International Journal of Earth Sciences Knowledge and Applications (2022) 4 (2) 157-166

IJESKA contribution to science

International Journal of Earth Sciences Knowledge and Applications

journal homepage: http://www.ijeska.com/index.php/ijeska

Research Article **e-ISSN: 2687-5993**

Shear Sense Analyses of Basement Complex Rocks in Parts of SW Nigeria

Olufemi S. Bamigboye[1]*, Toba E. Bamidele[1], Adeonipekun D. Adedoyin[2], Taofeeq A. Issa[1], Omolayo A. Omorinoye[2]

[1]*Geology and Mineral Sciences Department, Kwara State University, Malete, Nigeria*
[2]*Geology and Mineral Sciences Department, University of Ilorin, Ilorin, Nigeria*

INFORMATION

Article history
Received 31 August 2021
Revised 09 December 2021
Accepted 10 December 2021

Keywords
Shear sense
Deformation
Oko/Olla
Kinematic indicator
Pan African

Contact
*Olufemi S. Bamigboye
olufemi.bamigboye@kwasu.edu.ng

ABSTRACT

The study area, Oko/Olla is part of Osi sheet 224 southwest and falls within the Basement Complex of South-Western Nigeria. Field and petrological studies revealed that the area is underlain by metamorphic complexes and late intrusives which include: migmatite, granite gneiss, porphyroblastic gneiss, banded gneiss, fine grain granite, diorite with aplite and pegmatite occurring as intrusions. Migmatite is the dominant rock within the study area. The petrogenetic affiliation of the rocks as indicated by the rocks and mineral assemblage represented by plagioclase +alkali feldspar +biotite ±muscovite ±hornblende in the quartzo-feldpartic rocks of the area, are suggestive of amphibolites facies of metamorphism. Kinematic markers which include folds, boudins, σ– and δ–type porphyroclasts, and strike-slip and dip-slip faults were used as shear sense indicators. Detailed analysis of folds revealed asymmetric fold shapes with preponderance of Z–shape folds. The dominant Z–shape drag folds are consistent with the ductile and brittle dextral shear sense indicated by asymmetric boudins and porphyroclasts geometry. Structural analysis from this study indicates that the ductile fabric was overprinted by brittle deformations resulting from the uplift of the area to a low temperature-pressure conditions which is more favorable for brittle deformations. This over printing relationship is suggestive of continued movement of Olla and Oko areas after uplift of the areas during Pan African thermo-tectogenesis. It is therefore concluded on the basis of petrological evidences as well as clear overprinting relationships as revealed by decisive kinematic markers that although there are some sinistral and conflicting shear sense indicators in the area, dominant network of dextral ductile and brittle shear sense in the study area is consistent with the N-S regional structure in the Basement Complex of Nigeria.

1. Introduction

In the reconstruction of the tectonic history and structural evolution of an area, the sense of displacement which gives information about the direction of movement in a shear zone to be either dextral, sinistral, normal or reverse is the most important as noted by Passchier and Williams (1996). The preponderance of shear sense indicators in the study area made the area an interesting area of study.

The Oko and Olla area lies approximately between latitudes 8°05′42″ and 8°15′00″N and Longitudes 5°06′34″ and 5°15′00″E (Fig. 1). They fall within the southwestern part of the Nigerian Basement Complex which according to Caby (1989) forms the southern part of the Pan African-Trans-Saharan mobile belt. The study area like every other parts of the Pan-African Basement Complex of Southwestern Nigeria bears orogenic imprints characterized by high grade metamorphism, folding, faulting, widespread, granitic intrusions and migmatisation (Rahaman, 1976; Okonkwo, 2008).

The main goal of this study is to define the field characteristics and structural attributes of the rocks within the study area with particular interest on the shear sense indicators and their implications on the structural evolution of the area. The reliability of shear sense is only determined in a shear zone when different structural indicators give a consistent sense of displacement. However, the term shear zone, as used by Ramsay (1980) encompasses both clean-cut faults and ductile shear zones which were mapped with other kinematic indicators to unravel the structural evolution of the area.

