IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⁒ Vol. 9, Issue 5, May 2022

DOI: 10.17148/IARJSET.2022.9511

INVESTIGATION OF NICKEL MINERALIZATION IN MALAM TANKO SERPENTINITE SHEMI, KATSINA STATE, NORTH WEST NIGERIA

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Abstract: The MallamTanko serpentinite forms a discontinuous north-south trending body with sharp contacts against vertically foliated and finely banded biotite-rich gneisses and schists, which pass rapidly outwards to more massive quartzo feldspathic gneisses and migmatites. Two blocks of potential ore body have been defined, comprising 29million tonnes of nickeliferous serpentinite of 1.2%Ni (350,000tonnes Ni approx.) and 1.2million tonnes of 1.7%Ni (21,000tonnes Ni approx.), all in the inferred category of resource. The Nickel is in serpentine and Cr-hematite. No sulphide or silicate nickel mineral was found in the serpentinite body.

I INTRODUCTION

Serpentinite occurrences have been reported along the Anka fault as aligned bodies that are traceable intermittently for about 150 km, from Ribah through Tugan Kudaku and Maikwonaga to SadoSerpentinite (Wright and Ogezi, 1977; Onyeagocha, 1979). Another serpentinite body at MallamTanko is an 8-km string of small bodies aligned N-S in gneissic rocks. Serpentinite was also reported in the Federal Capital Territory, about 300 km due south of the northwestern occurrences. The serpentinites are typically intrusive bodies up to 15 km in length and 1 km in width, although most are much smaller. Pods and dissemination of chromite have been found in some serpentinites which are also associated with anthophyllite asbestos, talc and magnesite Serpentinite (Onyeagocha, 1979) suggesting a peridotite origin brought to the surface from upper mantle regions through thrust faults. Some derived soils of limited extent over the serpentinites and other ultramafic-mafic rocks are enriched in nickel.

II REGIONAL GEOLOGY AND STRUCTURE

The basement complex is one of the three major lithological components that make up the geology of Northwestern Nigeria. The Nigerian basement complex forms a part of the Pan-African mobile belt and lies between the West African and Congo Cratons and south of the Tuareg Shield which was affected by the c. 600Ma Pan-African. The Pan-African deformation was accompanied by a regional metamorphism, migmatization and extensive. Late tectonic emplacement of granites and granodiorites and associated contact metamorphism accompanied the end stages of this last deformation. The end of the orogeny was marked by faulting and fracturing which have a consistent NE-SW and NW-SE trends (Fig 1).

Within the basement complex of Nigeria three major rock groups are distinguishable (Fig 1), namely:

i). The Migmatite–Gneiss Complex

ii). The Schist Belts (metasedimentary and metavolcanic rocks)

iii). The Older Granites (Pan African granitoids)

i). The Migmatite–Gneiss Complex This is a polymetamorphictnigmatite-gneiss complex composed largely of migmatites and gneisses. The migmatite-gneiss complex is considered to be the basement sensustricto, and most radiometric ages lie in the range 600 ± 150 Ma, dating the imprints of the Pan-African orogeny, but with relict Eburnean (c. 2000 Ma) and Liberian (c. 2700Ma) ages obtained in many localities. Metamorphism is generally in the amphibolite facies grade. (Holt, et.al 1978).

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ii). The Schist Belt (Metasedimentary and Metavolcanic rocks) The supracrustal schist belts consist dominantly of schists, phyllites and quartzites with minor volcanic rocks, banded iron formations and conglomerates. Metamorphic grades are variable from amphibolite facies in the southern belts to predominantly greenschist facies in the northern belts. The dominant tectonic fabric is a steeply dipping N-S phyllitic to slaty cleavage arising from isoclinal folding. Radiometric ages of the schist belts range between c.1100 Ma (Kibaran) and c. 600 Ma (Pan-African).

iii). The Older Granites (Pan-African Granitoids) These are syntectonic to late tectonic granitic rocks, which cut both the migmatite-gneiss complex and the schist belts. The granitoids include rocks varying in composition from granite to tonalite, with smaller bodies of syenite, charnockite and gabbro. They have generally yielded radiometric ages in the range of 750-500 Ma, corresponding to the Pan-African age

