplines. Smaller scale structures can mimick larger and regional structures (Pumpelly’s), and an understanding of the latter is sufficiently guarded by detailed study enabled by the former. This work was done in order to provide the pedestal for further investigating geological structures in the study area owing to the non-availability of such information despite the abundance of literature on the petrology of the rocks.

The paper starts by discussing on the Geometry of Joints, their spatial abundance and behavior and integrating it with result from the analysis of the spatial distribution of lineaments extracted from satellite images according to their density, intersection density, length and orientation.

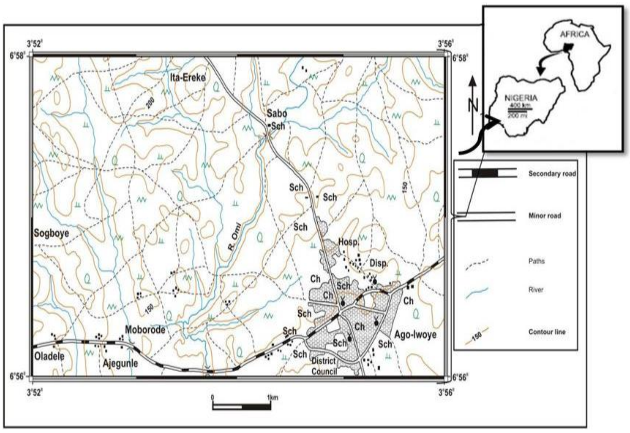

Figure 1. Location of Study Area

2. STUDY AREA PHYSIOGRAPHIC SETTING

The study area lies within latitudes N 060 56′ and 060 58′ and longitudes 0030 52′ and 0030 56′ in Ago-Iwoye, NE, SW Nigeria. The area is accessible through Ilisan road. However, the area is also linked by many major and minor roads from other places like Ishara, Ijebu-Ode, Ijebu-Igbo, Oru, and Awa. The area studied fall within the tropical rain forest region of Nigeria with most of the parts covered by bushes inhabited by human. The climatic condition ranges from warm to hot having a temperature range of about 25^{o}C to 32^{o}C alternating wet and dry season with maximum rainfall of ~1500mm. The topography of the area studied is irregular hence the region is said to have a rolling, wavy or undulating; the topography of the area influences the drainage pattern in terms of elevation and depression of landforms making the drainage sub-dendrite like due to the haphazard turnings exhibited by the Omi River. The drainage flows downwards in a fairly south westerly direction.

3. REGIONAL GEOLOGIC SETTING

Regionally, the geology of the area belongs to the basement complex of Nigeria. Rocks previously described in this region include A polycyclic Migmatized-Gneiss complex that is characterized by grey foliated Biotite Acid/Biotite Hornblende quartz feldspathic gneiss of tonalitic to granodioritic composition (Rahaman, 1981); Mafic to ultramafic component which outcrops as discontinuous boudinaged lenses or concordant sheet of amplibolites with minor amount of biotite-rich ultramafite; and Felsic component, a varied group comprised of pegmatite, aplite quartz-oligoclase veins, fine-grained granite gneiss, and porphyritic granite.

4. MATERIALS AND METHODS

Initial study of rock types was done by carrying out a detailed geological mapping of the entire region within the coordinate specified by Fig1 through traversing and positioning with the aid of GPS. This was done in order to understand the geology of the area, and determine the different rock types present. Petrographic analysis of selected rock sample was carried; samples were selected on the basis of physical similarities and hand specimen mineralogical composition.

In mapping joints in the area, length and attitude of the joints were recorded from the outcrops at various locations. The orientation of the joint relative to the entire outcrop was described. These measurements were made on outcrops on different locations within the study area.

In measuring the orientation of the joints, the approach of Omosanya et al (2011) was adopted in which the surfaces of the joints were assumed to be straight, the results obtained from the contact method; which is the most commonest technique of measuring strike and dip along surfaces, a technique that assumed that the surface being measured is smooth were compared with standing/kneeling method of measuring strike and dip with measurement taken in the same manner as bedding (Barnes, J.W. & Lisle, R.W, 2008).

The contact method is done in such a way that the edge of the compass clinometers is placed on the surface of the joints whilst the compass is held horizontal and parallel to the strike, the value of the strike is read by rotating clinometers till it reads zero dip while the standing/kneeling down method entails standing over the surface with the compass opened and held parallel at waist height; this technique is most suitable on large uneven planes of relatively low dip while using this method, azimuth technique of reading the strike was adopted which involved the non-rotation of the clinometers but the reading of the value of the compass and subtracting it from 360^{0} (Omosanya, et al 2011).

The joints were described by assigning them letter J and the number described their position in each grids. The average perpendicular distance was measured by taking three (3) spacing a, b, c between the joints and finding the average, this was done in order to establish the different joints sets present on the outcrops.

The orientation were plotted on rosette diagrams and histograms to understand the trend of the major tectonic force(s) in the region and as well as on the outcrop.

Where possible dip of the joints was plotted, not only this, orientation of veins and intrusion were measured where otherwise possible. The orientation of the joints was plotted on a rosette diagram, and a histogram was used to analyze the behavior of joints in the area. The joints were later described based on the following criteria:

- Whether the joints are systematic or nonsystematic
- The orientation of joints present
- The number of joints sets present

- Their cross cutting relationship
- Overall appearance of the joints
- The dimension of the joints
- Joint spacing and density
- The relationship of joints and petrological units
- Variation of joints with petrological units
- Relationship of the Joints to other geological structures
- Whether joints are isolated or connected to regional network.

A pair of satellite imageries over the study area and its boundaries covering about 48 sq km on a scale of 1:800,000 was acquired from Google Earth® in August 2011. The area is bounded by Latitudes 06° 55’ 30’’N to 06°58’30’’N and Longitudes 003° 51’54’’E to 003°58’ 42’’E respectively. The imageries were manually analyzed to identify and delineate lineaments as well as structural trends in order to facilitate geological interpretation and integration with outcrop data. The interpreted lineaments were digitized on Coreldraw 12 with their orientation plotted on Rosette diagram. Manually extracted lineaments are evaluated in order to obtain further information on the distribution and nature of the lineaments. In this study four processes of evaluation were applied. These are: 1) density analysis, 2) intersection density analysis, 3) length analysis, and 4) orientation analysis. The results obtained were subsequently compared with the ground truthing (outcrop lineament).

