IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 4, Issue 5 Ver. II (Sep. - Oct. 2016), PP 29-34
www.iosrjournals.org

The Interpretation of Aeromagnetic and Satellite Imagery for Structures in Coincident with Gold Mineralization in Anka Schist Belt, Northwestern Nigeria

Salau, S. L, Danbatta, U. A. and Agunleti, Y. S
Department of Geology, Ahmadu Bello University, Zaria, Nigeria

Abstract: Several studies have shown that gold deposits in Nigeria are mainly of orogenic nature. They are structurally controlled and spatially associated with shear zones and hydrothermal veins formed in response to the regional stress field. The Anka schists belt has been mined for gold since the 1940s and continues till date. The workings in recent times are mostly artisanal but it is an area considered by most exploration geologists to hold promise of major gold deposits. This study used aeromagnetic data; satellite imagery and digital elevation model (DEM) to define lineaments associated with the major Anka fault system (AFS) and their relationship with gold mineralization in Anka schist belt. The total magnetic intensity (TMI) covering the area was processed, filtered and transformed to other grids such as First Vertical Derivative, Analytical signal and Horizontal gradient. While ArcGIS software was used to integrate the various layers of information.The TMI enabled the identification of structures, trends, domains of varying intensities and frequencies. The integration of the deduced deformation and the gold occurrences indicate that the dominant mineralisation is more associated with later stage deformation and less with the more regional long trending Anka fault. The results consistent with the observation of Morey et al (2005) for the Bardoc Tectonic Zone, Eastern Goldfields Province of Western Australia

Keywords: *Aeromagnetic, Satelite Imagery, Anka fault System, Lineaments, hydrothermal*

I. Introduction

Orogenic gold deposits are present in metamorphic terranes of various ages, displaying variable degrees of deformation. (Groves et al., 1998). They are structurally controlled and spatially associated with shear zones and hydrothermal veins formed in response to the regional stress field. Faults and shear zones are potential pathways of fluids (e.g. Sibson & Scott, 1998) and the, knowledge of the structural architecture of a mineralized area, the distribution and orientation of faults and shear zones, their formation and possible reactivation during the structural evolution and the tectonic conditions is a key to understanding the formation, origin and location of mineral deposits as well as for exploration and findings of new targets (Saalmaan 2007).The structures (deduced from the interpretation of magnetic lineaments) of a well-known deformation zone (theAnkaSchists Belt) has been studied in relation tomapping of gold occurrences.

II. Regional Geologic Setting

The Schist Belts (GSN, 1994) comprise low grade, meta-sediment-dominated belts trending N-S which are best developed in the western half of Nigeria (Fig. 1). These belts are considered to be Upper Proterozoic supracrustal rocks which have been infolded into the migmatite-gneiss-quartzite complex. The lithological variations of the schist belts include coarse to fine grained clastics, peliticschists, phyllites, banded iron formation, carbonate rocks (marbles / dolomitic marbles) and mafic metavolcanics (amphibolites). Some may include fragments of ocean floor material from small back-arc basins. Rahaman (1976) and Grant (1978) suggested thatthere were several basins of deposition whereas Oyawoye (1972) and McCurry (1976) considered the schist belts as relicts of a single supracrustal cover.