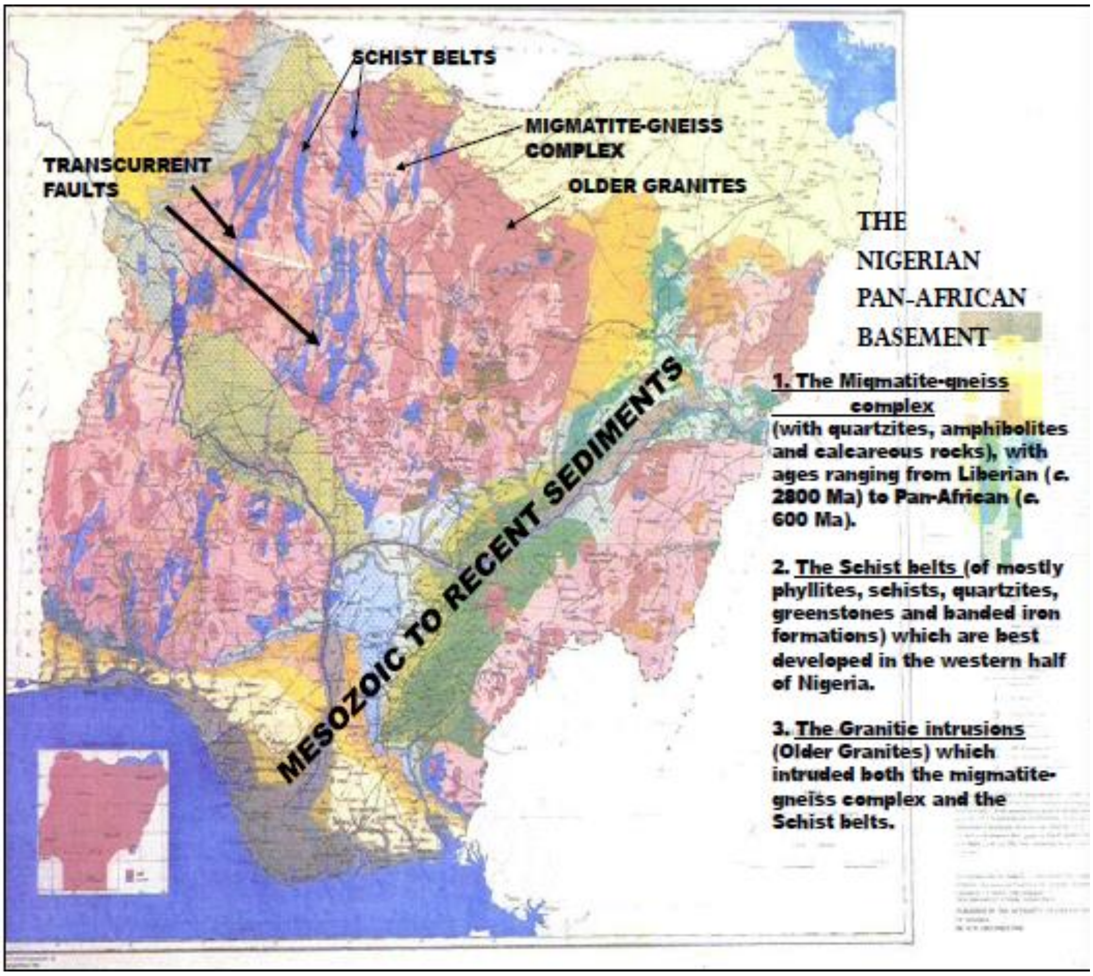

Figure 1. Geological map of Nigeria showing the main rock groups and transcurrentfaults, (NGSA 2010)

The Mallam Tanko Serpentinite

The area of interest is made of a pear-shaped body of serpentinite, diorite, amphibolites and greenstone bounded by gneisses to the east and porphyritic granites to the west (Figure 1). The serpentinite and associated rocks are collectively known as the MallamTanko Serpentinite (Wright and Ogezi, 1977; Onyeagocha, 1979). The basic-ultrabasic rocks appear to have been emplaced within a N-S trending fault zone; and the southern part where the serpentinite is more common is cut by some NE-trending faults. The serpentinite shows striated surfaces (slickensides) in many places. (McCurry 1973)