5. RESULT AND DISCUSSION

Rock types identified during initial mapping exercise include biotite-gneiss, banded-gneiss, (migmatised in some parts and intruded by pegmatite) and granite. The hand specimen description of the rocks is given below:-

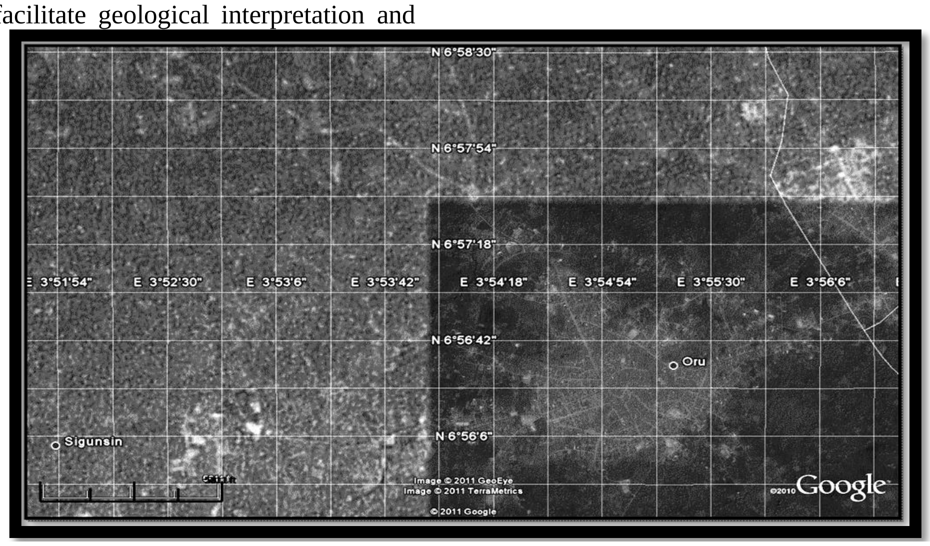

Fig 2. Satellite map of the Study Area (Google earth, 2011)

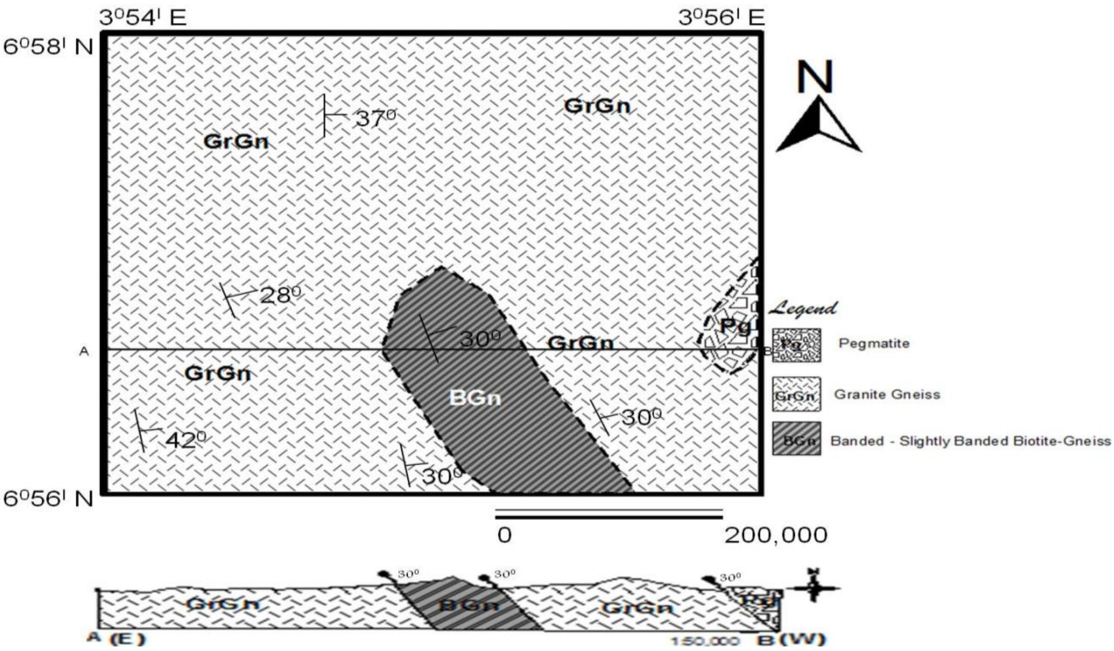

Figure 3(a). Geological Map of the Study Area based on Petrographic studies (b) Cross section along section AB.

5.1 Migmatised-Gneiss

Migmatised gneiss has the same composition as gneiss, but it has been brought to melting or near-melting so that the veins and layers of minerals became warped. The minerals are dark colored and are dominantly composed of mafic minerals such as biotite and hornblende. The dark colored host rocks (Paleosome) have been intruded by veins of fine grained lighter rock consisting of quartz and feldspar (Metasome).

5.2 Banded Gneiss

In the banded gneiss, mafic and felsic bands resulting from the segregation of minerals are clearly distinguishable. The mafic bands are constituted by biotite and hornblende while the felsic bands consist of quartz, muscovite, and orthoclase feldspars. The felsic bands measures ~1.5cm, while the mafic bands measures ~0.5cm. The mineral grains are medium and coarse textured. Both gneisses are thought to have been derived from granitic protolith.

5.3 Granite Gneiss

These are metamorphosed granite rocks that cover most of the study area except in the south eastern part where there is emplacement of the other rock types. The granite gneisses consist of quartz, feldspar (microcline), mica (muscovite), and hornblende. The minerals are medium grained and coarse textured. The rocks are slightly foliated, with two phases of foliation, an obvious alignment of light coloured minerals separated ~1.4cm apart and an indistinguishable set of foliation.

5.4 Pegmatite

The minerals are large grains and coarse textured with some of the grains ranging from 2.2-5cm. They are composed primarily of light coloured minerals such as plagioclase, muscovite, tourmaline, and quartz while sometimes they contain dark minerals such as biotite. In most of the pegmatites within the study area, plagioclase feldspar is the dominant mineral with a modal percentage estimated between 45-50%. The pegmatites are simple pegmatites and they occur as dykes, or irregular pockets in some of the other rock types within the study area.

6. PETROGRAPHY OF ROCKS

From petrographic study (fig.4), it was discovered that rocks within the study area are Biotite gneiss {Qz(~30%), Plag (~25%), Bio (~25%) and other minerals (~30%)}, most of which are slightly banded with foliation plane oriented approximately N50^{0}E in cross nicols. Next rock type is the slightly foliated granite gneiss {Qz(~30%), Plag (~25%), Bio (~50%) and other minerals (~5%)}, the slightly foliated Granite Gneiss can also be called Banded Biotite Granite -Gneiss on the basis of biotite being the dominant essential mineral. The orientation of the foliation plane from observation under the cross polarized light is approximately N30^{0}W. The pegmatites{Qz(~40%), Plag (~15%), Bio (~20%) and other minerals (~25%)} occur as metasome in the older rock types and are generally trending NE-SW in map view. The Granite Gneiss is everywhere present in the study area except marginally on the eastern part where it is intruded by the Pegmatite, and in the South, where it could have contributed to the metamorphism of the Banded Gneisses that are oriented NW-SE.

6.1 Joints

The joint spacing was measured at three points perpendicularly between two parallel joints, the values averaged. The average perpendicular distance between the joints was taken as the a-spacing; these values were plotted for all the locations in Fig 5. The average spacing ranged between 4cm (between J38&J39, LOC 4) and 67cm (between J11 and J15, LOC 15). Systematic joints found in the study are include J7 &J8 and J36 & J37at LOC 2, J1 & J2, J11&J12, J33 & 34, J26&J27, and J31&J32 at LOC 4, and J22& J23 and J30 & J33 at LOC 7; while spacing between joints in other locations are not equal and as such are categorized as Non-systematic joints.