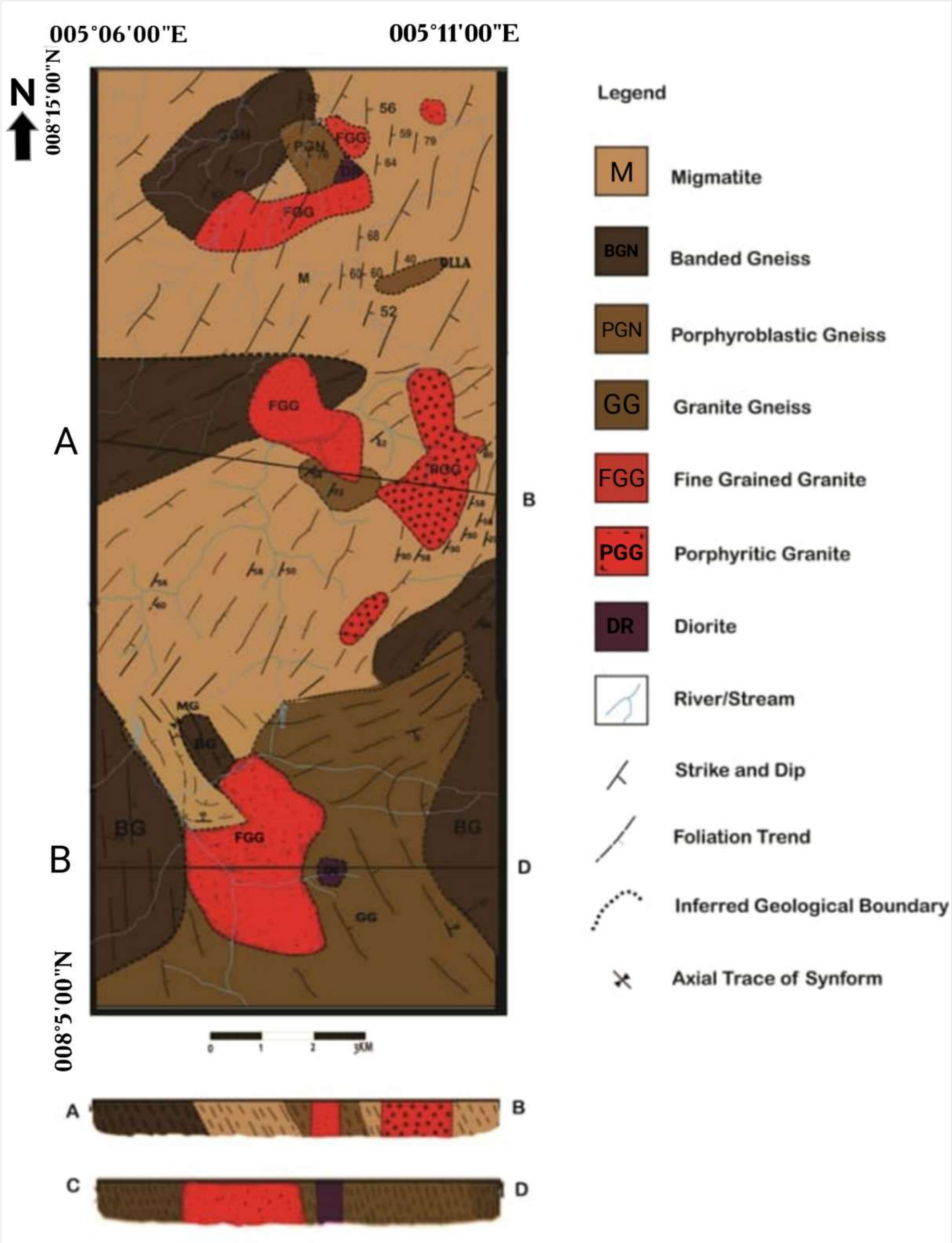

Fig. 1. Geological map of the study area showing spatial distribution of rock units

Small-scale structures undergo significant modifications either in the course of a single progressive or successive phases of multiple deformation episodes, hence they provide indelible information about tectonic activities in an area. This study is an important complement to the study of structural and deformation patterns within the southwestern sector of the Nigeria Basement Complex.

The present paper is an attempt to understand the significance of the small scale deformational features as reliable shear-sense indicators based on the field observations.

2. Materials and Methods

The study is divided into two parts. The first part was a field study carried out on a scale of 1:25000 using Global Positioning System (GPS) and Clinometer Compass for traversing. During the fieldwork, measurements were taken and recorded. This was complemented by field notes, sketches and photographs. Rock samples were collected for petrographic studies. The second part of the study which is post field was aimed at determining and interpreting structural evolution from field data. This was carried out by resolving and determining sense of shear of ductile and brittle structures. Field data were integrated with photomicrographs of thin sections, maps, stereonets and rose plots which were used to determine the kinematics and presume paleostress direction in study area.

