Mineralization and Geochemical Investigation of Tin Deposit around Maigemu Village, Jos East LGA, North Central Nigeria

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Abstract

Principally, Tin exists in Nigeria as tin oxide (SnO_2) called cassiterite or tinstone, which is the chief ore of tin. It is widespread metal and the earth's crust contains about 0.0002-0.0008 per cent or 2 to 8 grams per tonne of rocks. The primary deposit is considered workable if they contain up to a minimum of about 0.3-0.5 per cent tin (3-5 kg to a tonne of ore). The aim of the investigation is to delineate the likely Tin mineralization occurrences in the study area so as to aid further exploration studies that will identify Tin rich targets worth investing resources for detail exploration project before mining. The area of investigation is typical of both the basement complex of Nigeria and the Mesozoic younger granite ring complexes which intruded the previous and covers over 80% of the study area. In assessing the mineralization potential of the research area, a preliminary geological and geochemical investigation was carried out with emphasis on the mineralization pattern and the local geology, as well as taken into consideration the location, accessibility and topography. Basically, there are two lithological (Migmatite gneiss and biotite granite) exposures encountered in the course of the mapping exercise, outcropping both within the river channel, the low-land and upland. A total of 18 soil samples and panned concentrates were taken from the accessible area with an average of 500m spacing between each profile and each sampling point. Geochemical analysis reveals that tin concentration ranges from 7ppm to 1112 ppm with a mean value of 142.89 ppm and a background value of 53ppm. The threshold value being 159 ppm, indicates that there are three (3) isolated anomalous tin values. Comparing the background value (53 ppm) with the crustal abundance (2.2 ppm), the concentration is relatively high and this is traceable to placer tin deposit from the younger granite series.

Key words*: Tin, Cassiterite, niobium, mineralization, Geochemistry*

1.0 Introduction

The study area is located at about 11km Southeast of Toro town (fig.1) with the northern boundary just about 800m south of Maigemu village which is under Jos East local government area of Plateau state. The concession area is bounded by longitude $9^0$10’45’’E to $9^0$13’00’’E and latitude 9^0 57’ 00’’N to 10^0 00’30’’E with few settlements in and around it. The investigated area has a rough and rugged terrain which is characterized by several hills forming chains of integrated uplands and covering over 80% of the landmass within the tenement. The high plains are characterized by the younger granite rocks forming both the inner and outer rings complex with hills ranging from 2500 – 4000 feet above the sea level