Longer joints are systematic with relatively constant separation between them; other joint sets are located within the longer joints. The systematic joints are parallel and sub parallel to each other, they occur on different scales, microscopic (<25cm in length) and megascopic (>25cm in length) when compared to the size of the different rock exposures. The non-systematic joints have no observable spatial relationships (they have irregular average perpendicular distance/spacing).

The joint are oriented in virtually all directions, E-W, N-S, NE-SW, NNW-SSE & ENE-WSW. In the study area, a total of three hundred and twenty six (326) joints were mapped on seventeen (17) exposures. The dominant orientations of Joints are E-W & ENE-WSW suggestive of dominant N-S or NNW-SSE directed stresses, next to these dominant orientations are N-S, NE-SW and minor NW-SE orientation joints. The multiple orientations support the hypothesis of polycyclic nature for rock types of the study area; the tectonic forces producing these fractures were operative at different time in the history of the area. A purely E-W orientated force may correspond to shear stress which is responsible for the compression of the structures, in this instance the conjugate joint sets (fig.6 a&b).

The joint lengths along the direction were measured. Outcrop 2 (fig.8) appears to be the exposure with the longest sets of joints; on it J8 measured ~216cm in the N-S direction (this is the longest joint in the entire study area (fig.7)). On the same outcrop, J19, J29, J30 & J15 measured ~192, ~183, 172, and 148cm respectively; on the basis of the length they were described as master joints and they measured ~182cm on the average.

T-junction is a common intersection geometry observed on some of the exposures mapped, for example the intersection of J5 with J6, and J7 with J6 (Fig.6b). This geometry has great implication for fluid transmission through the rock, as it enhances permeability across the intersection. In terms of their tip geometry, most of the joints die out gradually, some curve and die out, others branch and die out. At certain points, some of the joints branch out in smaller set of joints exhibiting a Y-shaped geometry at the tip. The intersection or behavior of these joints at their tips can be used to establish the relative timing of these joints (fig 6c&d).

No plumose marks or hackle structures were seen on the joint surface, this does not mean the joints are not extension fractures, it shows how lithology controls the behavior of the joints surfaces, plumose structures would have been obvious in sedimentary rock units not hard rocks.

Plumose structure is present on joints in a variety of rock types, but it is most clearly displayed in rocks of uniform fine-grained texture (Twiss and Moores, 2007). In relationship to other structures, the joints are seen cutting across most of the Quartzo-feldspathic veins, pegmatite intrusion, tension gashes, and boudinages in the field (Fig.9, a-e) while some others are parallel to foliation (Fig.9f). The implication for this is that the joints seen in the rocks are younger than most of the other structures.

The amount of joints mapped in different rock type may be a function of mechanical strength of the rock, the low tensile strength of the rocks may be responsible for the amount of joints found on some of the exposures relative to others within the study area. On outcrop 12 which was described to be granite gneiss, about seventy-three (73) joints were mapped whereas on the granite at location 10, seven (7) joints were mapped. The granite gneiss is thought to lower tensile strength because of the development of foliation planes which are zones of weaknesses in the rock.