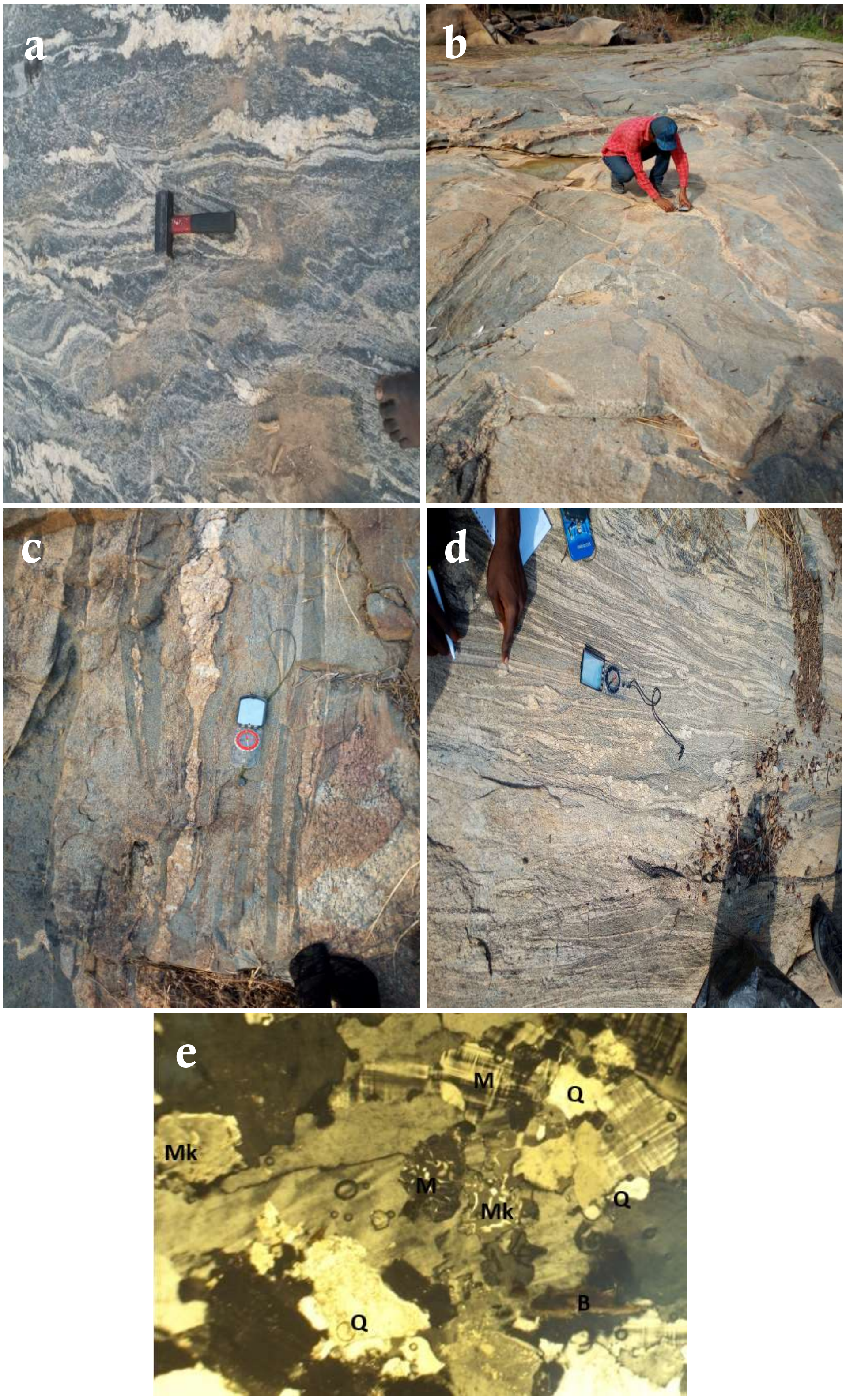

Fig. 2. a) Felsic and mafic components in a migmatite outcrop to the northeast of Olla. Note structures such as cross cutting veins, xenolith and pegmatitic intrusion within the rock exposure, b) Quartzo-feldspatic vein warped into asymmetric folds with left sense of shear in a migmatite southwest of Oko, c) Quartz-feldspar veins stretched into asymmetric pinch-and swell structure, NW of Oko, d) Right and left sense of shear in deformed quartzo-feldspartic veins in a migmatite south of Oko and e) Interlocking crystals of quartz, microcline, plagioclase and biotite in a Porphyritic granite south of Oko. Note: Q-Quartz, P-Plagioclase, M-Microcline, B-biotite and Mk- Myrmekite

Fig. 3. a) Antithetic rotation of ductile-flow folds and sharing in the granite gneiss NE of Olla. Arrow here is showing sense of shear, b) Faulted xenolith of biotite gneiss hosted in porphyritic granite gneiss. The sinistral fault is an indication of left sense of shear, c) Faulted xenolith of biotite gneiss hosted in porphyritic granite gneiss. The right lateral displacement is an indication of dextral sense of shear and d) Fold transposition resulting from progressive coaxial strain with sinistral sense of shear

3. Geology and Structural Setting of Oko and Olla

The study area is underlain by metamorphic complexes such as migmatite gneiss and granitic gneisses. Igneous rocks in the area include granites, and minor late intrusive (Fig. 1). Migmatite is the dominant lithology within the study area followed by the gneisses. The migmatites mapped outcrops as low lying to gently rising exposures (Figs. 2a-b). They occur as mixed rock with two to three lithological units. Units within the migmatitic rocks comprises of granite gneiss, porphyritic granite and fine grain granite.

Some of the outcrop in Olla comprises of porphyritic granite gneiss and fine grained granite gneiss which graded into banded gneiss. Field evidences show that the migmatite is an injection type, with the magma of more felsic neosome cementing enclaves of the paleosomes together with the other units (Figs. 2a-d). The gneissic component of the migmatite is defined by alternating bands of leucocratic and melanocratic minerals (Figs. 2b-c, e). Structures within the migmatite include cross cutting pegmatitic intrusions and quartz veins some of which are warped into simple and complex folds (Figs. 2a-b, d). The granitic gneiss in the study area (Figs. 3a-c) outcrops as low-lying to gently-rising exposures. They are mostly concentrated to the southeastern part of the mapped area. Most of the exposures have poor to well defined alternating leucocratic and melanocratic bands defined by penetrative foliation planes (Figs. 3c-d). The bands are usually made up of elongated interlocking feldspar and quartz crystals inter banded with flakes of biotite and hornblende (Fig. 3e).

Characteristically, the gneisses are differentiated into medium-to-coarse grained granite gneiss and porphyritic granite gneiss with phenocrysts of plagioclase and microcline feldspars. Occasionally large and lineated crystals of quartz, feldspars and autoliths were also observed in some of the exposures within the study area (Figs. 3c, 4a-b). The long axis of some of these grains ranges from 2 to 4cm and are parallel to general north-south striking trend of foliations within the study area. Concordant and discordant veins of quartz and pegmatite, some of which have been folded were also observed cross cutting this lithology (Figs. 4c-d).

Minerals within the gneisses as revealed by their modal composition from photomicrograph are microcline, plagioclase, quartz, biotite, tourmaline, garnet and opaque minerals (Fig. 4e).

Granites in the area occur mainly as low-lying exposures with conical shape top (Figs. 5a-c). This lithological unit occurs in a number of varieties within the study area as late intrusive and part of the Older Granite class of the Basement Complex of Southwestern Nigeria (Rahaman, 1976; 1988). The porphyritic granites (Figs.5a, c and e) are mainly leucocratic to mesocratic with porphyries of quartz; plagioclase, microcline and biotite as the main constituents.

The fine-to- medium grained granites (Figs. 5a and e) occur as both leucocratic and melanocratic granite suite. They, together with the porphyritic type cover over 25% of the geology of the study area and form ridges in areas north of Oko. They are intruded by quartz veins, aplite and pegmatite veins. They also occur as felsic component of the migmatites in the area. The rocks in the entire area study have been generally compressed asymmetrically with the axial plane in SW-NE (Fig. 1). Other ductile deformations are crenulations on this general deformation. The foliation direction in the area is essentially in the NE-SW with the exception of those in the SE corner of the study area whose foliation trend are in NW-SE. This difference in the direction of foliation planes also confirm the larger deformation in the entire area studied.