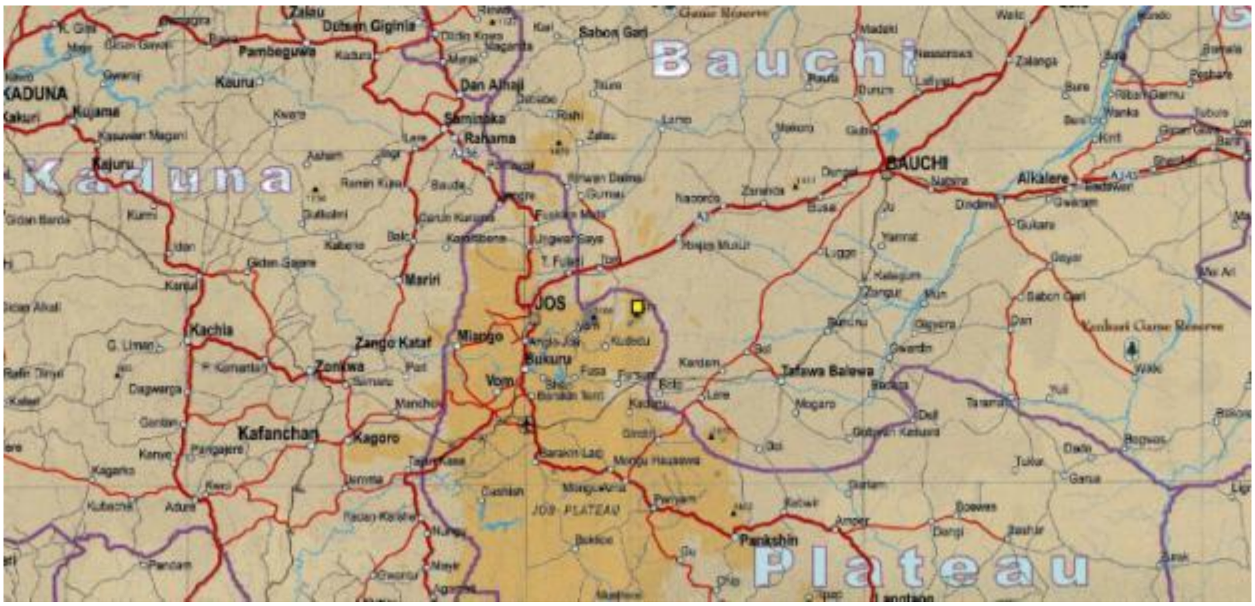

Fig.1 Map showing location of the study area in yellow shaded box

Nigeria is blessed with vast numbers of solid minerals in which tin deposit is not an exceptional. The mineralized pegmatites have yielded about 5% of the total cassiterite in Nigeria while over 95% was mined in the Younger Granite province and were won from alluvial deposits derived from tin –bearing granites and lodes (fig.2). Tin has been mined and used in Nigeria as early as the 9^{th} century with exquisite bronze artifacts from three sites in the Igbo-Ukwu area of Anambra State dating back to this period. These artifacts are older than the earliest Benin bronzes, which are dated to the 13th century (Kinnaird JA et al., 2016). Tin is a relatively soft, pliable and ductile metal with a silvery white colour. It is a metallic element (Sn) which occurs in group 14 (or IVa) and period 5 of the periodic table. The atomic number and atomic weight of tin are 50 and 118 respectively.

Tin and columbite-tantalite mineralization in Nigeria can be classified into three main types, two of which are primary while the third is secondary (Olade, 1980; Kinnard, 1984). The primary deposits were formed by magmatic and hydrothermal processes, whereas the secondary (placer) deposits are derived from the Younger Granite Province (Kinnard et al (1979). Ogunleye (2017) published a comprehensive review of tin mineralization in Nigeria, while the paper by Kinnard et al (2016) is a 'classic' on tin mineralization in Africa with substantial coverage of deposits in Nigeria. The three types of Sn-Nb-Ta deposit are:

1. Sn and Nb-Ta in Younger Granites
2. Sn and Ta-Nb in the Older Granite Pegmatite
3. Placer Deposit.

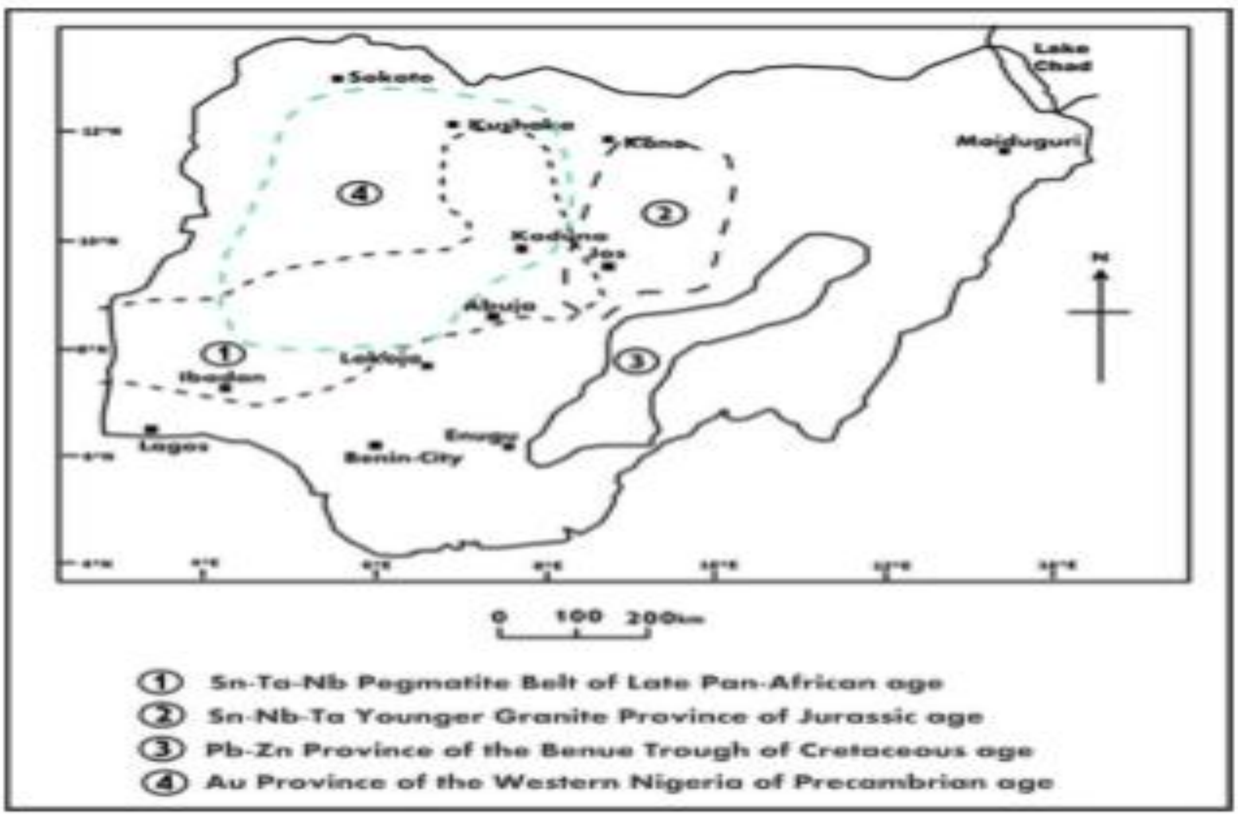

Fig 2: Metallogenic Map of Nigeria (modified after Okunlola, 2005

The origin of the Sn-Nb-Ta mineralization in the Younger Granite Province is related to the petrogenesis of the Younger Granites. Wright J.B (1970) suggested that cassiterite and its associated ore minerals in the Younger Granite ring complexes of Nigeria were not basement-derived, but originated at deeper levels as part of the primary melts. This suggestion was based on the premise that the Younger Granite magmas probably originated in the upper mantle, as salic melts, generated by pressure relief, partial melting, and a concentration of low melting constituents beneath a broad crustal dome, and modified by interaction with basement rocks. Tin ores occur in the Younger Granite complexes in two primary forms: (i) disseminations and (ii) veins and greisens. Disseminations of accessory cassiterite occur in association with columbite, tantalite and other ores (monazite, zircon, cryolite, rutile, ilmenite, beryl, molybdenite, sphalerite and chalcopyrite) in the roof zones and margins of peraluminous biotite granites in most of the Younger Granite Complexes, but known enrichment is focused in parts of the Jos-Bukuru, Tongolo, Tibchi, Dutsen-Wai and Afu complexes. The values in particular granite may vary from zero to over 400 ppm SnO_2 (Olade M.A. 1980, Imeokparia EG, 1988). There are two distinct groups of granites in Northern Nigeria which differ considerably in age, structure, and mode of origin. These are the Older and Younger Granites which range in composition from granite to granodiorite with subordinate diorite and quartz – syenites. The Younger Granite is discordant, high level, magmatic intrusion with strong alkaline affinities. Jacobson (1963) have attributed the age of Older Granite to early Paleozoic whereas the Younger Granite is Jurassic. Falconer (1921) first recognized the essential difference between the Older and Younger Granites when minerals surveyed in the Northern Nigeria was established in 1911. According to Macleod and Turner (1971), they described the general geology of Jos Plateau and confirmed the presence of economic minerals such as cassiterite (tin) and columbite (niobium). Small amount of cassiterite-tin ore and columbite-tantalite are from the pegmatite associated with the Older Granite. Other environments that have the Basement Complex comprising of the pegmatite and migmatite are Nasarawa State, Kaduna State, etc. Cassiterite (SnO_2), stannite (Cu_2SnFeS_4) and cylinderite ($Pb_3Sn_4FeSb_2S_{14}$) are the major ore minerals of tin. Tin ores occur mainly in veins, stockworks, disseminations, pegmatites, replacements and placers. Primary tin deposits are formed by magmatic, hydrothermal and/or replacement processes. Secondary deposits are the products of weathering of primary deposits, and the subsequent transportation and deposition of the resulting sediments in a new environment.