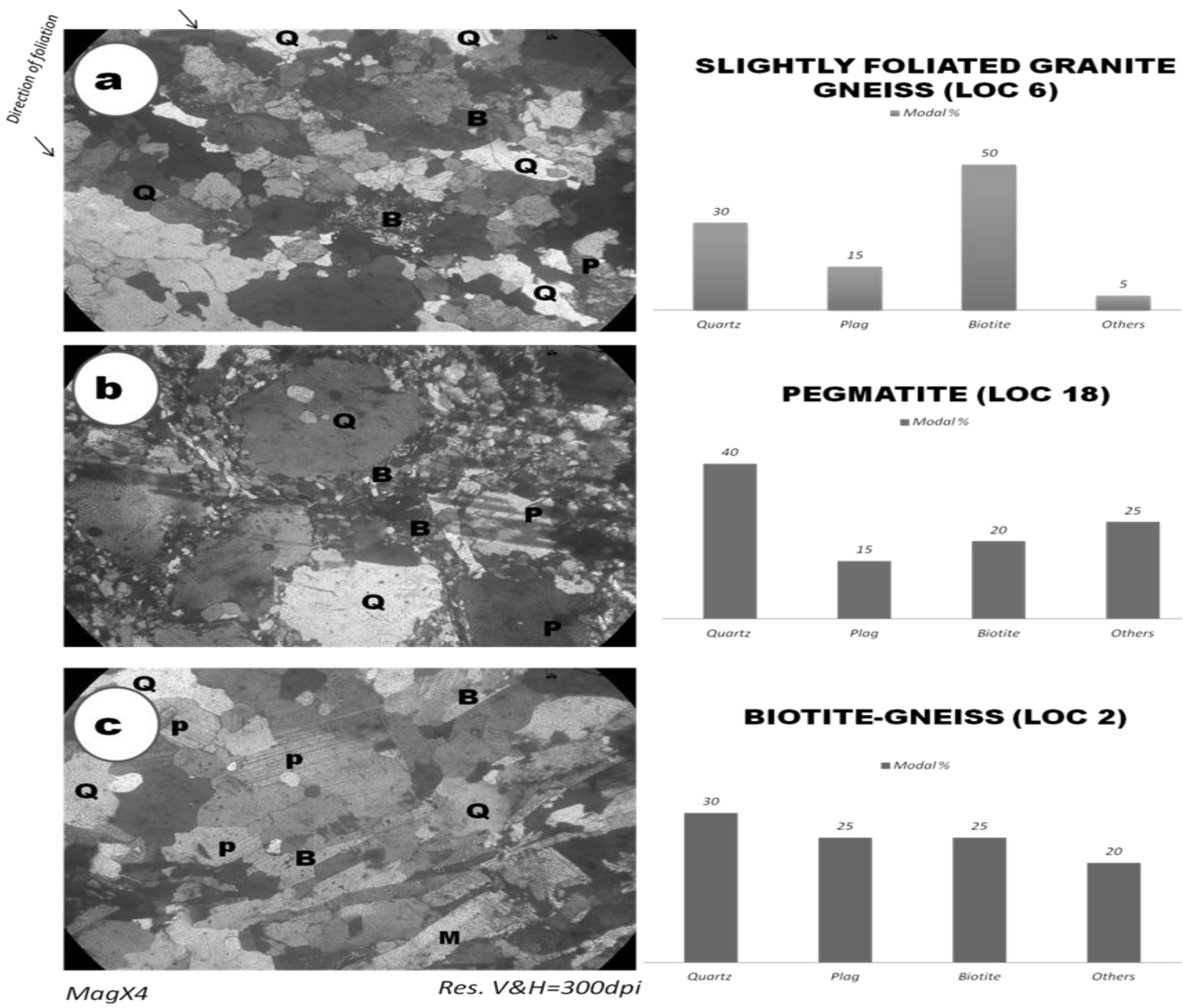

Figure 4. Photomicrograph of Rock samples

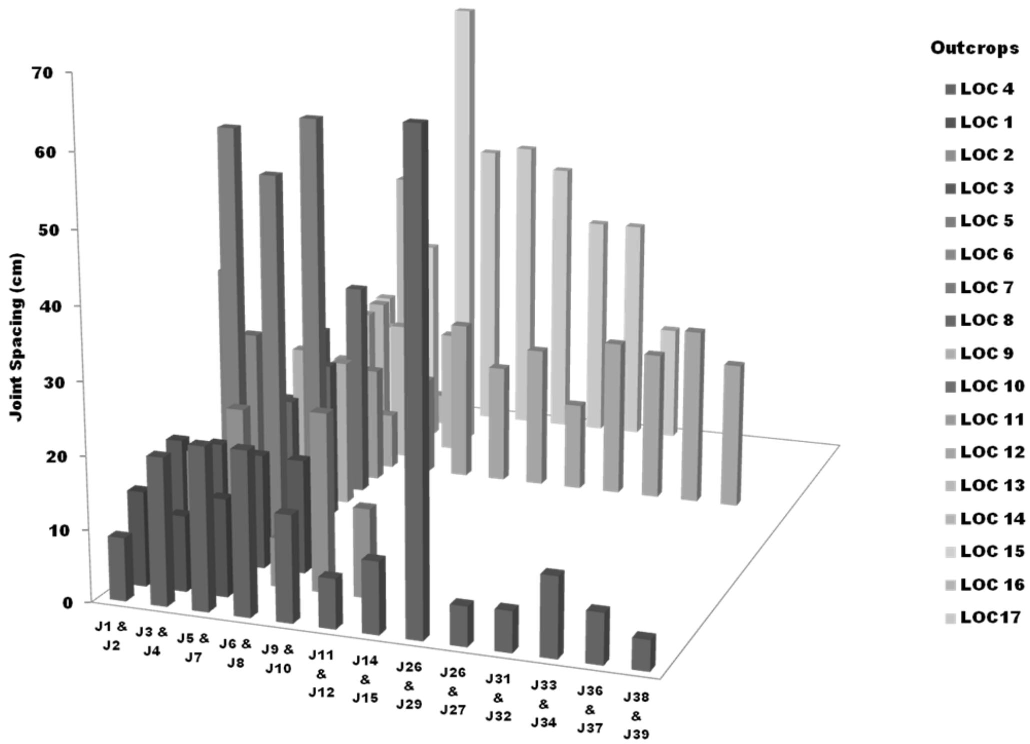

Figure 5. Plot of Average perpendicular distance between Joints mapped

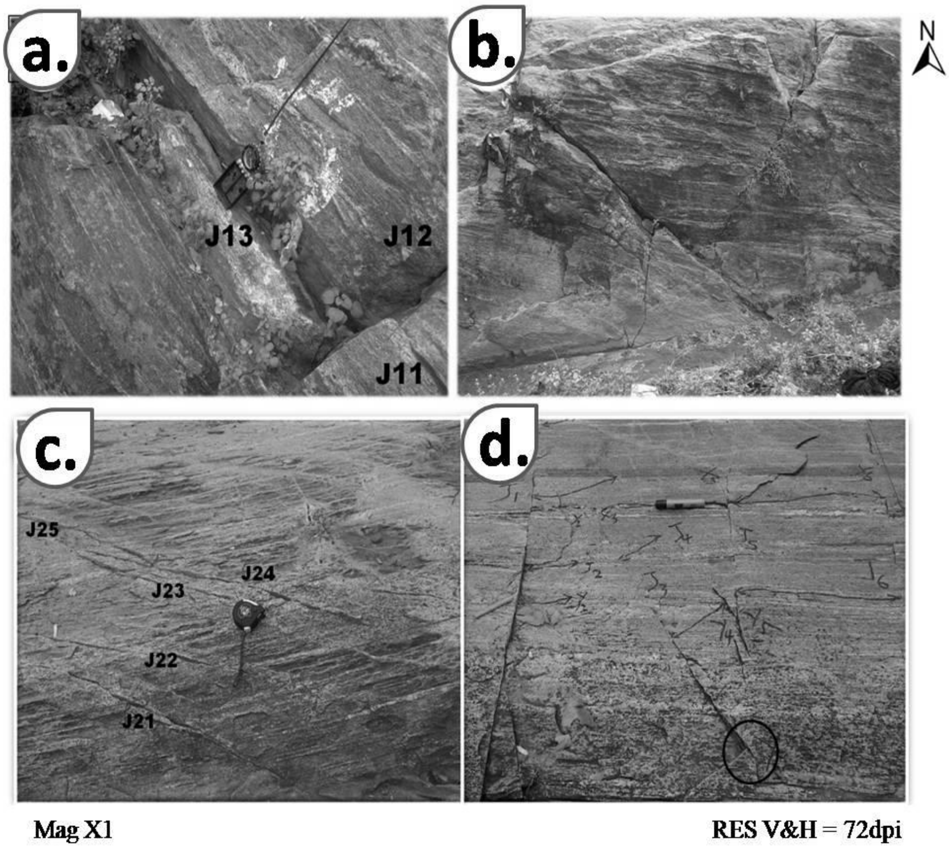

Figure. 6 (a & b) Conjugate Joints at LOC 1 & 3 (c) Joints exhibiting a gradual dieing out Tip geometry (LOC 2) (d) Joints with a curved out tip geometry (LOC 12)