4. Results and Discussions

4.1. Structural elements and shear sense indicators

For a better understanding of the shear sense indicators and their implications on the deformation patterns and structural evolution of the study area, the definition of the term shear zone, as used by Ramsay (1980) which encompasses both clean-cut faults and ductile shear zones was adopted. The three types of shear zones as identified by Ramsay (1980) were mapped in the study area and they include:

(i) Brittle shear zones
(ii) Brittle-ductile shear zones
(iii) Ductile shear zones

The direction of displacement or sense of shear in each of the microstructures and kinematic indicators as well as their relationship with the mechanisms through which structural fabrics developed was determined.

4.1.1. σ– and δ–type porphyroclasts

As noted by Yakeu et al. (2014), the shape of both the grain and tail structures is controlled by the association of the object, matrix and the shearing deformation gradient in shear planes as observed in the matrix. During deformation episodes, phenocrysts and porphyroblasts act as rigid bodies and were used to determine the sense of displacement from the orientation of their tails. Based on the grain-tail relationship within the shear-zones, sigma and delta types of grain-tail complex were recognized (Figs. 6a-d) within the study area. The rotation structure in the megacrystals of K–feldspar and quartz in the porphyritic gneisses and migmatites within the study area develop mainly the sigma and delta clast-tail system. These porphyroclasts are structures linked to rigid object in mylonitic matrix.

Though some veins appear to be strongly deformed (Fig. 3c, 4d and 6d), the shape of the porphyroclasts reveals that they are weakly to moderately deformed and have undergone a rotation recorded either around the clast or sigmoidal lens or within the matrix.

4.1.2. Folds

Folds within the area generally include tight-to-open folds with many other asymmetric folds. Crenulations and boudins are other related structures associated with shear folding within the study area and they are mainly asymmetric deformations. These fold structures were used as kinematic indicator due to the fact that the short attenuated limb of an asymmetry folds is amenable to be treated as a shear zone (Carreras et al., 2005).

Symmetry and orientation of the shear-related folds are influenced by many variables other than the shear sense. In consequence, shear related fold has complex link with kinematics, as evidenced in shear zones where shear sense can be established from other kinematic criteria. The prominent shear related fold northwest of Olla (Fig. 3c) shows typical geometry of a synthetic fold which is characterized by a thinned, short transported limb with left sense of shear. This is similar to the constructional faulting associated with recumbent folding identified by Okonkwo (2001) in Bode-Saadu area.

In other asymmetric folds within the study area (Figs. 2a, d,4d, 6c), rotations of the fold axial planes were observed to be parallel to general strike direction or have been tilted from vertical to the northwestern direction mainly. This is followed by progressive fold tightening which reflects the rotation of the principal direction of the finite strain relative to the instantaneous stretching axes of flow and shear sense direction in the transported fold (Fig. 3d and 4b).

4.1.3. Boudins

Boudins as noted by Goscombe and Passchier (2003) are the most reliable indicators of shearing the study area are formed due to layered parallel extension or layered perpendicular shortening in the rocks having considerable differences in the viscosity across their layering (Fig. 5e). Boudins and pinch and swell structures in the area developed from pegmatite intrusions, rock enclaves and xenoliths showing interbedded characteristic with the relatively less competent host rocks. The characteristics of the boudins of the quartzo-feldspartic vein within the area shows they are more competent than the rock they intruded.

Boudins are observed in competent (quartzo–feldspathic) veins where they are of pinch–and–swell type. They are related to each other by thin stretched quartzo-feldpathic inter–boudins zones. Most of the pinch and swell structures occur as asymmetric boudins which are common structural element in high strain and shear zones as noted by Goscombe and Passchier (2003). Figs. 4b and 6a are shear band boudins with left and right sense of shear respectively. They display antithetic and synthetic character with respect to shear sense. The delta (δ) type rotation is another structure common with quartzo-feldspartic veins in the area.