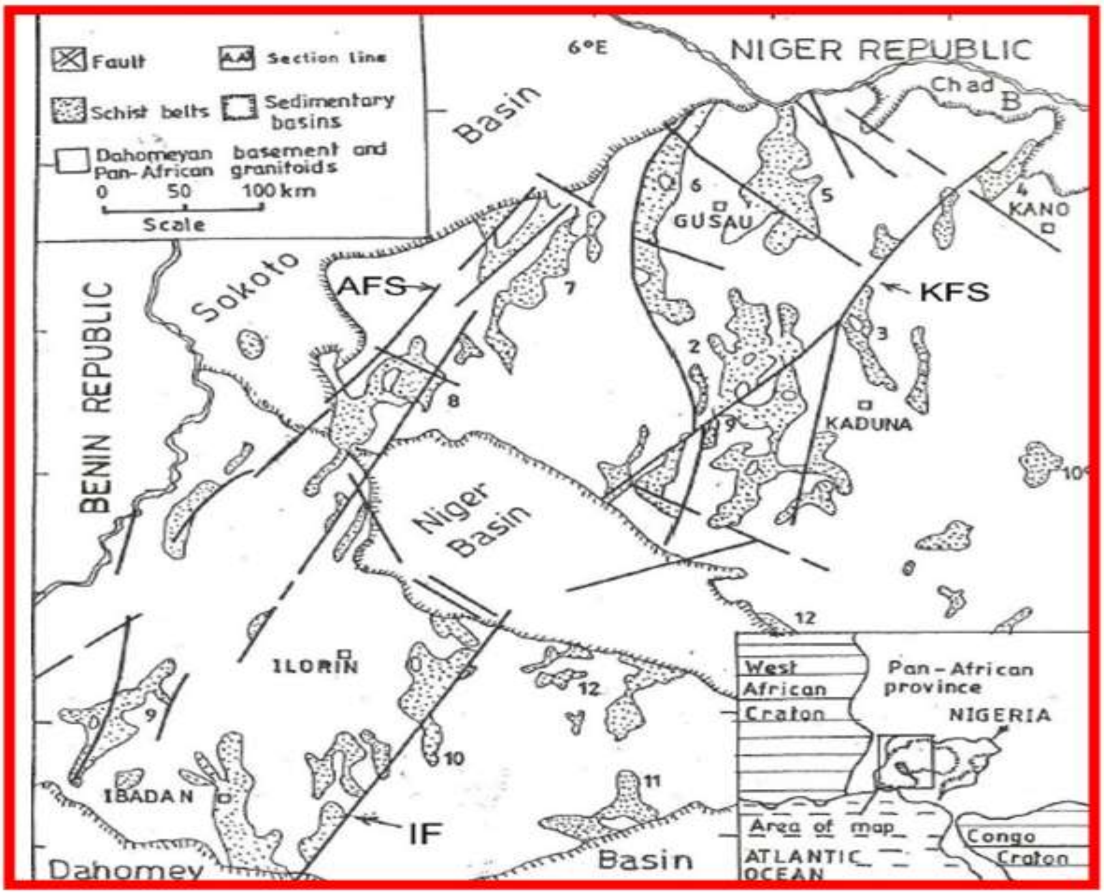

Fig. 1: Simplified geological map of the Northern and Southern part of Western half of Nigeria, showing the distribution of the schist belts and the location of major lineaments (modified after GSN, 1994). The schist belts are: 1. Zungeru-Birnin Gwari, 2. Kushaka, 3. Malumfashi, 4. Kazaure, 5. Wonaka, 6. Maru, 7. Anka, 8. Zuru, 9. Iseyin-Oyan River, 10. Ife-Ileshe, 11. Igarra-Kabba-Lokoja, 12. Toto, AYI = Anka-Yauri-Iseyin fault system. KZI = Kalangai-Zungeru-Ifewara fault system.

Olade and Elueze (1979) considered the schist belts to be fault-controlled rift-like structures. Grant (1978), Holt (1982) and Turner (1983), based on structural and lithological associations, suggested that there are different ages of sediments. However, Ajibade et al. (1979) disagree with this conclusion and show that both series contained identical deformational histories. The structural relationships between the schist belts and the basement were considered by Truswell and Cope (1963) to be conformable metamorphic fronts and it was Ajibade et al. (1979) who first mapped a structural break. The geochronology of the schist belts remains problematical although the ages of the intrusive cross-cutting Older Granites provide a lower limit of *ca* 750 Ma. A Rb/Sr age of 1040 $\pm$ 25 Ma for the Maru Belt phyllites has been accepted as a metamorphic age by Ogezi (1977). The belts are confined to a NNE-trending zone of about 300 km wide with the following localities been mapped in details: Maru, Anka, Wonaka, Igara, Zuru, Kazaure, Kusheriki, Zungeru, Kushaka, Isheyin Oyan, Iwo, and Ilesha where they are known to be generally associated with gold mineralization. Of all these schist belts listed above, the Anka schist belt was considered for this study. Danbatta (2008) compared the structural events of some schist belts in NW Nigeria (Table 1) to indicated similar structural trends. In the Anka schist belt, two deformational episode D1 & D2 was reported by (Holt, 1982) to be NNE-SSW and E-W respectively.