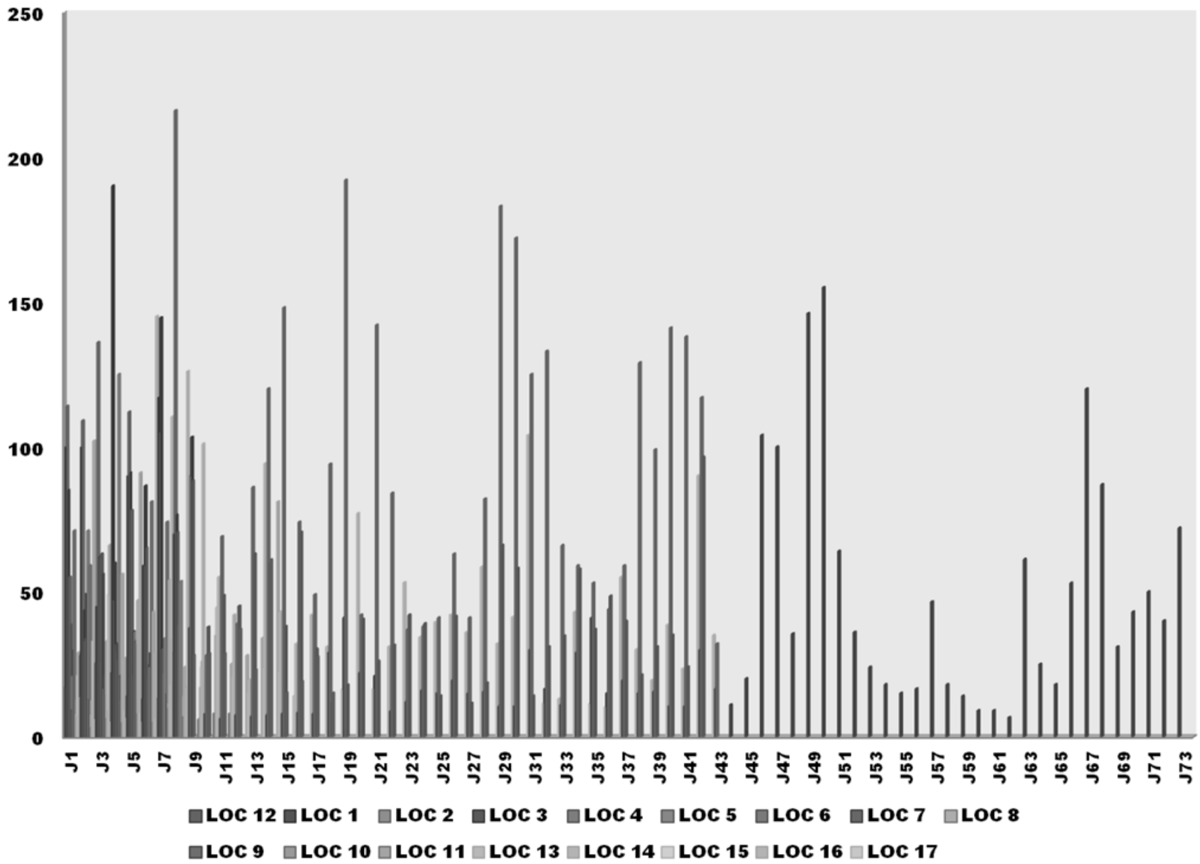

Figure 7. Length of Joints in the Study area

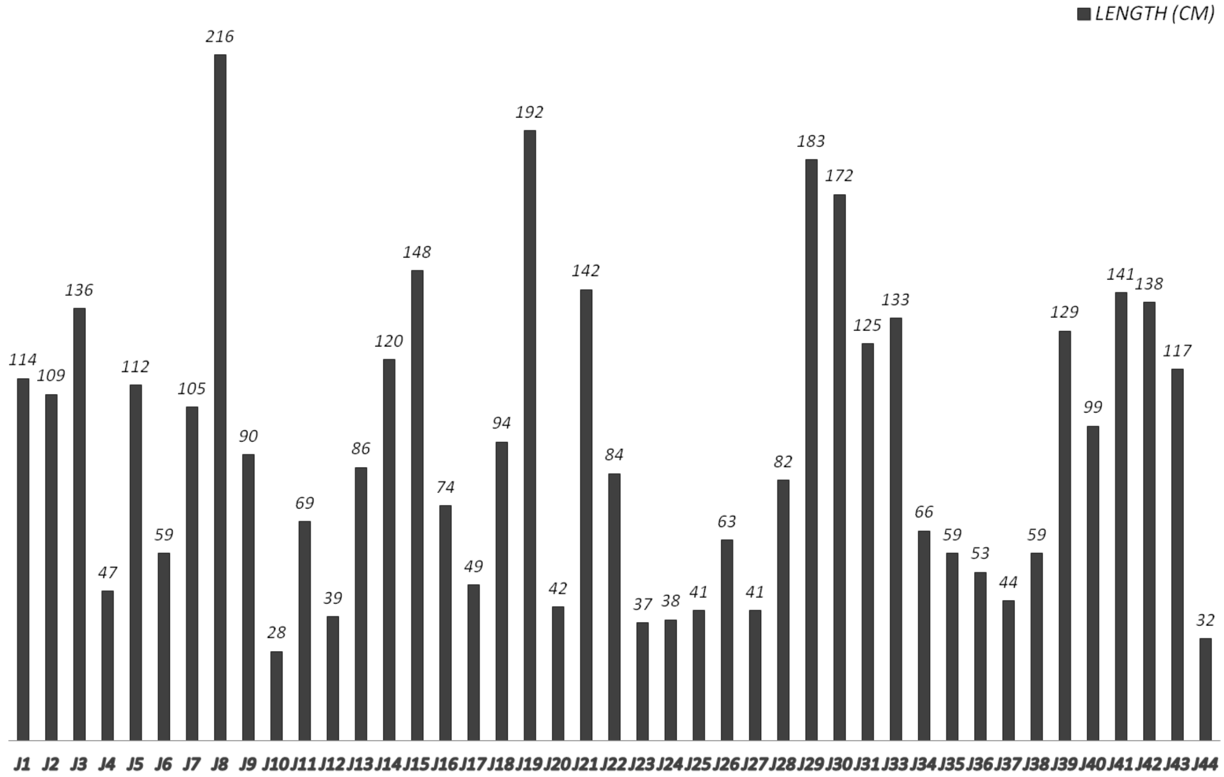

Figure 8. Length of Joints measured on Outcrop 2

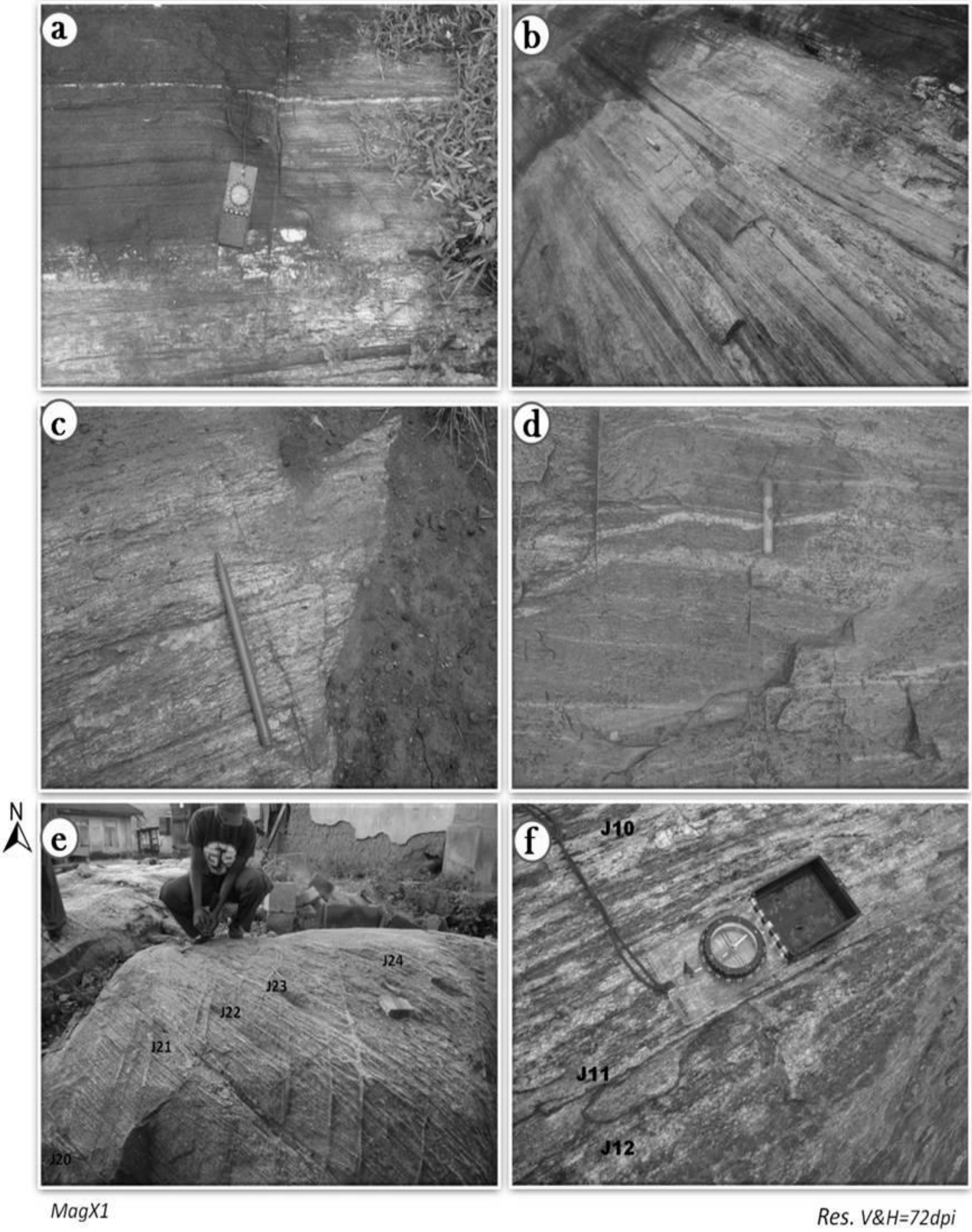

Fig.9: Cross cutting relationship between the Joints and other structures (a) Joint cross cutting a vein at LOC 9 (b) Joints running parallel to Pegmatite intrusions at LOC 12 (c) Joint cross cuts a tension gash at LOC 17, Joint cross cutting (d)foliations (e) Joint Lineations at LOC 2 (f) Joint run parallel to foliations at LOC 1

6.2 Lineaments

