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# Structural Analysis and Aeromagnetic Interpretation of Spot Image for Mineral Potentials in the Jos-plateau Area, North Central Nigeria

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**Abstract:** This study involves the structural analysis and evaluation of mineral potentials in the Jos-Plateau, Central Nigeria. The study revealed the structural trend (NE – SW, NW – SE, E – W and N – S) in the study area.The follow-up ground check revealed that some of the lineaments are fractures and these fractures continue into the basement complex and show the same general trend as those in the granite.The fracture traces localized within the complexes itself may represent “Relaxation joints” which show up in microscopic scales, which may have played a significant role in controlling mineralization in the area.Lineaments (faults) are represented by pattern breaks, trending NE – SW and NW – SE. These pattern breaks have been retraced geologically but are known to agree with the general structural grains, confirming the Pan African and Transvaalian orogeny that has occurred in the Nigeria basement. The length of these lineaments ranged from 0.4kilometres to 6.5 kilometres.Mineralization in the area is controlled by structural trends and the mineralized ducts are bounded by faults. The minerals in the mineralization vein include Tin and Columbites, associated with the biotite granite and cassiterite whichis associated with hornblende-fayalite granite. Major rocks types include Diorite, Migmatite, and biotite granite. It is recommended that Nig. Sat 1 Images should be used alongside other geophysical data in the study area for mineral exploration. This will enhance the knowledge of surface structures (abundance and trend) and mining of shallow placer deposits in the area.

**Key words:** Structural trends · Mineralization · Lineaments · Fractures · Faults · Jos-Plateau

## INTRODUCTION

The study area covers 8600km$^2$ from latitudes 9°36 to 9°60$^I$N and Longitudes 8°32 to 8°56$^I$E and is bounded by 300-600meter escarpments around most of its circumference, with an average altitude of 1280 metres and its highest point at 2010metres. It is the only region of temperate climate of Nigeria (Fig. 1). Major towns are Jos, Bukuru, Rukuba, Barkin Ladi, Ganawuri, Vom, Kigom, which fall within Plateau State. The residents of the area are mainly farmers, miners and civil servants.

The area under study is located near the central part of Nigeria. It covers 8600 km$^2$ with average altitude of 1280 to 2010 metres. It is within the Nigerian basement complex and the Younger granite complex, covering Jos-Bukuru complex, Ganawuri, Rukuba, Kagoro, Miango, Forum and Kigom complex. The rock types of the basement complex comprise a group of older granulite gneisses succeeded by a series of migmatite, granite-gneisses and granites, forming a single petrogenetic unit.

Tracing of structural provinces and boundaries beneath cover rocks, has been possible because of their general uniformity and flat lying state which makes them effectively transparent to magnetism, even in places where the basement geology is exposed, and the boundary can be mapped geologically. Geophysical studies can provide useful structural information that can be used to determine the altitude of the boundary at depth and provide evidence of thrusting or depositional overlap.

Nigeria Sat-1 image is indispensable for reconnaissance geological surveys, structural interpretations, image classification for lithology delineation, vegetation cover analyses and ground trotting. Demonstrating the geological application of the Nigeria Sat-1 image with respect to structural geology of the study area, involves image interpretation, lineaments extraction and analyses.Processed satellite data enhances structures that are probable host for mineralization and also map sub-regional surface geology.