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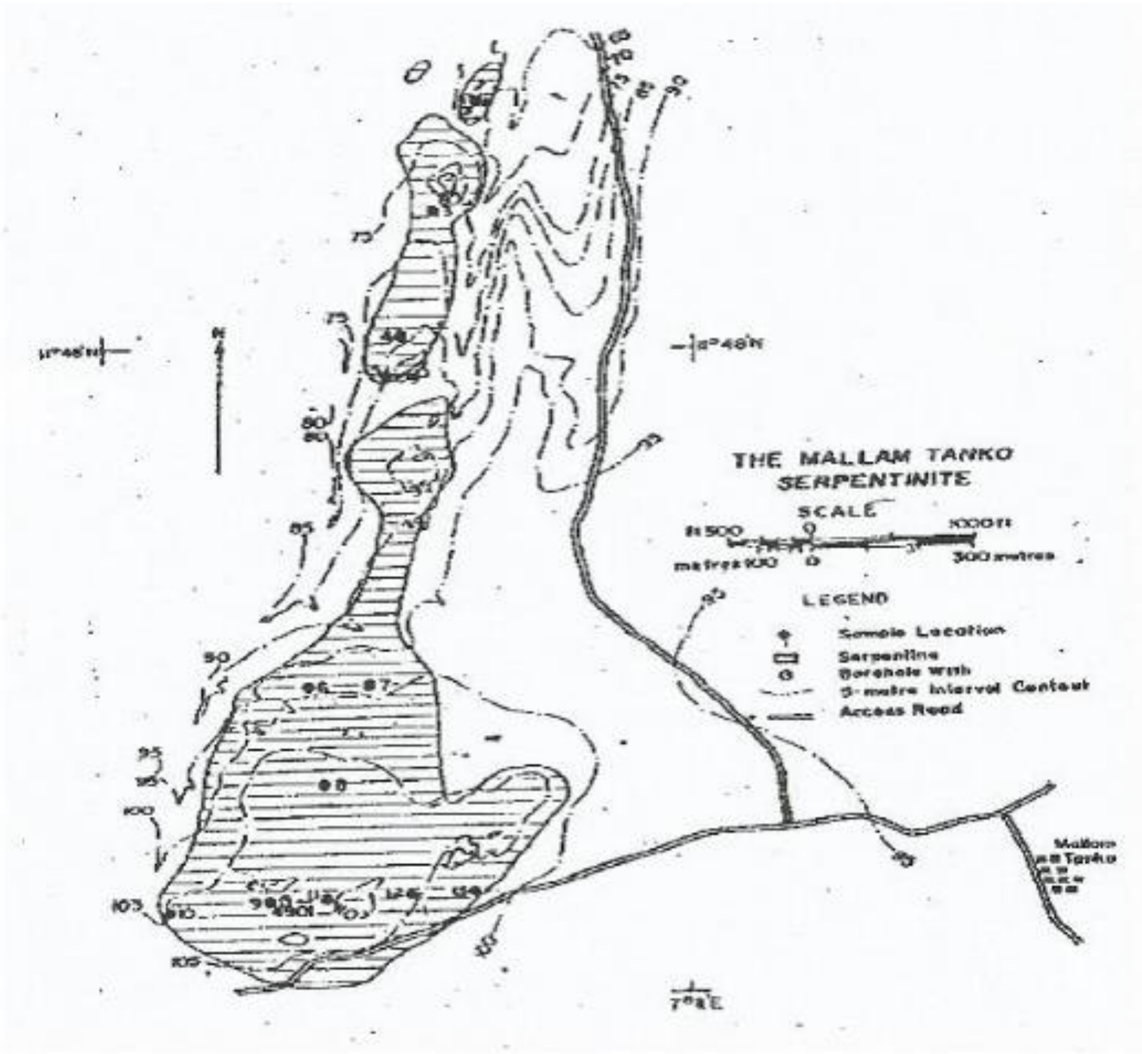

Figure 2. Geological Map of the MallamTanko Serpentinite (after Onyeagocha, 1979)

The serpentinite appears to represent tectonic blocks of possibly upper mantle peridotite emplaced along a faulted axial plane of a synclinorial fold and clearly postdates the surrounding Precambrian (Pan-African) country rocks.

