The Use of Nigeria SAT-1 and GIS in Assessing the Mineral Potential of Rafin-Gabbas, North Central Nigeria


Abstract: This study represents a part of an ongoing research program to evaluate the lithologic mapping capabilities of NigeriaSat-1. Rafin Gabas is located in Nassara state and falls within the Younger Granite province of Nigeria. Wolframite and cassiterite have been found to occur within this area. The topographical map of the study area was generated from the SRTM (Shuttle Radar Topography Mission Data). The DEM was converted into a contour map using the ERDAS and ArcView softwares. The NigeriaSat-1 image of the area was subjected to various image processing techniques such as edge enhancement, principal component analysis and filtering. Samples from wolframite-bearing-quartzite veins were analysed and old tin mines were studied. The various ancillary data were integrated in ILWIS software. Geological information such as lithological boundaries and lineaments were derived from the NigeriaSat-1 image. The lineaments were found to occur in the NE-SW direction and they range in length from 300 Km to 2.5 Km and some cut across rock boundaries. The results of the XRF analysis show an average of 62% Wo4. Tailings from the old mines were observed to contain some amounts of Cassiterite which could be reworked. The various data generated were integrated in a GIS environment and a mineral probability map was produced. This study has shown that the application of a GIS to efficiently display, analyze and model complex spatial relations between remotely sensed data and other geologically descriptive variables allows the user to develop and test many more hypotheses regarding the significance of remotely sensed data in mineral resource investigations than would be possible using manual techniques alone.

Key words: Lithologic mapping, DEM, Rock boundaries, GIS, Manual techniques

INTRODUCTION

The project area is located at Rafin Gabas in Nassara State of Nigeria (Fig. 1). The Rafin Gabas area is located at lat. 8°27'N and long. 8°00'E and lat. 8°35' N and long. 8°07' E (Fig. 2) and falls within Topo sheet 230NW (Domwa) and Akwanga sheet 209. It is about 12.6km SE of Agwada town. The area is accessible by an untarred road from Agwada. A key function of many forms of quantitative mineral resource assessments [1,2] is the estimation of the number of undiscovered deposits.

Wolframite is the dominant ore of tungsten with a chemical composition of (Fe,Mn) WO4. It is usually brown-blackish, reddish or grayish in colour. The colour variation is due to the presence of impurities. This mineral has a specific gravity (S.G) of 7.3 and hardness of about 4.3-4.5. When smashed with a hammer, it breaks unevenly or brittles. The ore is usually associated with hydrothermal or pneumatolytic veins/greisens in igneous and metamorphic rocks. Most of the mineralization is found within quartz veins within the country rocks. Quartz is one of the most abundant minerals found in the rocks of the earth crust and formed under a wide range of Pressure-Temperature conditions prevailing in the crust. In different crustal environments, quartz is crystallized from silica melt, precipitated from aqueous solution or formed as a result of solid state transformation during metamorphic events. Such metalliferous quartz veins are known to have formed usually at temperatures of 200 to 500°C and 1 to 3 kb pressure, few kilometres below the surface.
Fig. 1: Map of Nigeria showing study area

Fig. 2: Topographical Map of study area

General Geology: The wolframite deposit at Rafin Gabas, forms part of the Pan-African mobile belt and lies between the Pan-African mobile belt and lies between the West African and Congo Cratons and south of the Tuareg shield [3-7]. The Palaeozoic and Precambrian rocks in northern Nigeria can be divided into four major groups.

1) The Basement Complex (sensu stricto) underlies the entire area and includes all rocks older than the late Proterozoic metasediments. It includes metasediments of high metamorphic grade such as paragneiss, basic and calcareous schist, marble and quartzite, as well as orthogneiss and possible (Eburnian) granite. The whole basement has been through at least two tectonic-metamorphic cycles and consequent metamorphism, migmatisation and granitisation has extensively modified the original rocks so that the generally occur as relict rafts and xenoliths in migmatites and granites.

2) More extensive areas of gneiss and ancient metasediments occur in north-west Nigeria. The metasediments recognized within the Basement Complex are believed to be relics of an old supracrustal cover of probable Birrimian age and are termed Older Metasediments in order to distinguish them from late Proterozoic supracrustal sediments which are known as the Younger metasediments.