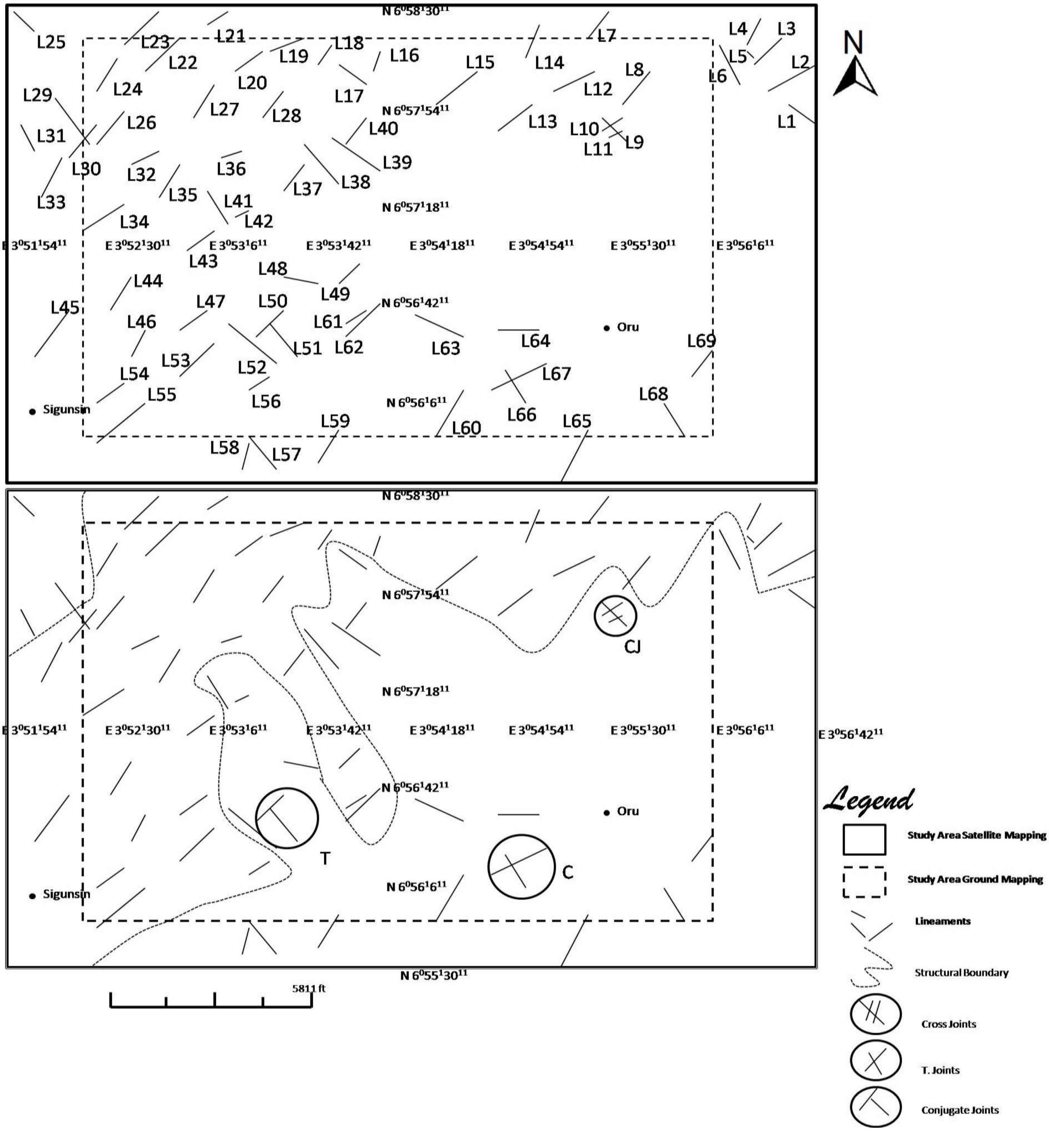

Figure 10. Lineament Map of the Study Area

A total of sixty-nine (69) lineaments were extracted from the satellite map; they were labeled from the NE anticlockwise back to the starting point. The length and orientation of each lineament was determined manually and the extracted lineaments were digitized on surfer 8. Other linear structures on the maps correspond to major roads, footpath and fence line. Lineaments were picked with high degree of certainty on the basis of their color contrast relative to their environment of occurrence.