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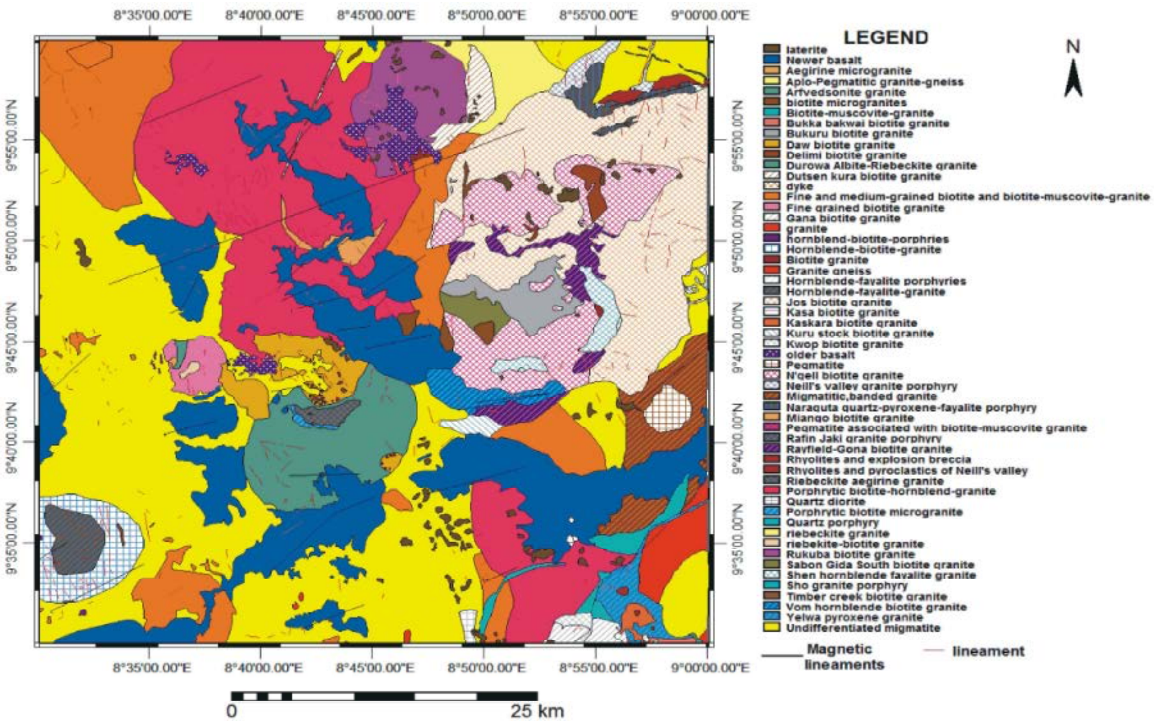


Fig. 1: Geological Map of Study Area overlain with Magnetic Lineaments and Lineaments Extracted from Spot Image. (Modified GSN)

Comparing the geological map with interpreted aeromagnetic map and the satellite image creates detailed mineral potential map of the study area.

## Methods of Study

**Field Mapping:** The method of traverse from one complex to another was used and the instruments used include compass for direction and strike measurement, measuring tape for length and width measurement, hand lens for field identification of samples, field note book and a digital camera. Past works on geological mapping in the area was reviewed and acquisition of the topographical map of the area (bench work), indicating routes and other important physical features such as stream and spot heights. Contour lines were used as a useful guide during the mapping exercise.

Detailed mapping was also carried out, where structural measurements were taken on the various complexes including photographs of some important features. Rose plots of the data obtained from the structural reading showed the structural trends in the area.

**Pattern Breaks:** Both subtle and bold linear features were observed cutting across and disrupting the general structural grain of the anomalies on the aeromagnetic map (Fig. 1). They are suggestive of some of the major features like faults, fractures; shear one etc. (Batterham *et al.,* 1983). They were displayed in forms of discontinuity, disruption or displacement of anomaly patterns. These were recognized through a number of phenomena which includes region of magnetically flat or quite zones, changes (or discontinuous trend) in wavelength of the anomalous pattern across each of the zones. This is suggestive of some variation in the basement depth, profile delineated by magnetic high and lows and with steeply dipping gradients produced by the lowest value of their contour, may probably be due to fault. Similarly, linear disruption of adjacent anomalous pattern may have been caused by faults or contacts separating magnetic from non-magnetic limits.

Based on the descriptive parameters highlighted above, the determination of probably faults patterns was made possible. Each of these pattern breaks mapped has dominant NE-SW trend, interpreted qualitatively confirming the Pan African orogeny that occurs in the Nigerian basement complex. These presumed faults (lineament) cover distances ranging from 0.4kilometres to 6.5 kilometres often running parallel to one another.

**Intrusives:** Intrusives were recognized in the study area and they constitute part of the undifferentiated basement complex which underlain the younger granite rocks. They include older granite and migmatite.

**Older Granite:** They are the most obvious manifestation of the pan-African orogeny in this part of West Africa (Rahaman, 1988). Older granites were reported by Macleod, (1956); Jones and Hockey, (1964) as forming north-westerly trending dyke-like bodies. These vary in width from a few metres to about 100ft. According to their report, the field relations indicate that, the main phase granites have been emplaced partly by intrusions and partly by replacement, though it is not clear which of these two modes of emplacement has been dominant.