3) Younger Metasediments- form well defined north-south trending belts which are extensively developed in the north-south. The rock types are varied ranging from psammitic to pelitic sediments of low metamorphic grade, with occasional conglomerate facies and interbedded lavas. They have been steeply folded along with the Basement Complex during the Pan-African orogeny, so that they now occur in synclinorial keels in a sea of granitic material, resembling the greenstone migmatite association of cratonic regions [8].

4) The Older Granite Series- includes rocks intruded during the Pan-African orogenic cycle. The earliest rocks appear to be basic and intermediate intrusives represented by small, irregular bodies of quartz and pyroxene diorite and gabbro. Granitisation on an extensive scale profoundly modified earlier rocks and resulted in widespread migmatites and granitic rocks. This granitisation culminated in the intrusion of a diverse and widespread suite of syn-to late-tectonic granites, granodiorites and syenites.

5) Volcanic rocks- are the youngest rocks recognised in both north-west and north-east Nigeria. They belong to a post-Older Granite episode of high level magmatic activity.

Field Geology: Rafin Gabas and its environs were mapped and the rock type encountered include: (Fig. 3).

- Coarse grained silicified biotite granite
- Dark grey fine-medium grained amphibolite
- Granite gneiss
- Coarse grained quartz schist

The coarse grained silicified biotite granite (Younger granite) occurs as undulating hills trending generally North-South. The Rafin Gabas village is located in the valley between two of such hills. The low lying outcrops are usually decomposed and greissenised. The granite is
composed of quartz, microcline perthite, mica + muscovite and ferromagnesium minerals. Tin, wolframite, Topaz chalcopyrite are disseminated or are found in pockets on this rock.

Amphibolites are dark grey medium grained rocks occurring as boulders/low lying outcrops in contact with gneisses. Boulders of amphibolite also occur at latitude 08° 29.55′N and longitude 08° 02.52′E. Quartz schist occurs together with mica schist and quartz boulders on the crest and slopes of the ridges. It is a brown white fine-sugary grained rock consisting of mainly quartz, feldspars and sericitic mica on the its surfaces.

Biotite-gneiss also form part of the rock type in the project area. They are characterized by abundant oligoclase and contain little microcline. They are well foliated. The granite gneisses are formed under low to medium grade metamorphism, though rare occurrences of high grade charnockitic rocks have been noted elsewhere. Those gneisses with high content of mafic minerals may weather to clayey soils.

Structures/Mineralization: The wolframite mineralization of the Rafin Gabas area is confined to biotite granite and the gneiss/amphibolite group which borders the granite. Two types of mineralization phenomena were recognized.

- Drusy type- this occurs as spherical clots/drusy cavities in the granite with crystallized quartz projecting from the walls of the cavities towards the centre. These cavities were found to be mineralized with Tin, Topaz and wolframite.
- Lodes, veins and stringers- is the most important type of mineralization in the area. The quartz veins, veinlets and stringers in which wolframite mineralization is associated were found to traverse the coarse grained biotite granite and the schists.

The veins, where exposed trend generally in the North-South (NW-SE or NE-SW) and dip (50-70) W. Traceable length range from 0.5 m-10 m and few cm to about 3 m wide as in the case of Husseni’s paddock and Daban ungwan kwano sites. The associated minerals include the milky white fine-sugary textured quartz, chalcopyrite, pyrite, sphalerite and galena which are subordinate.
One of the wolframite sites is located at lat. 08° 29.55'N and long. 08° 02.52'E on an elevation of 321 m. It is 2.38 km south (180° bearing) from Rafin Gabas. This paddock is about 20 m long, 15 m deep and about 7 m wide. Two types of country rocks were identified:

- A low-lying dark coarse-grained silicified biotite granite in which some parts have been decomposed to a yellowish brown coarse-grained granite with clay in fillings in the fractures. The granite outcrop extends NW-SE about 3 km long by 200 m wide.
- A dark greenish fine-grained amphibolite occurring as fragments/boulders scattered with the granite rocks in and around the paddock. The presence of amphibolite suggests minor basic intrusion in the area.