Petrology

Rock chip samples were collected in a random manner at locations where outcrops are available. This has resulted in the collection of about 46rocks samples of serpentinite of varying degree of alteration and weathering.The serpentinite mass composed of serpentine (84-94 wt.%) and in minor amounts, other silicate minerals as talc, chlorite, tremolite, anthophyllite and tiny remnants of olivine. The original peridotite silicate minerals have been so completely serpentinized and mineralogically reconstituted (Shibayan 1985). Opaque minerals present are mostly Cr-hematite, magnetite-hematite and goethite (3-5 wt.%). Veins of anthophyllite asbestos and zeolites appear as late structures in the serpentinite. Full mineralogical analysis has been done by the Activation Laboratories, Ancaser, Ontario Canada. The data is in Appendix 2 and also presented in Table 1 and Figures 3-4.

The degree of alteration, mostly silicification, varies from mild to intense where there is almost complete replacement of the serpentine and other green minerals by quartz.

Table 1. Modal mineralogical composition of the serpentinite

Measurement Type		BMA		
Sample Name	**S3**	**S239**		**S108**
Mineral Mass (%)				
Sulfides	Chalcopyrite	0.000	0.002	0.000

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Pyrite	0.002	0.002		0.000
Oxides/Hydroxides	Magnetite/Hematite	0.83	1.92	0.82
Hematite-Cr	**3.21**	**0.12**		**1.61**
Goethite	0.77	1.34		0.62
Rutile	0.00	0.00		0.00
Chromite	0.00	0.68		0.00
Silicates	Quartz	0.22	4.76	8.90
K-Feldspar	0.00	0.01		0.00
Plagioclase	0.00	0.00		0.00
Mica	0.01	0.00		0.00
Clinochlore	0.18	0.02		0.10
Amphibole	0.00	0.01		0.03
Hornblende	0.00	0.00		0.00
Serpentine (Mg-Serpentine)	**89.21**	**77.33**		**64.64**
Serpentine-Altered	**4.50**	**10.01**		**19.57**
Antigorite (Fe-Mg Serpentine)	0.20	1.27		0.28
Talc	0.07	0.56		1.73
Si-Al Clays	0.00	0.00		0.00
Zircon	0.00	0.00		0.00
Phosphate/Carbonates	Apatite	0.00	0.00	0.00
Dolomite	0.00	0.00		0.00
Calcite	0.00	0.00		0.00
Mixed-Unclassifiable Spectra	Goethite/Clay Mixed	0.00	0.02	0.11
Low Counts	0.02	0.03		0.03
Others	0.78	1.92		1.55
Sum	**100**	**100**		**100**

Mineral Volume (%)			
Chalcopyrite	0.00	0.00	0.00
Pyrite	0.00	0.00	0.00
Magnetite/Hematite	0.41	0.94	0.40
Hematite-Cr	**1.58**	**0.06**	**0.79**
Goethite	0.52	0.91	0.42
Rutile	0.00	0.00	0.00
Chromite	0.00	0.37	0.00
Quartz	0.21	4.69	8.76
K-Feldspar	0.00	0.01	0.00
Plagioclase	0.00	0.00	0.00
Mica	0.01	0.00	0.00
Clinochlore	0.18	0.02	0.10
Amphibole	0.00	0.01	0.03
Hornblende	0.00	0.00	0.00
Serpentine (Mg-Serpentine)	**91.43**	**79.03**	**66.00**
Serpentine-Altered	**4.61**	**10.24**	**19.99**
Antigorite (Fe-Mg Serpentine)	0.20	1.29	0.28