The magnetic amplitude over the older granite (at the centre of the study area) shows value of 37nT and they run through an estimated length of 1.2 km. the magnetic susceptibility varies from 0.010603 S.I. units to 0.194759 S.I. units. Predominantly granite subordinates quartz-syenite mainly biotite-hornblende-granites, relatively homogenous, granites. Both porphyritic and non-porphyritic varieties, but individual masses mainly limited to one type.

The older granite include autochthonous and parautochthonous granites and later intrusive members possibly migmatite in part. The intrusive granites are grouped into porphyritic biotite and biotite-hornblende-granites (OGP), even-grained biotite-hornblende granites and quartz-syenites (OGL) and certain fine to medium-grained biotite granites.

**Migmatites:** The migmatite are a varied group, ranging from coarsely raised gneiss to move diffuse-textured rocks of variable grain size and frequently porphyroblastic. The latter includes augen and blebby gneisses which are widely distributed as small bodies among the main migmatites, but also from zones which have been mapped by Jones and Hockey(1964) and Oyawoye, (1964) as subordinate units. Amphibolites and calc-silicate rocks are also present, the former usually occurring as thin bands or bounding with composites migmatites, the latter as bands of varying width and extent.

The magnetic amplitude over the migmatite (at western region of the study area) shows value of 80.5nT and magnetic susceptibilities varied from 0.012719 to 0.055255 S.I. units. The Migmatites form a heterogonous group which includes veined and banded gneisses, porphyroblastic blebby and augen gneisses and streaky nebulitic gneisses as well as subordinate amphibolites, calc – silicate rocks and schist. There is little doubt of the mainly sedimentary origin of the pre – existing rocks, but because of the poor degree of exposure and the absence of distinctive marker horizons no large scale stratigraphy and structure have been established for now.

The period of formation of this complex series of migmatites and granites is referred to as the older granite orogenic cycle. No satisfactory age determination are available for the older granite of the study area, but they can be correlated with similar rocks from more westerly parts of the Nigeria basement (Jacobson, and Jaques, 1944) and assigned to the same late Cambrian to Ordovician orogeny. An age determination from an unmigmatized biotite – granulite gave an age within the time range for the older granite cycle.

**Younger Granite:** The younger granites are discordant, high level intrusions which transgress all units of the basement complex. They have been preceded by extensive acid volcanism and emplaced by ring faulting and block subsidence. The suits are predominantly acidic, with granites and rhyolites underlying most of the study area. Intermediate and basic rocks occur in many parts of the complexes, but most of the syenites are quartz – bearing. Gabbros, micro –gabbros and dolerites occupy less than 1 percent of the total area and comprise only a minor part of any complex in which they occur.

**Lineament Extraction and Analysis:** A lineament is a mappable simple or complex (composite) linear feature of a surface whose parts are aligned in a rectilinear or slightly curvilinear relationship which differs distinctly from the parts of adjacent feature and presumably reflects as a sub-surface phenomenon. They are expressions of ancient deep – crystal structures, which periodically, have been reactivated as tectonic events.

These planes of weakness and particularly their intersections may provide high permeability channels for ascent of deeply derived mineralization. These lineaments are therefore extracted from the aeromagnetic map and satellite image of the study area (Figs. 1 & 2).

By way of analysis, the major structures plotted from the lineaments generated shows that NE – SW and NW-SE structures are more abundant in the study area. Relicts of E – S and N – S are also observed. These structures agree with the trends of Pan African fractures and faults found in the basement complex of Nigeria and with the measured trends of foliations and fractures etc, as discussed earlier. Lineament analysis applied to mineral exploration attempts to define the most favourable location for mineral concentrations and in hydrological exploration for accommodation of water in fractures.