A quartz vein striking NW-SE (165) and dipping west (50-60) has been exposed in the pit at a depth of about 20 m. This vein is about 2.5-3 m wide, although not fully exposed and 6 m long. The vein is composed predominantly of fine milky quartz in which wolframite crystals may be embedded. Some pockets of large crystals of biotite were observed in the fabrics of the quartz vein.

Two wolframite-bearing quartz veins are located at lat. 08° 29.5'N and long. 08° 06'E on an elevation of 149 m. This vein is 7 km SE of Rafin Gabas. The two veins are being worked here by artisanal miners and the bulk of wolframite production comes from this site currently. The miners work both the primary and the alluvial deposits.

Another wolframite-bearing quartz vein is located on a flat terrain adjacent to the western side of quartz schist ridges. It has a coordinate of lat. 08° 29.5' N and long. 08° 06.06' E on an elevation of 168 m.

Dip of vein = west (50)
Over burden thickness = 1-1.5 m
Length of intermittent exposed vein = 150 m
Width of excavation = 4-5 m
Host/country rock = dark coarse-grained biotite granite and reddish brown laterite cover.

Another wolframite-bearing quartz vein is is located at lat. 08° 29.7''N and 008 06.32'E on an elevation of 169 m. Vein 2 is about 60 m west of vein 1 and trend parallel/sub parallel to each other in the NW-SE direction.

Dip of vein = west (45-50)
Over burden thickness = 1 m
Length of intermittent exposed vein = 100 m
Average width of vein = 2 m
Texture/colour of quartz vein = fine grained milky while quartz

**Cassiterite Sites:** A cassiterite site is located at lat. 08° 30.54'N and long. 8° 02.74'E on an elevation of 342 m. The old paddock is about 50 m long, 20 m wide and 15 m deep. The country rock is a pinkish coarse-grained biotite granite.

No exposed vein was observed. But the old excavation for tin on the granite trend 130 (NW-SE) which is believed to be the trend of the tin lode that was mined in those days. This pit is filled with water. It is therefore possible that when the pit is dewatered and cleaned, the vein may be exposed.

Sulphide mineralization was observed on the excavated debris/dump, especially chalcopyrite, pyrite and little sphalerite and galena. The granite is silicified and contain quartz veinlets/stringers which may be mineralized with tin and or wolframite. Another site is located at lat. 8° 29.26' N and long. 8° 02.8'E on an elevation of 325 m.

The site is about 481 m from Rafin gabas village. It was reported by a villager that work stopped here about 9 years ago due to lack of equipment to work the deposit at depth. It was also reported that aquamarine was mined in this site. But no pegmatite vein was observed in this area. The old working covers an area of about 100 m long 50 m wide.

A third cassiterite site is located at lat. 08° 30.55' N and long. 08° 02.66'E on an elevation of 330 m near an old mining camp. This site is about 1 km SE of Rafin gabas. The old working has a length of about 115 m, 60 m wide and 30 m deep. No vein was seen exposed, but sulphide minerals (Chalcopyrite, pyrite) were visibly seen in the old mine dumps. It was reported by the villager that large quantity of tin was mined here some years back. Work stopped due to the lack of equipment to work the deposit at depth. The country rock is a coarse grained decomposed granite.
Potential Sites for Cassiterite: A potential site is located at lat. 08° 30.34' N and long 8° 02.88' E on an elevation of 290 m. The site is about 1.5km SE of Rafin Gabas situated on small isolated outcrops of coarse grained biotite granite which is highly fragmented. A grayish black dyke with quartz grains striking 110 (NW-SW) was observed to traverse the granite. This dyke (suspected mineralized vein) is about 0.8m wide and was traced 30m along strike. A second potential site is located at lat. 08° 30.32' N and long 8° 02.8' E on an elevation of 321m. A grayish black dyke striking 125 (NW-SE) was observed on a coarse grained granite. The dyke is about 1.2m wide and was traced to about 10m long. It is medium grained in texture and is composed of quartz, pink feldspars, sulphides and ferromagnesium minerals.