III. Material And Methods

Semi-regional and computer based (structural) mapping make up the majority of the work used for this research. Deductions and interpretations of regional structural patterns within the Anka schist belt were achieved by relying heavily upon macro scale structural relationships defined from the acquisition and interpretation of aeromagnetic data sets obtained from the Nigerian Geological Survey Agency (NGSA). A high resolution aeromagnetic data of 1:50,000 sheets covering the Anka schist belt was used for this interpretation with other data set such as satellite imagery and topographic map and. The flight parameters of the aeromagnetic data are: Flight line spacing (500m), Tie line spacing (2km), Terrain clearance (80m), Flight direction is NW-SE while the Tie line direction is NE-SW. The basic tools used in the interpretation were: Oasis

Montaj software by geosoft with associated extensions of the package such as MAGMAP, SED, SPI, etc. The original total magnetic intensity (TMI) grid was processed, filtered and transformed to other grids such as First Vertical Derivative, Analytical signal, Horizontal gradient, SPI depth etc. The ArcGIS software by ESRI was used to relate and overlay various layers of information, such as magnetic data during interpretation. This was performed on screen in the ArcMap. Interpretation methodology consists of inspection of computer screen and hard-copy images, maps of the aeromagnetic data (TMI), first vertical derivative (1VD), analytical signal, SPI Depth to magnetic sources map, Bouguer anomaly map, SRTM map and other relevant data for detail quantitative and qualitative study. The TMI enabled the identification of structures, trends and domains of varying intensities and frequencies. It is a combination of both regional and residual signatures (fig. 2 & 3).

Table 1: Deformation and structural relationship of Anka Schist belt in relation to other NW Nigeria Schist belts (after Danbatta, 2008)

Belt/Source of information / Deformation events	Anka Belt (Holt, 1982)	Kushaka Belt (Grant, 1978)	Birnin Gwari (Ajibade, 1980)	Malumfashi Belt (McCury, 1973)	Maru Belt (Egbuniwe, 1982)	SW of Zuru Belt (Danbatta, 1991)	Kazaure Belt (Danbatta, 1999)
D4		Rare and relct minor folds. Local development a strain0slip cleavage	Steeply dipping folds and kinks. Axial planes strike N-S/E-W		Steeply dipping kinks with E-W strike		
D3		Open folds with NNE-SSW axial planes. Axes plunge north and south	Open folds NE-SW axial dip and rounded or angular crest.		Open to right Chevron folds and tight to isoclinals folds	Open folds with smooth profiles and sleep NNE-SSW axial planes dip	
D2	Steeply dipping, E-W striking bands.	Tight to isoclinals disharmonic folds with steep axes. Axial planes strike N-S	Co-planar with D1 open to isoclinals large scale folds of S, schistocity. Axial planes strike NE-SW.	Tight Isoclinals D2 folds with N-S axial planes strike Cleavages developed	Open to isoclinals folds. Steeply dipping N-S striking cleavage	Tight to isoclinals folds with moderate plunging axes, N-S cleavages developed.	Upright isoclinals folds with NNE-SSW axial planes. Cleavages developed
D1	Open to isoclinals upright folds with NNE-SSW axial planes and Axes.	Rare minor folds with E-W axial planes	Folding of cover rocks on NE-SW trending axial planes. Cataclasticdeformation of basement cover contact. Cleavage well developed	Early ENE-WSW foliation mated to Dc folds. Largely obliterated.	Reflicts flat lying folds with N-S axes and S1 clevage. Folds obliterated by transportation	Rare and obliterated minor folds with shallowly dipping E-W to ENE-WSW trends. S1 axial plane clevarage	Relict recumbent isoclinals folds with N-S trending axial planes. Mostly obliterated.