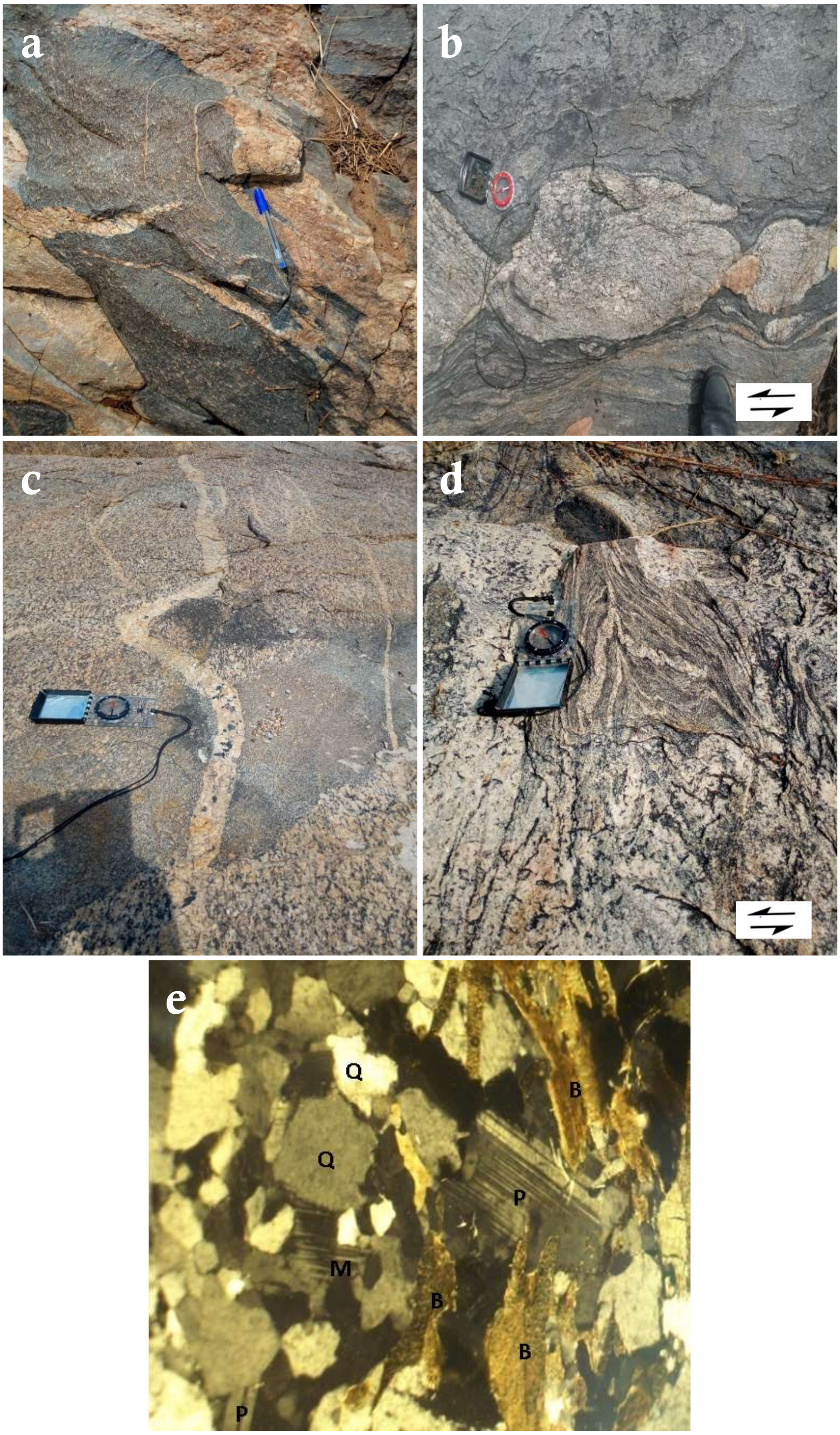

Fig. 4. a) Lineated grains of orthoclase feldspar in granite gneiss SE of Oko, b) A faulted asymmetric boudins of quartzo-feldspartic vein exhibiting sinistral sense of shear, c) A folded tourmaline bearing pegmatite hosted within porphyritic granite to the NW of Olla. Note the xenolith of a melanocratic granite in the middle of the photo and d) Asymetrical fold trains of quartzo-feldspartic veins within migmatite in Oko depicting left sense of shear