Potential Wolframite Sites: A potential wolframite site is located at lat.8° 30.28"N and long. 8° 02.89"E on an elevation of 317m. The site is about 1.3km SE of Rafin gabas village. It is situated on a low lying coarse grained silicified biotite granite. Quartz veinlets and lenses were observed on this granite boulders containing some specks of wolframite. The mineralization here appears to be both primary and eluvial.

Remote Sensing Analysis: Remote sensing has been variously defined but basically it is the art or science of telling something about an object without touching it [9]. It is also defined as ‘reconnaissance at a distance’ [10]. In general, remote sensing is the practice of deriving information about the earth’s land and water surfaces using images acquired from an overhead perspective, using electromagnetic radiation in one or more regions of electromagnetic spectrum, reflected or emitted from the earth’s surface. NigeriaSat-1 image covering the area of study was enhanced with Landsat data through a process known as pan-sharpening using the ERDAS imagine 8.6 at the NCRS’s image processing lab. The resultant image (Fig. 4) gave a better spectral resolution. Rock boundaries and lineaments became clearer. Digital processing of the satellite image for the study area generated several products ranging from single band images, colour composites (4,3,2 in RGB) and principal component images.

Some of these information were helpful in producing the topographical map. A lineament map of the area is shown in Figure 5.

XRF Analysis: Samples were taken from four mineralized veins and analysed in an XRF analyzer in the laboratory.
of CAMEC Nig Ltd, Jos. The stationary X-Ray spectrometer is based on the method of the Energy-Dispersive-X-Ray-Fluorescence analysis (ED-XRF). The atoms in the sample material, which could be any solid, powder or liquid, are excited by X-Rays emitted from a X-Ray tube or radioisotope. For increasing sensitivity the primary excitation radiation can be polarised by using specific targets between the X-Ray tube and the sample (ED-Polarisation-XRF). All element specific X-Ray fluorescence signals emitted by the atoms after the photoelectric ionisation are measured simultaneously in a fixed mounted semi-conductor detector or sealed gas-proportional counter. The radiation intensity of each element signal, which is proportional to the concentration of the element in the sample, is recalculated internally from a stored set of calibration curves and can be shown directly in concentration units. The results of the analysis is shown in Table 1 below.

**CONCLUSION**

The wolframite deposit here was found to be associated with quartz veins, veinlets and lenses as the primary deposits. The eluvial deposits are associated with decomposed granite, schist (in the case of Ungwan Kwano) and amphibolite. The quartz vein trend generally North-South and dip Westward. The width of individual veins and range from a few cm to about 3m, while the length of the individual veins also vary and range from a few cm to 10m. sulphide minerals (chalcopyrite, pyrite, sphalerite and galena) are associated with the wolframite and cassiterite mineralization in the area.

There is no doubt that a potential for wolframite and cassiterite exist in the Rafin Gabas area under investigation. Finding such deposits will however involve a lot of systematic sampling and prospecting. These veins/veinlets/stringer in the granite and gneisses are of great potential. Finding and working such veins at depth may be profitable since their presence can be indicated by wolframite released in the soil as eluvial deposit in their vicinity.
vicinity. Mineralized veins could also be a source of primary wolframite as observed in Ungwan kwano and Husseni’s sites. Although they may be unevenly distributed, there are likely to be many of such veins waiting to be discovered. The alluvials too may have some potentials as the streams draining the area have not been investigated.

The lineaments extracted from the Nigerasat-1 image are also potential conduits for mineralization especially where they are cross-cutting. The XRF analysis also shows that the mineralized quartzite veins have a minimum of 60% wolframite content which is good for the international market.

**Recommendations and Suggestions:**

- Since some of the known occurrences of wolframite were found in veins that are less than 1m long, data from a higher resolution satellite such as SPOT can be integrated with data from the Nigeria Sat-1 image to map smaller lineaments/structures.
- Structural studies on the area in order to define the genetic relationships between the mineralization and the different systems of fractures.
- Most of the mineralized veins could be deep-seated and can only be detected through geophysical methods such as electromagnetic and gravity methods which are highly recommended.
- Earth moving equipment like excavator and bull-dozer be sourced immediately and moved to site to open, up Husseini’s Paddock and other areas of interest so as to boost production.

**REFERENCES**