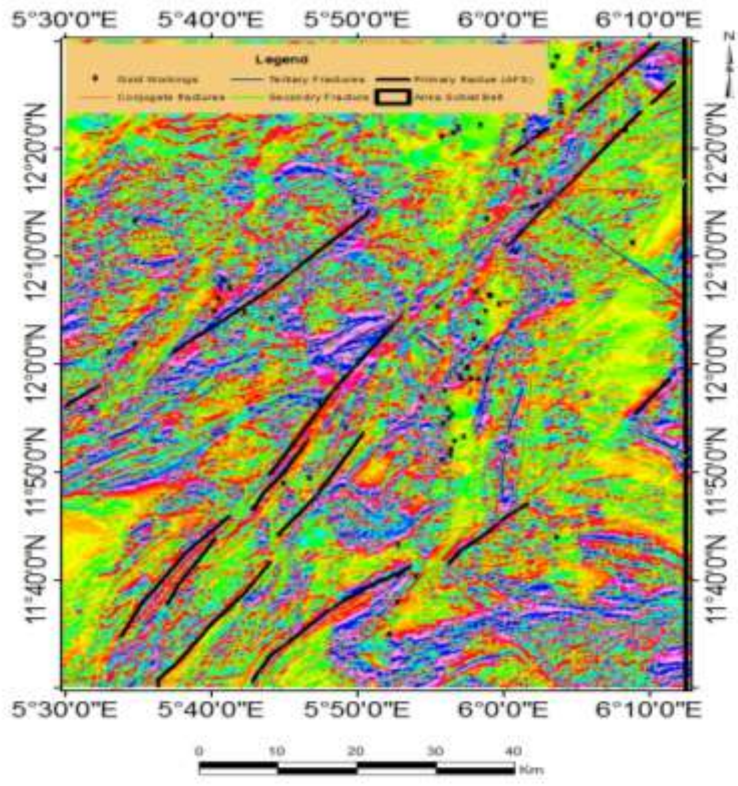

Fig.2: First Vertical Derivative Map of Anka Schist Belt

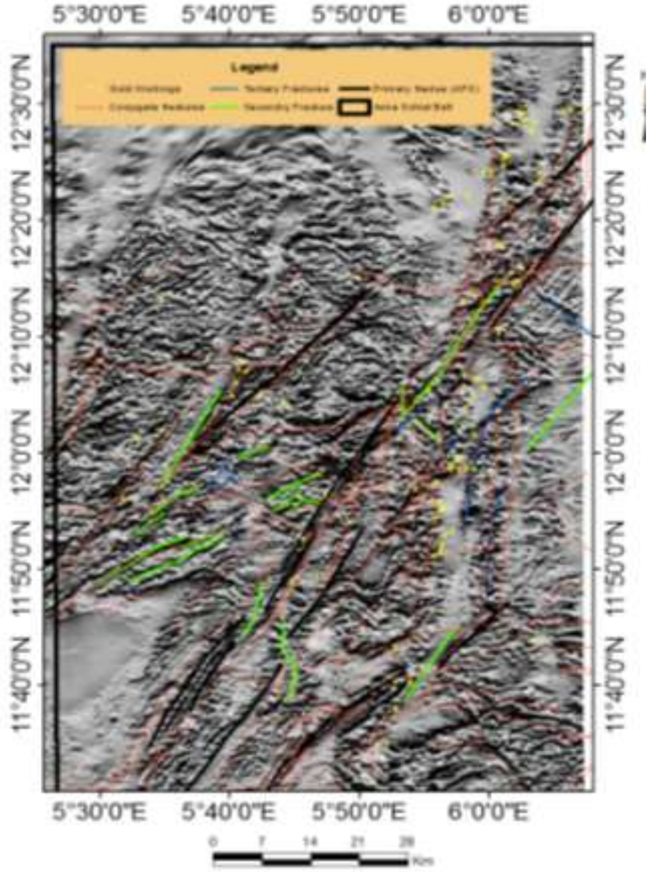

Fig.3: First Vertical Derivative Map (Grey Shade) of Anka Schist Belt

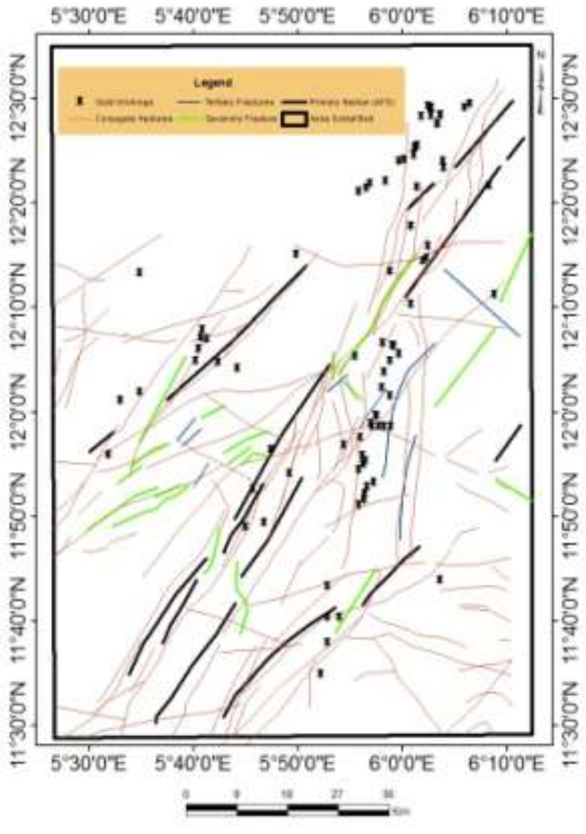

Fig. 4: An interpreted lineaments map of Anka schist belt in association with the major fault system.

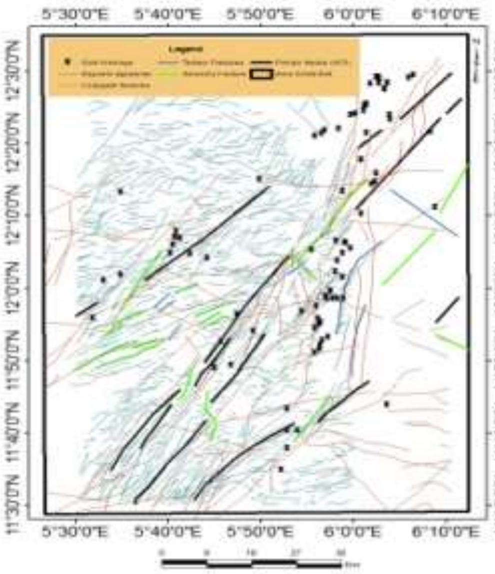

Fig. 5: An interpreted lineaments map of Anka schist belt in association with the major fault system (Note: the magnetic signatures)