Some workers like J.A Kinnaird, (1984) and D. Kuster, (1990) have done localized studies of chemical compositional characteristics in relation to cassiterite mineralization and the Pan-African Granitic evolution. The geological heavy mineral survey for Nb-Sn-Ta mineralization carried out by J.A Kinnaird, (1984) identified two stages of mineralization in Nigeria, the earliest been related to the palaeozoic granites while the last stage of mineralization is found in younger granites.

2.0 Regional Geologic setting

The area of investigation is typical of both the basement complex of Nigeria and the Mesozoic younger granite ring complexes which intruded the previous and covers over 80% of the study area, (fig.3). The younger granites are of alkaline anorogenic magmatism and the early stages of magmatic activity involved the eruption of large volumes of rhyolitic ignimbrites. Further eruptions occurred along more or less circular ring faults. Magma subsequently solidified in these fractures and formed marginal ring dykes of granite porphyry that define the outer limits of some complexes. Inside the peripheral ring fracture, a variety of mainly granitic rocks was emplaced, both as massive ring dykes and as more or less cylindrical stocks and bosses. The ideal pattern is one of concentric intrusions, becoming progressively younger towards the centre, but many complexes depart from this ideal.

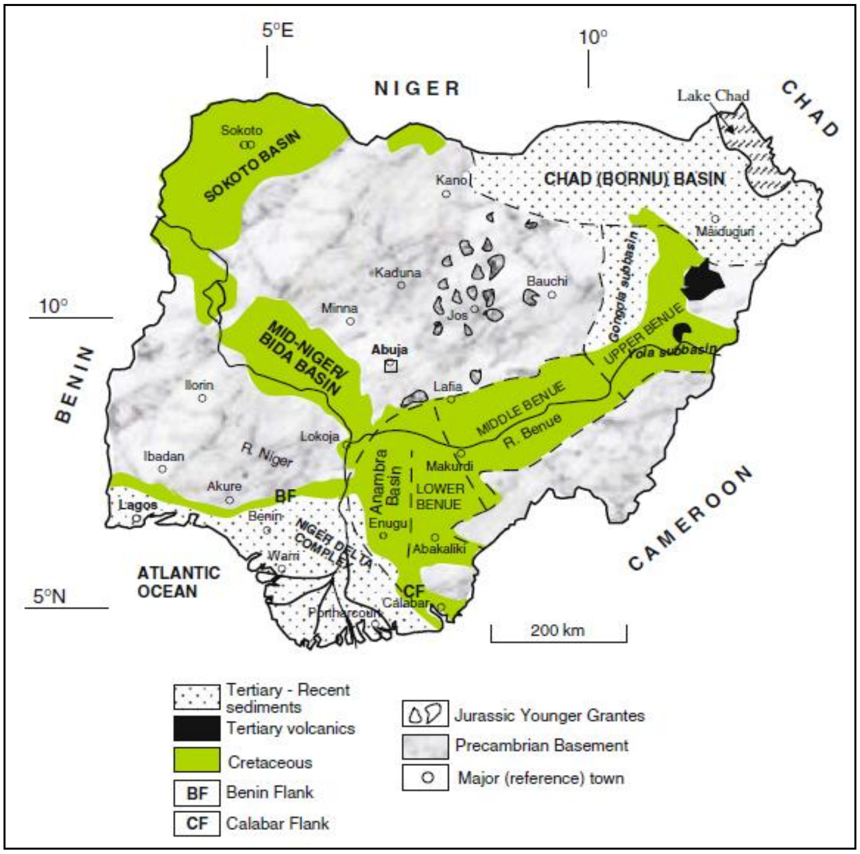

Fig. 3: Simplified Geology Map of Nigeria (Obaje, 2009)