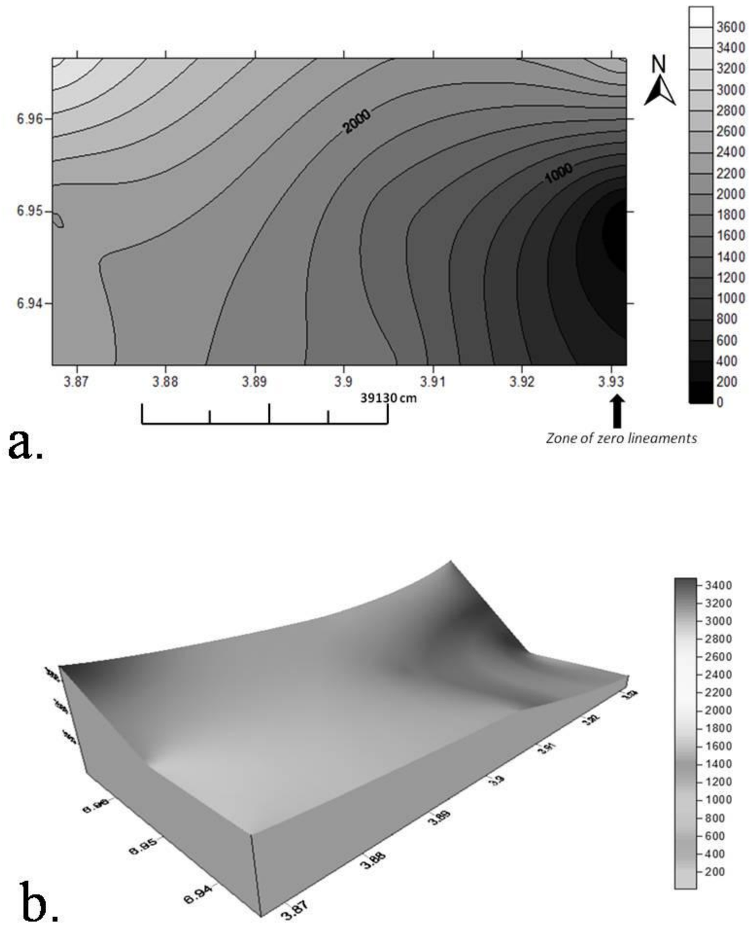

Figure 11 (a). Lineament density map of the study area (b) 3D cross section of the Lineament Density map

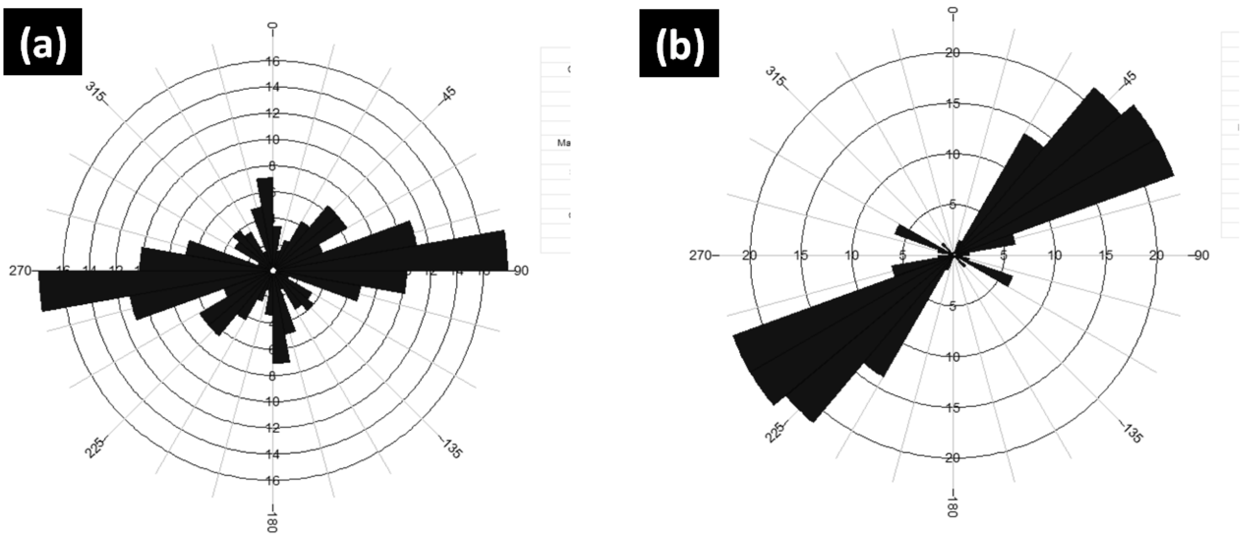

Figure 12 (a). Rosette Diagram for Orientation of Joints. (b) Orientation of Lineaments

The non-parallelism exhibited by most of lineament makes the estimation of the average perpendicular distance between them impossible hence the majority of the lineaments are non-systematic except for L21&L20 and L49 & L62 that are systematic. The following lineaments are parallel to each other, L23 & L22, L21 & L20, L28 & L40, L54 & L55, L15 & L13.

The rose diagram (fig.12b) shows the directional frequency of the mapped lineaments over the study area; the dominant orientation of the lineaments is NE-SW, less dominant is NW-SE, minor ENE-WSW and except for L64 that trends E-W. On the basis of the strike of the lineament, the area was subdivided into two structural domains; NE-SW & NW-SE oriented lineaments. Structural domains contain lineament facies i.e. lineaments that trends in the same direction and were produced by same tectonic process or processes.

Cross cutting relationship is seen between L66 & L67, L10 & L9, L9 & L11 and L29 & L30. In terms of intersection geometry, L66 & L67 exhibit a cross geometry, indicative of conjugate/ shear jointing relationship, same geometry exists between L29 & L31; T- intersection geometry exists between L51 and L50, in terms of timing,, L51 is younger than L50; tip geometries could not be determined because of the scale at which observation was made. Overall the lineaments occur as straight surfaces.

In order to establish the spatial density of the lineament, the lineament map was gridded into nine (9) sub-grids, and the total length of for all lineaments in each sub-grid was estimated from the summation of the lengths of lineaments within each grid; the total length obtained was later plotted at the center of each grid. The coordinates of each grid together with the total length/grid was then used to produce the lineament density map.

From the lineament density map, it was observed that the NE, NW & SW parts of the study area were highly dense and while the SE part is dense in terms of lineament concentration i.e. the amount of lineaments present on that side of the study area. This same trend was earlier observed during the ground mapping; very few joints were seen on exposures on the Eastern direction during the mapping exercise, this area is underlain by Pegmatite intrusions.

7. CONCLUSION

The study area is underlain by both metamorphic (Slightly foliated granite-gneiss and biotite gneiss) and Igneous rock (Pegmatites); areas of metamorphic rocks are intensely jointed owing to the weak/ low tensile strength of the rock relative to the igneous rock. When the result of Joints and Lineament mapping are integrated the following inferences are made:-

1. The dominant orientations of Joints are E-W & ENE-WSW suggestive of dominant N-S or NNW-SSE directed stresses,
2. Less dominant Joint orientation include N-S, NE-SW and minor NW-SE orientation joints,
3. Joint types mapped include systematic, non-systematic, conjugate, T-joints and cross joints,
4. The dominant lineament orientation is NE-SW, less dominant is NW-SE, both are suggestive of NW-SE and NE-SW tectonic (extensional forces), minor ENE-WSW and E-W orientation suggests shearing as displayed by the conjugate joints sets,
5. Evidence from the lineament density map suggest that the NE, NW & SW parts of the study area were highly dense while the E-SE part is less dense in terms of lineament occurrence
6. There is overlap between the minor NW-SE/ENE-WSW&NE-SW orientations in lineaments and joints; this implies that these fractures in both cases were produced by similar tectonic events while other orientations are product of dissimilar tectonic events/regimes.
7. The N-S orientation in Joints are not present in Lineaments,
8. Tectonic processes operative at larger scale (regional) are also predominant at small scales (Outcrop) while those taking place at outcrop scale may not be evidence of larger scale processes.