Fig. 6: Gold Workings in Anka Schist Belt

IV. Results and Discussion

Magnetic surveying played a major role in the delineation of metallic and non- metallic minerals (Gunn, 1993), such that mapping of appropriate stratigraphic horizons and identification of suitable structures, such as faults, folds, intrusions. are important aspects of the interpretation of magnetic data. Knowledge of the forms of anomalous responses due to different source geometry is fundamental to the estimation of magnetic source boundaries. Structural and stratigraphic signatures for mineralization are important here but these signatures are not always diagnostic, so many similar but un-mineralized zone may occur. Dickson (1997) suggested that mineralization processes can affect radioelement contents of rocks and therefore become useful tools in identification of potential mineralization. Since gold has little or no diagnostic magnetic signature, effort should be geared toward using magnetic data as an indirect tool for its zone of mineralization by identifying likely structural and geologic features favorable to mineralization. Holt (1982) used reconnaissance air-photo interpretation of the Anka belt to reveal presence of fracture systems. The fracture system digitized within the Anka schist belt include primary fracture system {The Anka Fault System, (AFS)},the Secondary fracture system and the conjugate fractures from oldest to youngest in that order. The primary fractures generally trend in a NE-SW which concurs with the trend of AFS as published in the lineament map of Nigeria Geological Survey Agency (NGSA). The secondary fractures also align parallel to the primary fractures and rarely NW-SE trends, while the conjugate/subsidiary fractures which are more prominent trends in NE-SW, N-S, NW-SE and rarely E-W (Fig. 4 & 5). The primary and secondary lineament from the study area was found to be deep seated while others are shallow. Gold workings so far encountered in the field at the time of this publication totaled 78 ranging in sizes between 5m-1500m in length and 2m-25m in width (Fig6). Over 75% of these gold workings falls within the silicified sheared zone which trend in a NNE-SSW direction for almost 80km in the eastern part of the map. On a regional scale, these gold workings are concentrated largely within the conjugate/subsidiary fractures, however no major gold workings was mapped to fall directly on both the primary and secondary fractures. This may be interpreted that, though the primary and secondary fractures serve as conduit for mineralized fluids, but itself are not mineralized especially for gold mineralization and this may support why most of the gold working are concentrated along the conjugate/subsidiary fractures. Large granitic intrusion at the south-western corner of the Anka schist belt as shown in the grey colour first vertical derivative aeromagnetic map must have displaced and altered the surrounding rocks.

V. Conclusion

This study reveal that gold workings in Anka schist belt are structurally control and supports the work of earlier workers, however more conjugate lineament were depicted from the interpretation of aeromagnetic data and satellite imagery to be NNE-SSW, NW-SE, N-S and NE-SW in addition to the major deep seated Anka Fault System (AFS).The magnetic signatures gave indication of likely ore bodies within the fractures/faults identified. The digitized lineaments' reveal multiplicity of magnetic signatures concentrated in almost 85% of the Anka schist belt and can augment other techniques used for gold exploration in the area.The integration of the deduced deformation and the gold occurrences indicate that the dominant mineralisation is more associated with later stage deformation and less with the more regional long trending Anka fault. The results consistent with the observation of Morey et al (2005) for the Bardoc Tectonic Zone, Eastern Goldfields Province of Western Australia

References

[1]. Ajibade, A. C., 1980: Geotectonic evolution of the Zungeru region, Nigeria.*Unpub. Ph.D. Thesis*, Univ. Wales, Aberystwyth, 320p.

[2]. Ajibade, A. C., Fitches, W. R. and Wright J. B, 1979: The Zungerumylonites, Nigeria: recognition of a major tectonic unit. Rev. Geol. Dyn. & Geogr. Phys., **21**, pp. 359-363.

[3]. Danbatta, U. A., 2008: A review of the evolution and tectonic framework of the schist belts of Western Nigeria, West Africa. African geosciences review 15(2): 145-158.

[4]. Danbatta, U. A., 1991: Geologic investigation of the SW portion of the Zuru schist belt, NW Nigeria.*Unpubl. M.Sc. Thesis, A.B.U. Zaria*, 150 p.

[5]. Danbatta, U. A., 1999: Geotectonic evolution of the Kazaure schist belt in the Precambrian Basement of NW Nigeria. *Unpublished. Ph.D. Thesis, A.B.U. Zaria*, 286p.

[6]. Danbatta, U. A., 2008: A review of the evolution and tectonic framework of the schist belts of Western Nigeria, West Africa. African geosciences review 15(2): 145-158.