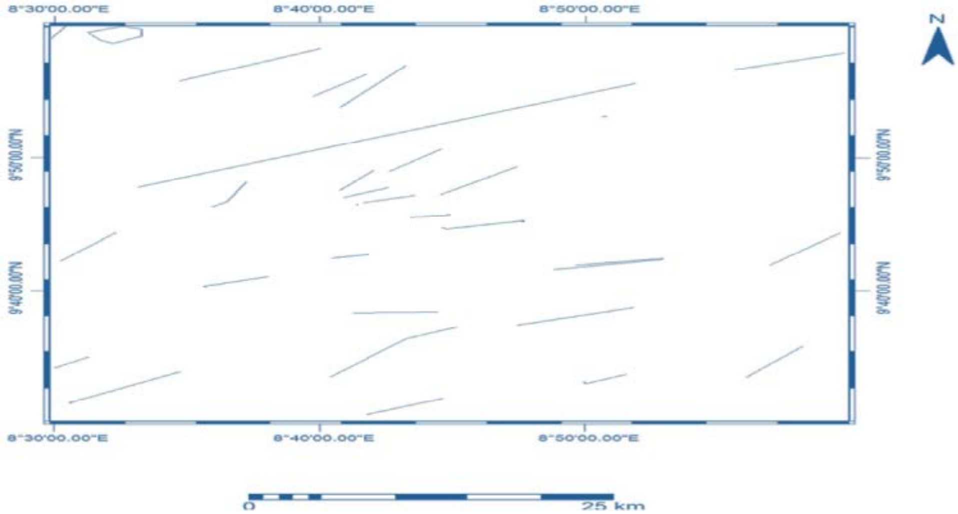


Fig. 2: Map of Lineaments Extracted from Aeromagnetic map of the study area

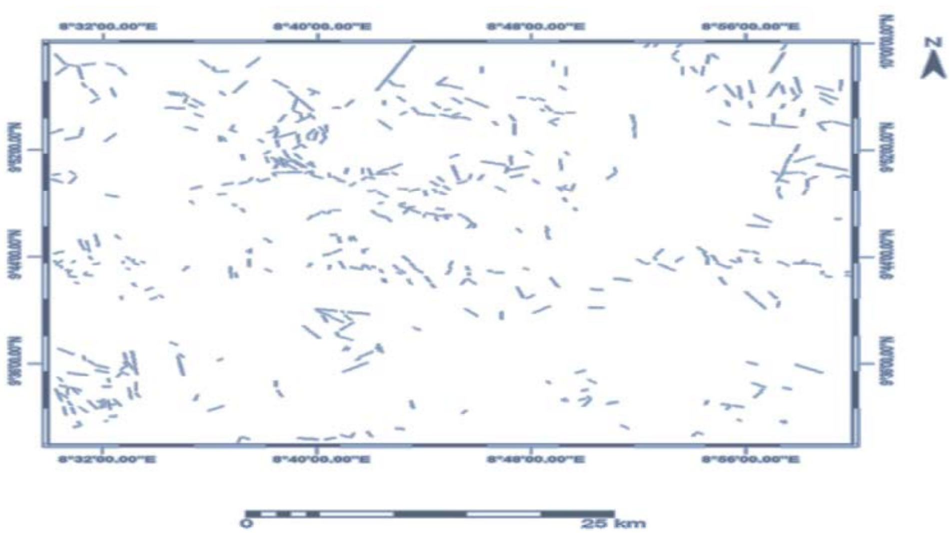


Fig. 3: Map of Lineaments Extracted from Spot Image of the Study Area

Some of the structures in this area are joints and folds which are linear structures while the veins foliation and dykes are planners.

**Joints:** Most of the joints observed and mapped in the study area, occur as joint sets and joint systems, with other approximately occurring as parallel, however sometimes the joints cross cut themselves in some locations.

These were seen as breaks or cracks on the rocks without any appreciable up or down movement on the break. This is a form of fracture, which may have resulted from the response of the rock due to too much stress. The strike directions of prominent joints were observed and measured in different complexes. General trend shown on rose plot.

**Faults and Folds:** Faults are fractures in rocks that have undergone relative displacement along the fracture plane. The fold here occurs as micro – fold and were seen distinctly in the migmatite, they tend to be similar folds, moving in a single direction caused by deformation in the semi – molten state, that is, they are flow structures in the migmatite.The ptygmatic and convolute folding are pressured due to the formation of differential stresses arising between layering of adjacent competent and less competent bands in the partially molten rocks.

Fig. 4: Fracture as seen on the Basement Complex

Fig. 5: Joints on Biotite Granite (Miango Complex)

**Foliation:** Differential stress has a very important influence on the texture of metamorphic rocks because it forces the constituents of the rock to become parallel to one another. Foliation is the defining structure in the basement rock where the alternation of dark bands consisting of mafic minerals and light bands consisting of feldspar, muscovite and quarts are seen. These were seen commonly and found in the migmatite and faintly in the granite gneiss.