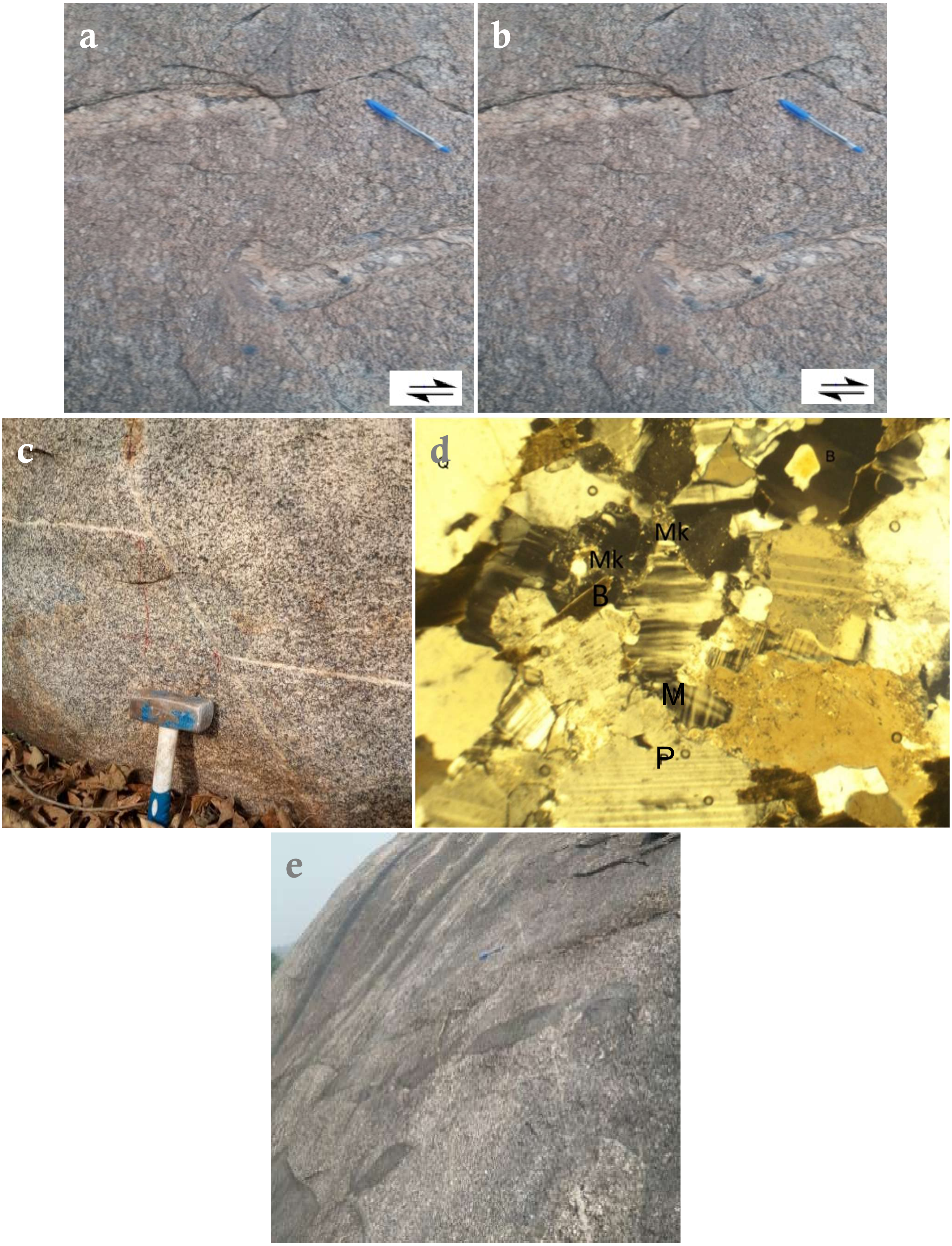

Fig. 5. a) A synthetic z shape drag fold resulting from clockwise internal rotation with dextral sense of share, b) Lateral offset of veins in brittle share zone. The displacements consistently show dextral sense of shear, c) A Normal fault mapped behind Olla Health Center, d) Porphyroclasts of plagioclase, microcline and quartz in a migmatite north of Oko, note the deformed quartz grain to the NE of the photonicrograph. Note: Q-Quartz, P-Plagioclase, M-Microcline, B-biotite and Mk- Mymekite and e) Shear band asymmetric boudins resulting from A-slip with dextral sense of shear in a granite NW of Olla

4.1.4. Offset markers

Veins, dykes and foliation are shear sense indicators in the study area that show gradual deflection of a pre-existing planar marker which are initially oblique to the shear zone (Figs. 5a, b and e). They are often direct reflection of the sense of relative displacement within a shear zone. Usually, they are accompanied by change in orientation of the external marker which is generally a passive rotation in accordance with the shear sense in the zone. The drag fold Fig. 6b is a typical example of such structure with a deflection offset of about 0.2 m.

Strike-slip tectonic systems such as these have been used to characterize the mature stages of orogenic belts (Woodcock, 1986; Woodcock and Fischer, 1986). In the study area, strike-slip faults occur, parallel to the direction of relative motion of the faulted rock on either side (Figs. 3b, 4a and 5e). They include drag and strike slip faults along which resultant rock bodies slide past each other. Dextral strike-slip faulting is the dominant brittle deformation developed in the study area (Figs. 3d, 5a and e). They are mainly observed in fault indicators like joints, veins and xenoliths. The drag folds occur as brittle to semi-brittle discontinuity with appreciable amount of displacement and connotative of ductile fabric overprinted by brittle deformation during uplift of the area to a low Temperature-Pressure condition.

The most conspicuous dip-slip fault in the area is the normal fault that affected the porphyritic granite gneiss behind the Olla Health Center. The throw in this case is about 0.3m (Fig. 5c). This fault is a further confirmation of extensional deformation in the area.