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Talc	0.06	0.53	1.62
Si-Al Clays	0.00	0.00	0.00
Zircon	0.00	0.00	0.00
Apatite	0.00	0.00	0.00
Dolomite	0.00	0.00	0.00
Calcite	0.00	0.00	0.00
Goethite/Clay Mixed	0.00	0.01	0.08
Low Counts	0.02	0.03	0.02
Others	0.76	1.87	1.51

There are no sulphide or silicate nickel minerals in the modal composition of the serpentinite. The nickel is therefore within the crystal structure of Serpentine and Hematite-Cr (Figures 3-4). The hematite, and goethite may be alteration products of an original ultrabasic magnetite. There is also no indication whether the nickel values are related to the degree of alteration and or weathering. Since lateritization is not observed over the serpentinite and associated rocks to any reasonable degree, the possibilities of nickel enrichment in the weathered residuum is not considered during this study.

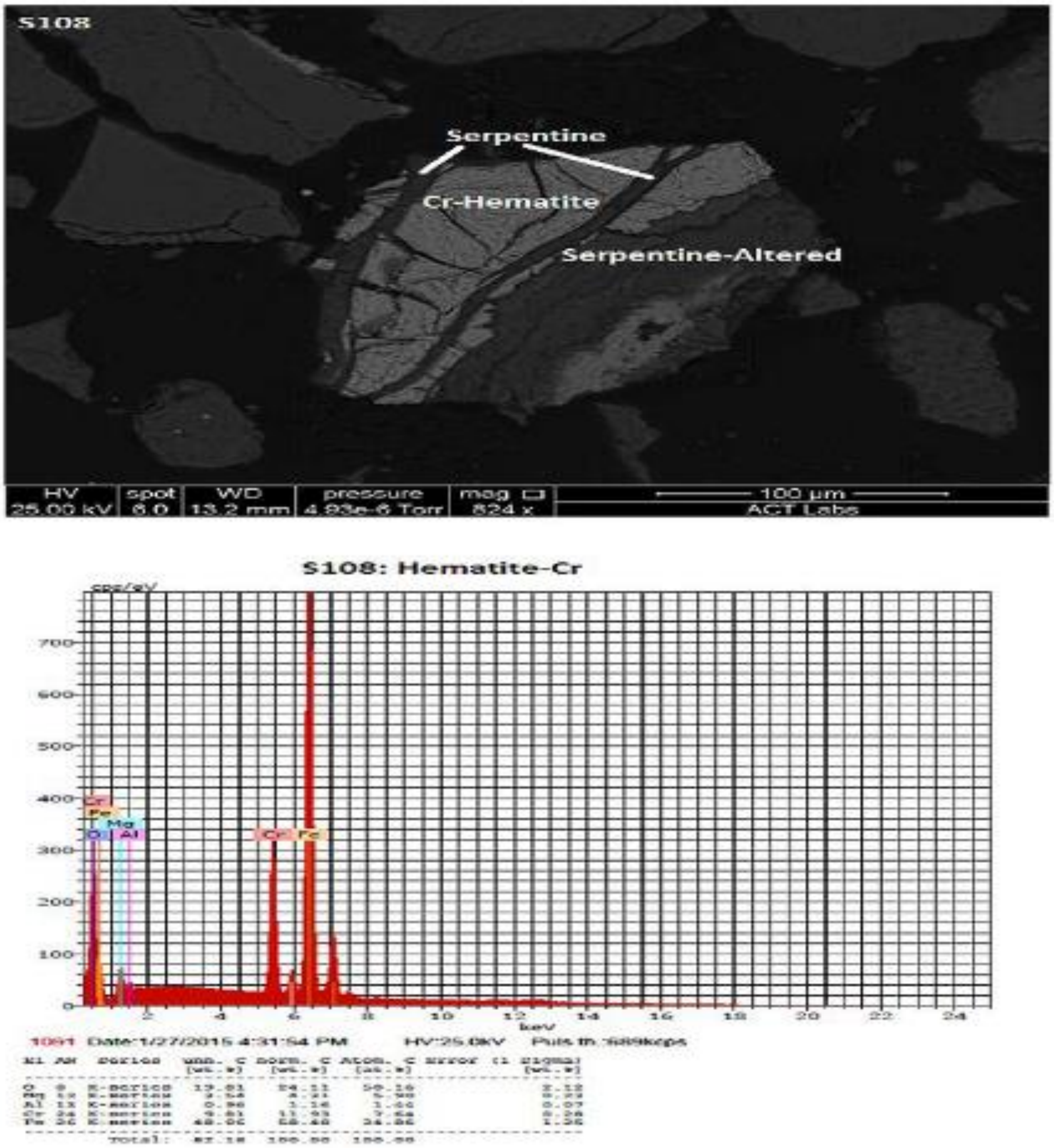

Fig 3. BSE Image and representative EDX Spectrum of Sample in Serpentinite with Pod

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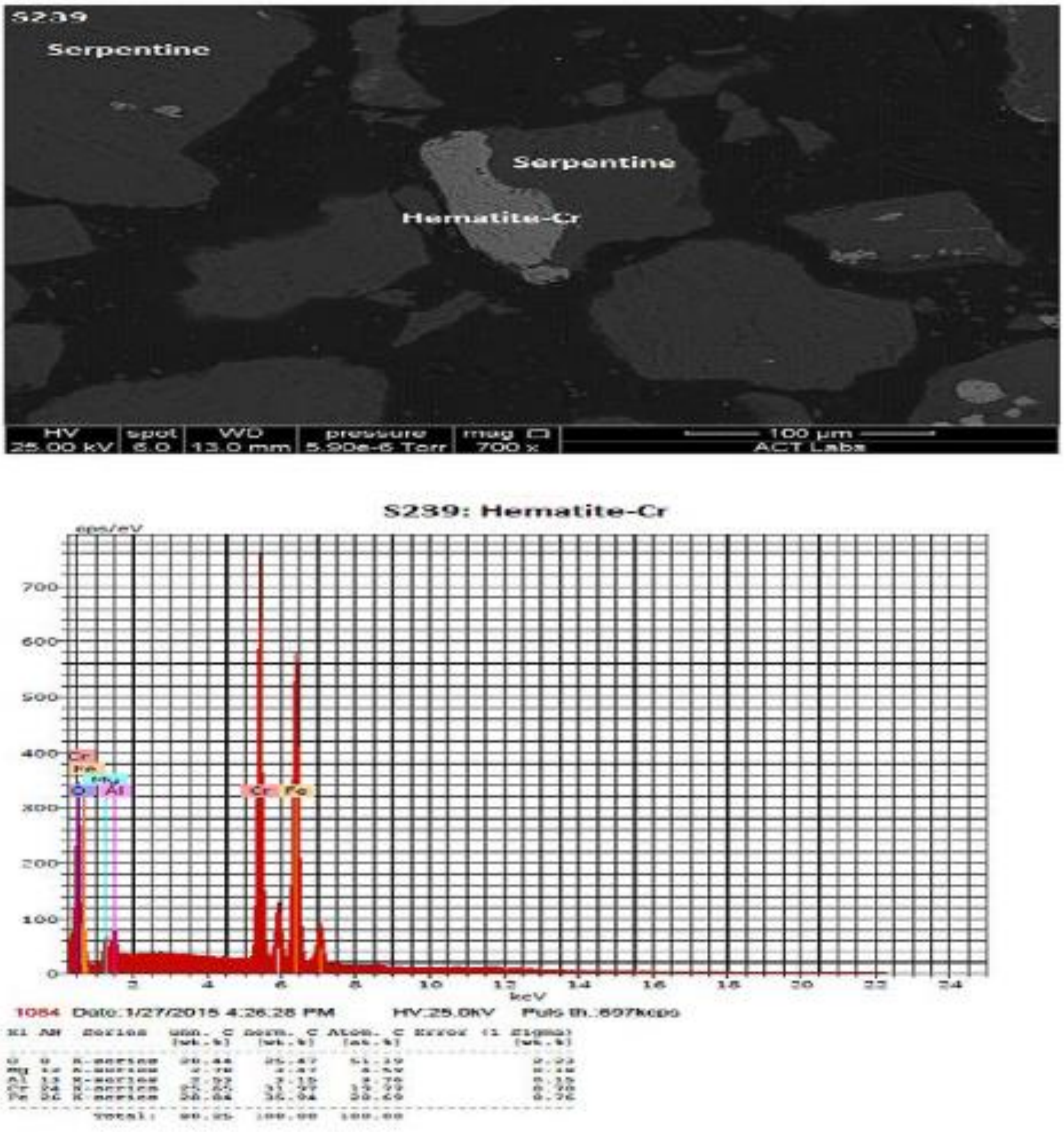