[7]. Dickson, B.L. and Scott, K.M.,1997: Interpretation of Aerial Gamma-ray Surveys- Adding the Geochemical Factors. *AGSO Journal of Australian Geology and Geophysics, 17(2), pp 187 – 200.*

[8]. Egbuniwe I. G., 1982: Geotectonic evolution of the Maru belt, NW Nigeria.*Unpublished Ph.D. Thesis* University of Wales, Aberrytwyth, 275 p.

[9]. Garba, I. (2002): Late -African Tectonics and Origin of Gold mineralization and rare metal Pegmatite in the kushaka schist belt, Northwestern Nigeria. Journ. Of Mining And geology, vol.38 (1), pp.1-12.

[10]. Grant, N. K., 1970: Geochronology of the Precambrian Basement rocks from Ibadan, southwestern Nigeria. *Earth and Planetary Science Letters* 10, 29-38.

[11]. Grant, N. K., 1978: Structural distinction between metasedimentary cover and an underlying basement in the 600 m.y. old Pan-African domain of Northwestern Nigeria, West Africa. Geological Society America Bulletin 89, 50-58.

[12]. Groves, D.I., Goldfarb, R.J., Gebre-Mariam, M., Hagemann, S.G., Robert, F. (1998) – Orogenic gold deposits: A proposed classification in the context of their crustal distribution and relationship to other gold deposit types. *Ore Geol. Rev. Special Issue*, **13**, 7-27.

[13]. Gunn, P.J., 1993: The Causes of Magnetic Responses in Massive sulphideore bodies and their host rocks

[14]. Holt, R., 1982: Geotectonic evolution of the Anka belt in the Precambrian basement complex of Northwestern Nigeria.Unpublished Ph.D. Thesis. Open University, England, 254 p.

[15]. McCurry, P., 1976: The geology of the Precambrian to Lower Palaeozoic rocks of northern Nigeria – a review. In: Geology of Nigeria. C. A. Kogbe (E.d.). Elizabethan Publishing Company, Lagos, 15-39.

[16]. McCurry, P., 1973: Geology of degree sheet 21 (Zaria), Nigeria.Overseas Geol. Mineral Resources 45

[17]. Morey, A.A, Weinberg R.F. and Bierlein, F.P 2007:The structural controls of gold mineralisationwithin the Bardoc Tectonic Zone, Eastern GoldfieldsProvince, Western Australia: implications for goldendowment in shear systems. Miner.Deposita 42,583

[18]. Olade, M. A. and Elueze, A. A., 1979: Petrochemistry of the Ilesha amphibolites and Precambrian crustal evolution in the Pan-African domain of southwestern Nigeria. *Precambrian Research* 8, 303-318.

[19]. Oyawoye, M. O., 1972: The basement complex of Nigeria. In: African Geology (edited by Dessauvagie, T.F.J. and Whiteman, A. J.). Ibadan, Nigeria, 67-99.

[20]. Rahman, M. A., 1976: Review of the basement geology of southwestern Nigeria. In: Geology of Nigeria (edited by C. A Kogbe).Elizabethan publishing Company Lagos, 41-58

[21]. Saalmaan, K: Structural control on gold mineralization in the Satulinmäki and Riukka prospects, Häme Schist Belt, southern Finland,Bulletin of the Geological Society of Finland, Vol. 79, 2007, pp. 69–93.

[22]. Sibson, R. H. And Scott, J., 1998: Stress/fault controls on the containment and release of overpressured fluids: Examples from the gold-quartz vein systems in Juneau, Alaska; Victoria, Australia and Otago, New Zealand. *Ore Geol. Rev. Special Issue*, **13**, 293-306.

[23]. Truswell, J. F. and Cope, R. N., 1963: The geology of parts of Niger and Zaria Provinces, northern Nigeria. Bull. Geol Sur. Nigeria 29.38 p

[24]. Turner, D. C., 1983: Upper Proterozoic schist belts in the Nigerian sector of the Pan-African Province of West Africa. Prec. Res. 21, pp. 5-79.Centre for promoting ideas USA