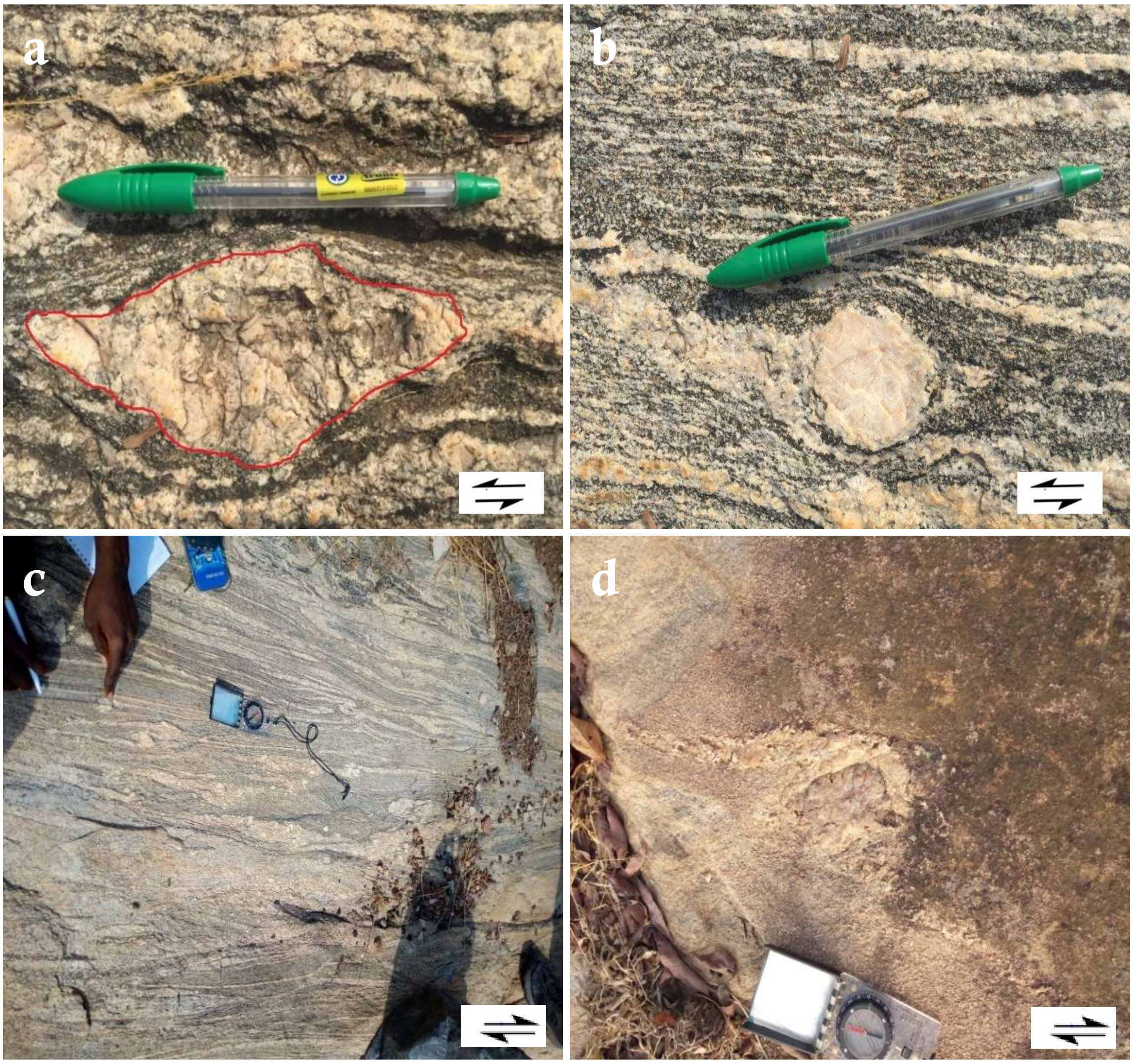

Fig. 6. a) Sigma clast-tail system in rotated phenocryst of orthoclase feldspar in a migmatite NW of Oko exhibiting dextral sense of share, b) Sigma type rotated phenocryst in a migmatite NE of Olla exhibiting sinistral sense of shear, c) Right and left sense of shear in deformed quartzo-feldspartic veins in a migmatite south of Oko and d: A rotated isolated quartz grain in a quartzo-feldspartic vein with right sense of shear. Note: Q-Quartz, P-Plagioclase, M-Microcline, B-biotite and Mk- Myrmekite

4.1.5. Stretching lineations

Stretching lineations are observed in the Olla area where they are characterized by linear prints of stretched quartz and feldspar phenocryts and biotite in the gneisses and mylonitic foliations. The stretching lineation strikes NE–SW mainly in the quartzo-feldspartic rocks. Figs. 3c and 5d indicate pressure shadow around phenocryst and boudins. The quartzo-feldspartic veins occur as deformed intrusions (Figs. 2a and c). They also occur as shear band boudins and are used as shear indicators. The deformed veins and pegmatitic bodies not used to determine sense of shear are used to interprete the tectonic transport and paleostress direction in the study areas (Agarwal, 1994; Bali and Agarwal, 1999).

4.2. Metamorphism in the study area

On the basis of petrology and petrographic deductions, a medium pressure Barrovian and Low-medium pressure metamorphism grades has been suggested for the Precambrian basement rocks in Southwestern Nigeria (Rahaman, 1986; 1988). These metamorphic types are based on the occurrence of index minerals like chlorite, biotite and sillimanite in the basement rocks of southwestern Nigeria.

As noted by Rahaman (1988), metamorphism in all Nigerian Precambrian Basement Complex rocks especially that of Ife-Ilesha and Ibadan areas (SW Nigeria) ranges from green schist to lower amphibolite metamorphic facies. Oyinloye (2011) however, used evidences in close association with that obtained from petrology, field relationships and structural analyses of Olla and Oko area to propose that the prominent gneissic foliations observed on some of the gneisses and migmatite suggest that metamorphism actually reached an upper amphibolite facies in some parts of the Basement Complex of Southwestern Nigeria. These penetrative foliation structures are also typical of the migmatites and gneisses around Olla and Oko area and similar to the clearly defined penetrative foliations and mineral lineations examplfied mainly by the orientation of amphibole crystals in the Sibisel shear zone as noted by Ducea et al. (2016). Field evidences show that most of the original primary texture and structures of the protoliths in the area have given way to metamorphic imprint represented by foliation textures in gneisses and migmatites of the study area. The mineral assemblage represented by Plagioclase +alkali feldspar +biotite ±muscovite ±hornblende (Figs. 3c and e) in the quartzo-feldspartic rocks of the area, are suggestive of amphibolites facies metamorphism grade.

4.3. Structural evolution of the study area

From the field study, the structural evolution of the Olla/Oko area is considered similar to that of the Pan-African fold belt in North-Western Cameroon (West Africa) as noted by Ganno, et al. (2010). From the petrology and detailed analysis of kinematic and shear sense indicators, all of which attests to polyphase deformation in the area during the Pan African orogeny, Oko/Olla could be said to have evolved through the following deformational episodes:

1. The first episode is an early Pan-African stage (D1) believed to have overprinted the older orogenies. Based on petrological and structural signatures, the earliest deformation D1 only affected the metamorphosed basement rocks within the study area.

2. D2 is believed to be responsible for the emplacement of granitic bodies. This episode was followed by uplift of the area to a low temperature-pressure condition during which faulting and jointing developed in the area.

3. D2 and D3 episodes were recognized as regional metamorphism which accompanied the Pan-African deformation. These resulted in the formation of structures such as faulting, folding, jointing, veins, intrusions, and mineral lineation (Olayinka, 1992). D3 phase included heterogeneous simple shear resulting mainly in dextral movements within the area as indicated by brittle and ductile shear indicators. Metamorphism was accompanied by penetrative foliation and mylonitisation during which minerals underwent modifications and development of strong preferred orientation of quartz, feldspar, biotite and hornblende into distinctive bands. Kinematic indicators in the study area include mylonites, asymmetrical folds and grain-tail systems which mainly exhibit dextral sense of shear. According to all the structural characteristics, the D3 phase of deformation is a dextral transpressive tectonic phase.