Other than for academic purposes, an integration of data on fractures (Lineament and Joints) from different scale and discipline would provide information on mass wasting surface (Moghaddam et al 2007),, failure plane (slope stability, dam stability, tunnel stability, strength anisotropy), fracture porosity/permeability useful for hydraulic hydrologic modeling and groundwater mapping (Kazemi et al 2009, Ahmed, et al, 2007), mineralization (Kporfor, J, Jiaguo., C, 2005, Kporfor, J.K.W., Ashley, E,, 2006, Derakhshani, R., A. Mehrabi, Z. Baghfalaki,, 2010), important geomorphic control, trellis drainage, lineaments, hydrocarbon migration, and interpretation of paleostress system (Omosanya et al, 2010, 2011b, Bensekhria, 2012, Derakhshani, and Farhoudi, 2005)

REFERENCES

[1] Ahmed, O.C.A., R. Nagasawa, K. Hattori, D. Chongo., M.F. Perveen,, 2007. Analytical hierarchic process in conjunction with GIS for identification of suitable sites for water harvesting in the oasis areas: Case study of the oasis zone of adrar, Northern Mauritania.. J. Applied Sci., 7: 2911-2917

[2] Barnes, J.W. & Lisle, R.W, Basic Geological Mapping, fourth Edition, John Wiley and Sons Limited, United Kingdom 2008.

[3] Bensekhria, A., 2012. Tectonic Deformations based on Lineaments Analysis of Mechtat Ain El Beida (Bou Arif Mountain) North East of Algeria. Asian Journal of Applied Sciences, 5: 117-124

[4] Casas, A. M., Cortes, Angel L., Maestro, A., Soriano, M.A.,Riaguas, A., Bernal, J., 2000, “A program for lineament length and density analysis”, Computers and Geosciences, Vol. 26, No. 9/10, 1011-1022.

[5] Ferre´ E., Gleizes G. and Caby R. (2002). Obliquely convergent tectonics and granite emplacement in the Trans-Saharan belt of Eastern Nigeria: a synthesis. Precambrian Research Vol. 114. Pp 199–219.

[6] Derakhshani, R., G. Farhoudi,, 2005. Existence of the oman line in the empty quarter of Saudi Arabia and its

continuation in the red sea.. J. Applied Sci., 5: 745-752.

[7] Derakhshani, R., A. Mehrabi, Z. Baghfalaki,, 2010. Spatial association of copper mineralization and faults in chahargonbad area, Iran.. Res. J. Environ. Sci., 4: 414-420.

[8] Kazemi, R., J. Porhemmat, M. Kheirkhah,, 2009. Investigation of lineaments related to ground water occurrence in a Karstic area: A case study in Lar Catchment, Iran.. Res. J. Environ. Sci., 3: 367-375.

[9] Kocal, A., Duzgun, H. S and Karpuz, C. (2002). Discontinuity mapping with automatic lineament extraction from high resolution satellite imagery. Unpublished report.

[10] Kporfor., J, Cheng Jiaguo , 2005. Regional Hydrothermal Copper Prediction Using Weight of Evidence Model in Northwestern Yunnan. Journal of Applied Sciences, 5: 1299-1305.

[11] Kporfor, J.K.W., E. Ashley,, 2006. Integration of geological data sets using fussy logic.. J. Applied Sci., 6: 217-222.

[12] Kumar, R., Reddy, T., 1991, "Digital Analysis of Lineaments- A Test Study on South India", Computers and Geosciences, Vol. 17, No. 4, 549-559.

[13] Leech, D.P., Treloar, P.J., Lucas, N.S., Grocott, J., (2003). "Landsat TM analysis of fracture patterns: a case study from the Coastal Cordillera of northern Chile", International Journal of Remote Sensing, Vol. 24, No. 19, 3709-3726.

[14] Moghaddam, M.H.R., M. Khayyam, M. Ahmadi and M. Farajzadeh,, 2007. Mapping susceptibility landslide by using the weight-of-evidence model: A case study in merek valley, Iran.. J. Applied Sci., 7: 3342-3355.

[15] Mostafa, M. E, Zakir, F. A. 1996, "New enhancement techniques for azimuthal analysis of lineaments for detecting tectonic trends in and around the Afro-Arabian Shield. International Journal of Remote Sensing", Vol.17, No.15, 2923-2943.

[16] Nalbant, S., and Alptekin, Ö., 1995, "The use of Landsat Mapper imagery for analysing lithology and structure of Korucu-Dugla area in western Turkey", International Journal of Remote Sensing, Vol.16, No.13, 2357-2374.

[17] Omosanya, K.O, Akimosin, A, Adio, N.A, Omosanya, H.O, Akinbodewa A.E, and Lawal, M.A(2011): A Simple 3D Visualisation Of Joints In A Migmatized Gneiss, Ago-Iwoye NE, SW Nigeria.- Intl J. Emerg Sci.1(3):418-432.

[18] Omosanya, K.O, & Ajibade, O.M (2011b): Environmental Impact of Quarrying On Otere Village, Odeda, Southwestern Nigeria. Ozean Journal of Applied Sciences 4(1), 2011, 75-82.

[19] Omosanya, K.O, Ajibade, O.M., & A. Akintola. (2010). "Architecture of Joints at Ago-Sunmonu, South Western Nigeria". Pacific Journal of Science and Technology. 11(2):625-635.

[20] Rahaman, M.A. (1981). "Recent Advances in the Study of the Basement Complex of Nigeria". First Symposium on the Precambrian Geology of Nigeria, Summary.

[21] Sabins, F.F., 2000, Remote Sensing – Principles and Interpretation: New York, W.H.Freeman and Company, 494 p.

[22] Twiss, R.J and Moores, E.M., "Structural Geology" 2nd edition, Freeman and Company Newyork, 2007,364.

[23] Wang, Jinfei, Member, IEEE, Howarth, Philip J., (1990). "Use of the Hough Transform in Automated Lineament Detection", IEEE Transactions on Geoscience and Remote Sensing, Vol. 28, No. 4, 561-566.

[24] Won-In, K., Charusiri, P., (2003). "Enhancement of thematic mapper satellite images for geological mapping of the Cho Dien area, Northern Vietnam", International Journal of Applied Earth Observation and Geoinformation, Vol. 15, 1-11.

[25] www.googleearth.com last visited August 12, 2011.

[26] Zakir, F. A., Quari, M.H.T., Mostafa, M.E.,1999, "A new optimizing technique for preparing lineament density maps", International Journal of Remote Sensing, Vol. 20, No. 6,1073-1085.