The dominant granites of the complexes range from peraluminous to peralkaline in composition and they are associated with smaller amounts of syenite, gabbro and anorthosite. Some of these magmas originated in the upper mantle, but the overwhelming preponderance of granite suggests that there was a contribution from crustal melting also. More than 50 complexes occur in Nigeria varying from <2 to >25 km in diameter (Kinnaird, 1981). The ring complexes cover a total area of about 7,500 km2 with individual massifs varying from 1,000 km2 to <1 km2. The majority are between 100 and 250 km2 with circular or elliptical outlines. The Younger Granites of Nigeria in particular are famous for their tin (cassiterite) mineralization, which is mainly associated with the biotite granites and most of the workable deposits are in alluvial concentration.

2.1 The Tenement Geology

There are two lithological exposures encountered in the course of the mapping exercise outcropping both within the river channel, the low-land and upland, these are; The migmatite gneiss and biotite granite.

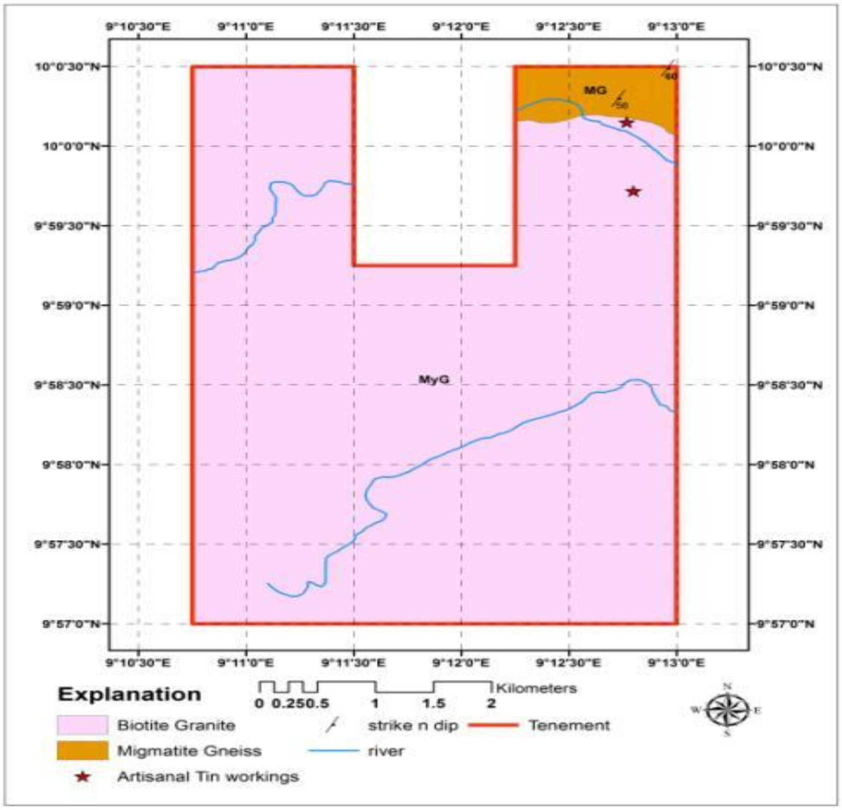

Fig.4: Geological map of the study area

2.2 Migmatite Gneiss

This unit represents the basement complex of Nigeria within the tenement being outcropped at the northeastern portion as seen in figure 4. They occur mostly as bouldery to low- lying with a general trend of NE/SW dipping southeast. The dominant paleosome which is the banded gneiss is generally grey in colour and composed of feldspar, quartz and mafic minerals. The foliation is marked by both lithological and mineralogical bands. The lithological band is made of mafic components bands alternating with felsic components bands. The bands sizes vary from places to places in the mapped area. The mafic bands range between 10cm – 1.0m wide, while the felsic bands range between 20cm - 1m wide. The felsic components comprise of quartzo-feldspathic materials, usually medium to coarse grained. They are layered with the mafic component band which is very dark, fine to medium grained and probably of amphibole/biotite composition. The mineralogical banding is marked by dark-colored mineral bands of about 0.5mm-5cm wide alternating with light colored mineral bands of about 2mm-2.5cm wide .