Minerals with needle – like and elongate crystal, like biotite define the foliation and lineation of the rock types as they align themselves in a direction perpendicular to the orientation of the applied forces. (Falconer,1911). And the structural concordance and transitional margin into migmatite indicate a formation by In – Situ Granitization. Fig. 4 shows fracture in the Basement Complex while Fig. 5 depicts joints on Biotite Granite within the Miango Complex. Fig. 6 shows the microgranite dyke along Ganawuri. Fig. 7 is the Vesicular Basalt (Pumic), few KM from Jos Wild Life Park while Fig. 8 shows Part of Miango Complex.

**Interpretation:** The joining pattern of rocks in the mapped area has a great influence on the direction of emergence and flow of the tributaries of the major rivers in the area. This is so because the porosity and permeability of the rocks in crystalline region depend on the concentration of these structures, which control the direction of rivers flow, its emergence, and accumulation.Furthermore, the joining pattern and direction also influences the choice of a quarrying face, when a rock is to be quarried. The tectonic history of these could also be explained on the basis of the direction of the joints in them.

The predominant trending direction of joints on the Ganawuri (Fig. 6) complexes, are NE – SW and NW – SE. While on the porphyry biotite granite (Fig. 5), the structures shows an E – W and N – S trending with relicts of NE – SW and NW – SE respectively. Fig. 9 shows the Rose plot of lineaments derived from Aeromagnetic data while Fig. 10 depicts the Rose plot of lineaments derived from Spot Image of the study area.