Figure 4. BSE Image and representative EDX Spectrum of sample of massive Serpentinite

NICKELIFEROUS SERPENTINITE OREBODY

Surface Expression

The surface shape and extent of the serpentinite body as revealed from detailed mapping shows blocks of serpentinite and associated rocks (diorite, amphibolites, greenstone) within a major north-south trending fault zone cutting mostly Pan-African (600±!50 Ma) porphyritic granite. Along the fault margins the granite is intensely deformed resulting in the formation of mylonites (phyllonites), best developed in the western margins.

DISCUSSION

i) The highest Ni values are recorded from two blocks where relatively fresh serpentinite is abundant (Block A, Block B). In these blocks the average Ni grade ranges from 1.2% (Block A, 13 samples) to 1.7% (Block B, 2 samples).
ii) The highly altered (silicified, leached, weathered) serpentinite and other basic rocks (diorite, amphibolite, greenstone) have predominantly the lowest nickel concentration (0.02-0.30%) as shown in Table 1.
iii) The overall average grade of all the samples analyzed (serpentinite, associated rocks and their altered varieties) is about 0.67% Ni.

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iv) In addition to Ni few other elements are enriched in the samples (Appendix 1), notably, Cr (up to 0.5%), Fe (up to 8%). However, these relatively high values do not constitute economic grades of the elements.

CONCLUSION

The serpentinite body is found to have suffered varying degree of alteration and weathering. The alteration consists of intense silicification which has almost completely replaced the serpentine and other mafic minerals with quartz and other forms of silica.

Nickel values in the serpentinite and associated rocks are varied but economic high values tend to cluster in some areas locally within the body, to constitute target blocks with grades about 0.5% to 2.2% (averaging about 1.2%). The intensely silicified serpentine and other basic rocks have nickel values 0.1% or less.

Two blocks of potential orebody have been defined, comprising 29 million tonnes of nickeliferous serpentinite @ 1.2% Ni and 1.2 million tonnes @ 1.7% Ni, all in the Inferred category of Resource.

There is no clear lateritic profile developed over the serpentinite body and therefore the possibility of laterite nickel occurrence was not investigated.

ACKNOWLEDGEMENT

Contributions from colleagues from the Department of Geology A.B.U. Zaria and Department of Mineral Resources Engineering, Kaduna Polytechnic is here acknowledged.

REFERENCES

1. Holt R., Egbuniwe, I.G Fitches, W.R and Wright, J.B (1978).The relationship between low-grademetasedimentary belts, calc-alkaline volcanism and the Pan-African orogeny in N.W Nigeria. Geol. Rundschau, 67:631-646
2. McCurry, P. (1973).Geology of Degree sheet 21, Zaria Nigeria. Overseas Geology and Mineral Resources No 45, H.M.O.S London.
3. Onyeagocha, A.C. (1979). The MallamTanko serpentinite: Petrology and economic implications. Journal of Mining and Geology, Vol. 16, No. 1, pp37-40.
4. Shibayan, Y. (1985).Investigation of possible chromite bearing serpentinites and associated rocks of NW Nigeria. Unpub. M.Sc. thesis, Ahmadu Bello University, Zaria, Nigeria.
5. Tennakone, K., Senevirathna, M.K.I. and Kehelpannala, K.V.W. (2007).Extraction of pure metallic nickel from ores and plants at Ussangoda, Sri Lanka. Journal of National Science Foundation of Sri Lanka, Vol. 35, No. 4, pp245-250.
6. Wright, J.B. and Ogezi, E.A. (1977). Serpentine in the basement of northwestern Nigeria. Journal of Mining and Geology, Vol. 14, No. 1, pp34-37.