Plate 1: An exposure of migmatite gneiss @ 10^0 0'13''N, 9^0 12'45''E

2.3 Biotite Granite

This unit represents the Mesozoic younger granite complex covering over 80% of the tenement. It was observed to have intruded the basement complex (migmatite gneiss) found within the area of study. The biotite granite play host to the tin mineralization within the environment and it occurs as ridges trending kilometers. Areas where accessible, the bouldery nature are generally fine to medium grained in texture and with black coloration as a result of major mineral constituent which is biotite.

Plate 2: An exposure of biotite granite in bouldery form @ 9^0 59'36''N, 9^0 12'28''E

3. Methodology

3.1 Geochemical Investigation

The approach of geochemical studies in mineral exploration cannot be overemphasized, owing to its immense benefit as a tool in delineating areas of likely mineralization by making use of soil and stream as sampling media. The choice of sampling media, especially soil owes to the fact that some of the deposits are disseminated within the soil and stream/river channels, hence, areas where high concentration are observed can easily lead to the ore body/primary source.

In this reconnaissance survey, a systematic sampling was carried out using soil as the sampling media. The area accessible was gridded into five (5) profiles with an average of 500m spacing between each profile and each sampling point. At each sampling point, samples were collected from three pits within a 50m radius to make a composite of that point which gives a representative sample of that area. A total of 18 soil samples were collected from the B – horizon and gravelly layer. The sampling depth varies from 0.5 to 1m depending on the thickness of the horizons.

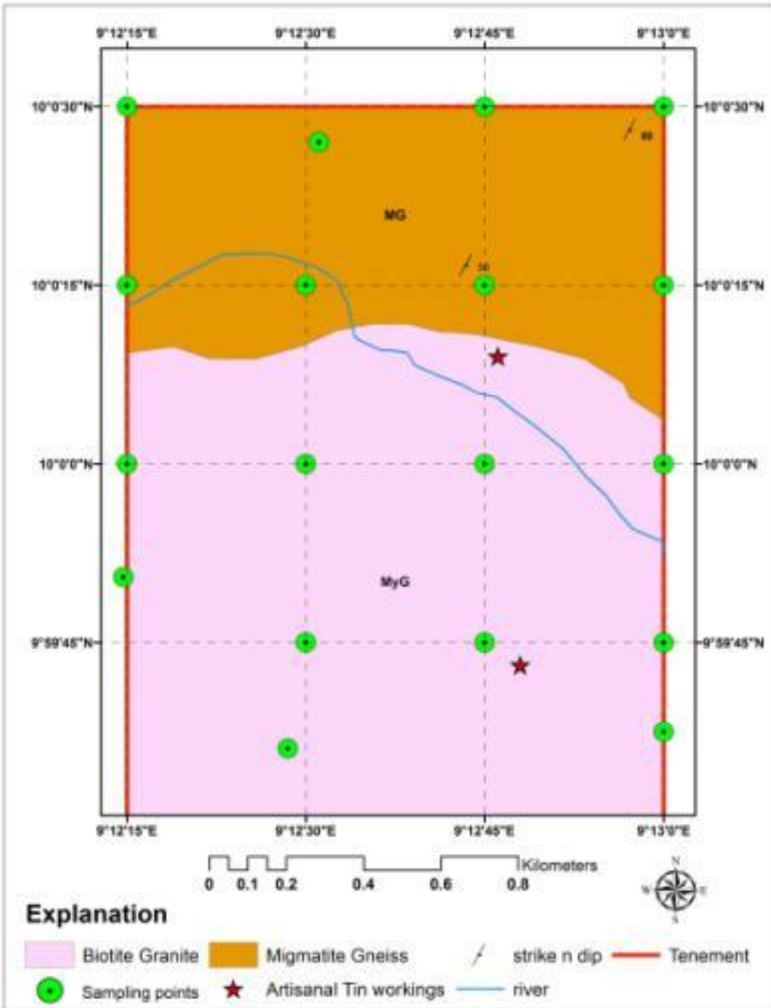

Fig. 5: Showing the sampling points

3.2 Mineralization Potential of the area

Having traversed the length and breadth of the accessible area within tenement, the investigated site is in no doubt highly prospective for Tin mineralization especially towards the last profile (close to the foot of the hills). Evidences of local activities and alluvial/eluvia panning reveal areas that are most prospective which has been marked for further exploration work.