Fig. 6: Micro Granite Dyke, along Ganawuri

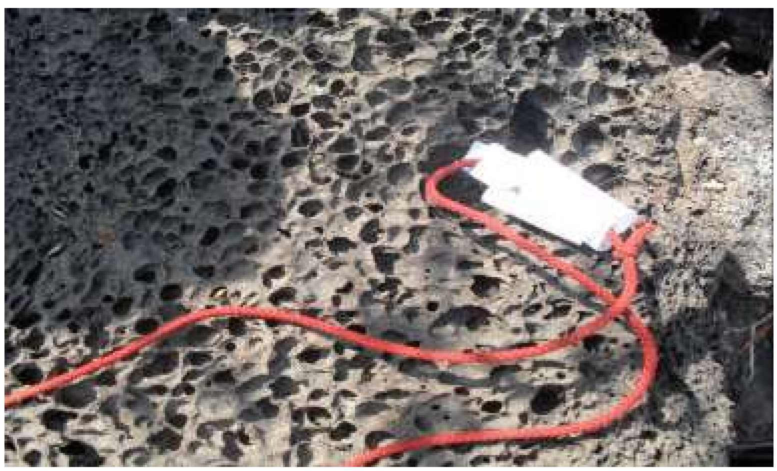

Fig. 7: Vesicular Basalt (Pumic), few KM from Jos Wild Life Park

Fig. 8: Part of Miango Complex

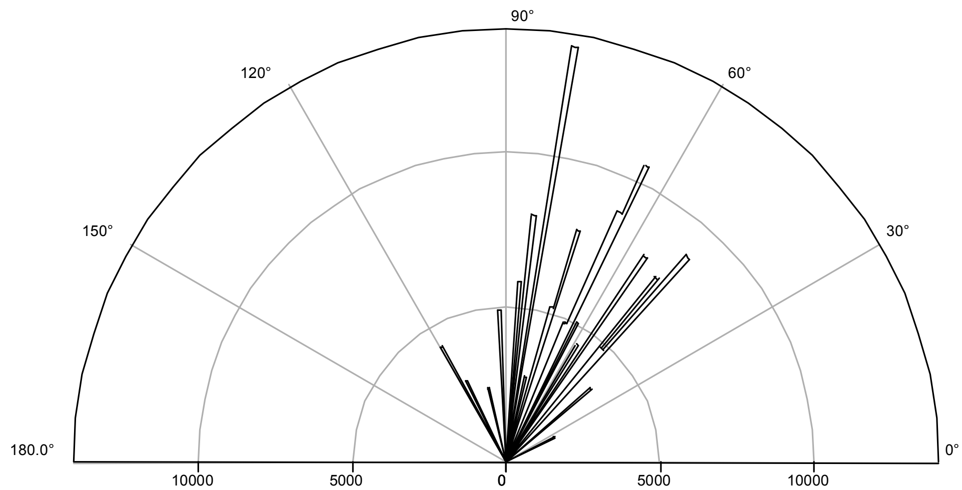


Fig. 9: Rose Plot of Lineaments derived from Aeromagnetic Data of the Study Area

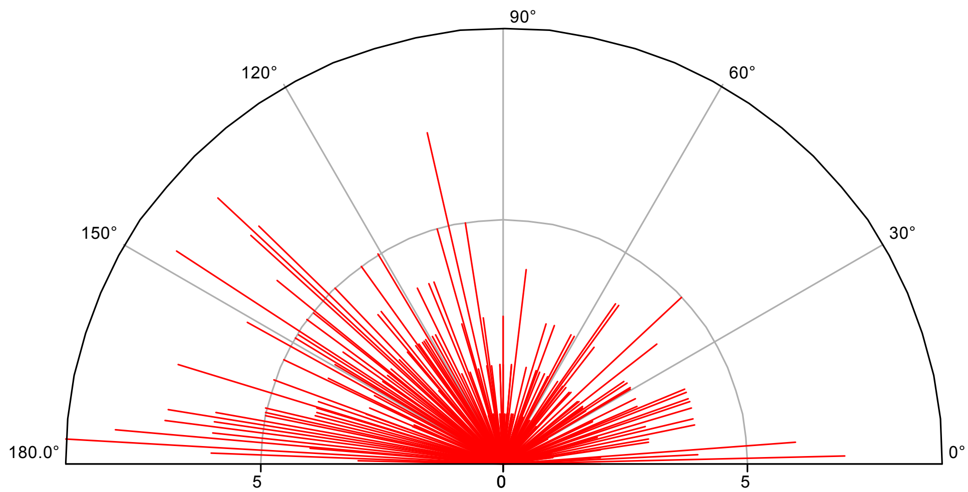


Fig. 10: Rose Plot of Lineaments derived from Spot Image of the Study Area

**Mineralization:** The richest and most extensive alluvial deposits of tin and columbite in Nigeria have been shed from the biotite – granites of the Jos – Bukuru complex. All the biotite – granites are known to be tin bearing and contain columbites as an accessory constituent. In the Rukuba complex area, there are abundant small intrusions of albitic biotite – micro granite which are accompanied by a considerable amount of tin mineralization. There is a large intrusion of albitic microgranite, north of the Rukuba River in the Central area, this has high columbite values.

A vein bearing thin lenticles of galena in green micaceous greisens occurs about half a mile north of the kigom hills below the Plateau escarpment. Columbite occurs in this area and deposits of molybdenite have been discovered and worked recently at the Northern margin. Finally, cassiterite is found in the overlying hornblende – fayalite – granite, where it has been metasomatized by Daw biotite granite in Ganawuri Complex.

## CONCLUSION

A follow up field mapping confirm the structural trend (NE – SW, NW – SE, E – W and N – S) in the study area.Also, a follow – up ground check revealed that some of the lineaments are fractures. Significant is the fact that these fractures continue into the basement complex and show the same general trend as those in the granite.The fracture traces localized within the complexes itself may represent "Relaxation joints". These relaxation joints show up in microscopic scales and they may have played a significant role in controlling mineralization. (Ashano, 2001, Ananaba & Ajaikaye, 1987).

Lineaments (faults) represented by pattern breaks, trending NE – SW and NW – SE. These pattern breaks have been retraced geologically but are known to agree with the general structural grains, confirming the Pan African and Transvaalian orogeny that has occurred in the Nigeria basement (Rahaman, 1988; Ogezi, 1988). The length of these lineaments (Fig.1) ranged from 0.4kilometres to 6.5 kilometres.Mineralization in this area is controlled by structural trends. The mineralized ducts are bounded by faults. The minerals in the mineralization vein are: Tin and Columbites, associated with the biotite granite and cassiterite which is associated with hornblende – fayalite granite Raeburn & Bain, 1926). Major rocks types include Diorite, Migmatite, and biotite granite. It is recommended that Nig. Sat 1 Images should be used alongside other geophysical data in the study area for mineral exploration. This will enhance the knowledge of surface structures (abundance and trend) and mining of shallow placer deposits.

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