4. The fourth episode in the structural evolution of the study area is the D4 tectonic phase which is mainly the phase of tectonic superposition representing ductile deformation that is overprinted by brittle structures which are composite deformational structures that accompanied the D3 episode in Olla and Oko area. To support this is the preponderance of porphyritic granite and porphyritic granite gneiss in the area. Other structures believed to accompany this stage are refolded folds (Figs. 2d-e) lineations and boudins. The dominant structural attributes in this episode reveals dextral sense of shear which is a pointer to transpressive movement within the study area during tectonic deformation.

5. Conclusions

This study has shown essentially that the part of southwestern Nigeria studied evolved through series of unilaterally directed paleostresses which affected rocks in the area in a plastic-brittle but more plastic manner. Structural analysis from this study revealed the dominance of ductile fabric overprinted by brittle deformations such as faults and fractures. This overprinting relationship is indicative of continued movement of the area after uplift during Pan African thermo-tectogenesis. The composite deformation of this area could be said to have resulted from the uplift of the area to a low temperature-pressure conditions which is more favorable for brittle deformations. Owing to the general believe that shear zone may be subsidiary to a larger system, so that the shear sense is only representative of the zone in question, it is concluded despite the presence of some sinistral and conflicting shear sense indicators in the area, that there is a dominant and consistent network of dextral ductile and brittle shear sense indicators in the study area. This is consistent with the N-S regional structure in the Basement Complex of Nigeria.

Conflicts of Interest

The authors hereby state that they do not have any conflict of interest.

References

Agarwal, K.K., Bali, R., 2008. Small-Scale Deformational Structures as Significant Shear Sense Indicators: An example from Almora Crystalline Zone, Kumaun Lesser Himalaya. e-Journal Earth Science India 1 (3), 119- 124.

Bali, R., Agarwal, K.K., 1999. Microstructures of mylonites in the Almora Crystalline Zone, Kumaun Lesser Himalaya. In Gondwana Research Group Memoir 6, pp. 111-116. Geodynamics of the NW Himalaya (AX Jain and R.M. Manickavasagam, Eds.) GRG Gondwana Research Group, Japan (9) (PDF) Microstructures of mylonites in the Almora Crystalline Zone, Kumaun Lesser Himalaya.

Caby, R., 1989. Precambrian terranes of Benin-Nigeria and northeast Brazil and the Late Proterozoic South Atlantic fit. Geological Society of America, Special Paper 230, 145-158.

Carreras, J., Druguet, E., Griera, A., 2005. Shear zone-related folds. Journal of Structural Geology 27 (7), 1229-1251.

Ducea, M.N., Negulescu, E., Profeta, L., Săbău, G., Jianu, D., Petrescu, L., Hoffman, D., 2016. Evolution of the Sibişel Shear Zone (South Carpathians): A study of its type locality near Răşinari (Romania) and tectonic implications. Tectonics 35, 2131-2157.

Ganno, S., Nzenti, J.P., Ngnotue, T., Kankeu, B., Kouankap, N.G.D., 2010. Polyphase Deformation and Evidence for Transpressive Tectonics in the KimbiArea, Northwestern Cameroon Pan African Fold Belt. Journal of Geology and Mining Research 2 (1), 001015.

Goscombe, B.D., Passchier, C.W., 2003. Asymmetric Boudinsas Shear Sense Indicators. Journal of Structural Geology 25, 575-589.

Okonkwo, C.T., 2001. Structural evolution of Bode Saadu area, southwestern Nigeria Africa. Journal of Science and Technology (AJST) Science and Engineering Series 2 (2), 17-24.

Okonkwo, C.T., 2008. Structural evolution of Precambrian Basement Rocks of Jebba Area. Global Journal of Geological Sciences 6 (2), 145-152.

Olayinka, A.I., 1992. Geophysical siting of boreholes in crystalline basement areas of Africa. Journal of African Earth Sciences (and the Middle East) 14 (2), 197-207.

Oyinloye, O.A., 2011. Geology and Geotectonic Setting of the Basement Complex Rocks in Southwestern Nigeria: Implications on Provenance and Evolution. In Earth and Environmental Sciences, InTech Europe, University Campus STeP Ri Slavka Krautzeka 83/A 51000 Rijeka, Croatia.

Passchier, C.W., Williams, P.R., 1996.Conflicting Shear Sense Indicators in Shear Zones; the Problem of Non-Ideal Sections. Journal of Structural Geology 18 (10), 1281-1284.

Rahaman, M.A., 1976. Review of the Basement Geology of Southwestern Nigeria. In C.A. Kogbe (Editor) Geology of Nigeria, Elizabethan Publishing Co., Lagos, p. 41-58.

Rahaman, M.A., 1988. Recent Advances in the Study of the Basement Complex of Nigeria. In Oluyide P.O., Mbonu W.C., Ogezi A.E., Egbuniwe I.G., Ajibade A.C. and Umeji A.C.(eds). Precambrian Geology of Nigeria. Geology Survey of Nigeria, 11-41.

Ramsay J.G. 1980. Shear Zone Geometry: A Review. Journal of Structural Geology 2 (1-2), 83-99.

Woodcock, N.H., 1986. The role of strike-slip fault systems at plate boundaries. Philosophical Transactions of the Royal Society of London A317, 13-29.

Woodcock, N.H., Fischer, M., 1986. Strike-slip duplexes. Journal of Structural Geology 8 (7), 725-735.

Yakeu S.A.F., Njanko, T., Njonfang, E.d, Fozing, E.M., and Tcheumenak, J. 2014. Fotouni-FondjomekwetDuctile Shear Zone" (West–Cameroon): Kinematic Markers and Consequences on the Structural Evolution of the Bandja Plutonic Complex. Syllabus Review, Science Series 5, 1-11.