(a) Local Activities – precisely at **10.00251'N, 9.21281'E and 9.99531N, 9.21333E,** an abandoned local pit for eluvia and alluvial recovery of tin was encountered at the time of visit. The villagers were engaged in gathering of materials from within and around the river channel and haven been washed, good recoveries were made from the panned concentrate as seen in the pictures below.

Plate 3: Abandon Local Pit at the study area

(b) Panned Concentrates

From some of the sampling points, the composite was subjected to washing for a possible tin recovery and interestingly most of the soil samples taken from the last profile shows good evidence of tin mineralization.

Plate 4: Carrying out washing of one of the composite soils for a possible recovery.

4.0 Presentation of Data

The result of the analysis (with emphasis on Sn and Nb) were used to prepare a concentration map in form of a point symbol map which is superimposed on both the geology and the trend map. This enables to see the distribution pattern of the elements within the study area.

Basic statistical parameter of the data obtained from the analysis were computed and this includes the average, background value, standard deviation and threshold as seen in table ... (see table 1 and 2)

RAW DATA Table 1.0

MS ANALYTICAL																	
XRF results by method WRX-650																	
		P	P +/-	S	S +/-	Cl	Cl +/-	K	K +/-	Ca	Ca +/-	Ti	Ti +/-	V	V +/-	Cr	Cr +/-
	Unit: PPM																
	SAMPLE IDENT.																
1	MG 1A		573	1765	551	667	174	661	68		117	2044	45	86	5	83	7
2	MG 2A		700		1841		589	847	83		151	6062	101	276	10	298	12
3	MG 3 NA	1084	274		2045		697	565	80		146	12223	183	293	12	303	13
4	MG 4A	776	192	1786	485	524	145	359	51		90	1900	39	114	5	128	7
5	MG 5A		688		1693		608	439	74		132	4659	85	264	9	273	12
6	MG 6A	726	194		1402		410	365	55		96	780	24	29	3	28	5
7	MG 7A		722		1920		656	1002	89		158	8493	134	194	10	198	10
8	MG 8A		536		1342		428	564	60		99	1748	38	22	4	15	4
9	MG 9A		518		1329		410	349	53		90	534	20	29	3	38	5
Standard	NIST 2710a		1292	18050	1778		986	20250	471	9234	272	3233	84	96	9		35
		Mn	Mn +/-	Fe	Fe +/-	Co	Co +/-	Ni	Ni +/-	Cu	Cu +/-	Zn	Zn +/-	As	As +/-	Se	Se +/-
	Unit: PPM																

	SAMPLE IDENT.																
1	MG 1A	207	8	3709	82		85		31		20	62	7	21	4		6
2	MG 2A	282	11	5260	106		99		39		24	70	7	31	5		7
3	MG 3 NA	423	13	10962	178		146		45		30	73	8	41	6		8
4	MG 4A	142	7	1835	56		62		29		20	45	6	21	4		6
5	MG 5A	374	12	5513	114		107		42		28	66	8	28	5		8
6	MG 6A	67	5	1160	48		56		31		19	53	6	25	4		6
7	MG 7A	404	12	9042	153		130		40		27	71	8		16		8
8	MG 8A	113	6	2510	65		67		27		19	34	6	14	4		6
9	MG 9A	69	5	825	40		48		26		17	45	6	12	4		5
Standard	NIST 2710a	2194	44	45141	547		280		51	3262	56	4009	60	1445	38		17
								1% = 10,000 ppm									
Results reported in parts per million																	
NIST 2710a: standard reference material used, results reported in parts per million (ppm), unless otherwise stated																	
Results are only representative of the sample submitted to the laboratory																	

MS ANALYTICAL															
XRF results by method WRX-650															

		Rb	Rb +/-	Sr	Sr +/-	Y	Y +/-	Zr	Zr +/-	Nb	Nb +/-	Mo	Mo +/-	Ag	Ag +/-	Cd	Cd +/-
	Unit: PPM																
	SAMPLE IDENT.																
1	MG 1A	8	2		3	284	6	356	7	15	3		5		17		19
2	MG 2A	10	2		3	506	9	285	6	44	4	6	2		17		19
3	MG 3 NA		8		4	553	10	2331	36	42	4		10		18		20
4	MG 4A	7.3	2		3	273	5	337	7	11	3		5		17		18
5	MG 5A		7		4	422	8	2043	32	29	4		9		18		20
6	MG 6A		6		3	115	3	624	11	7	2		6		17		19
7	MG 7A		7		3	285	6	1267	20	326	7		7		18		20
8	MG 8A	8	2		2	51	2	583	10	98	3	8	2		17		18
9	MG 9A	6	2		2	181	4	100	3		6	5	1		16		18
Standard	NIST 2710a	106	4	248	7	42	4	318	8	9	2	8	2	53	8		27
		Sn	Sn +/-	Sb	Sb +/-	W	W +/-	Au	Au +/-	Pb	Pb +/-	Bi	Bi +/-	Th	Th +/-	U	U +/-
	Unit: PPM																
	SAMPLE IDENT.																
1	MG 1A		29		32		46		14	39	5		51	191	8	14	3
2	MG 2A	136	10		31		55		17		19		67	397	12	37	4
3	MG3 A	85	10		32		63		19	30	7		73	303	12	53	5
4	MG 4A	27	9		30		42		12	42	5		49	213	8	24	3
5	MG 5A	106	10		32		58		18	39	7		67	341	12	43	5

6	MG 6A	531	13		31		46		13	45	5		47	83	6		9
7	MG 7A	1112	21		32		60		18	47	7		67	222	11	21	4
8	MG 8A	28	9		30		45		12	40	5		44	23	5		7
9	MG 9A		26		29		43		13	43	5		41	75	5		8
Standard	NIST 2710a		43		50	310	56		51		66		20	22	7		17
								1% = 10,000 ppm									
Results reported in parts per million unless otherwise stated																	
NIST 2710a: standard reference material used, results reported in parts per million (ppm), unless otherwise stated																	
Results are only representative of the sample submitted to the laboratory																	

MS ANALYTICAL																	
XRF results by method WRX-650																	
		P	P +/-	S	S +/-	Cl	Cl +/-	K	K +/-	Ca	Ca +/-	Ti	Ti +/-	V	V +/-	Cr	Cr +/-
	Unit: PPM																
	SAMPLE IDENT.																
10	MG 10A		588	1912	550		488	461	62		107	1840	42	60	5	83	6
11	MG 11A	762	237		1805		615	1187	90		149	7024	113	149	9	161	9
12	MG 12A		645		1525		563	689	74		114	6328	102	55	7	32	6

13	MG 13A	679	195		1435		447	342	55		93	981	28	29	3	24	5
14	MG 14A		1050		2825		1119	1208	120		237	44698	657	173	20		31
15	MG 15A	754	222		1677		499	408	67		106	990	31	16	3	25	5
16	MG 16 NA		720		1886		669	684	82		144	7207	120		23		17
17	MG 17 NA	772	218		1542		512	307	61		110	3541	65		15		13
18	MG 19 NA	940	258		1861		689	584	77		152	11313	168	39	9		18
Standard	NIST 2710a		1292	18050	1778		986	20250	471	9234	272	3233	84	96	9		35
		Mn	Mn +/-	Fe	Fe +/-	Co	Co +/-	Ni	Ni +/-	Cu	Cu +/-	Zn	Zn +/-	As	As +/-	Se	Se +/-
	Unit: PPM																
	SAMPLE IDENT.																
10	MG 10A	181	8	2767	70		72		31		20	45	6	26	4		6
11	MG 11A	225	9	5760	111		102		33		25	70	7	26	5		7
12	MG 12A	187	8	4988	102		98		33		24	67	7	31	5		7
13	MG 13A	80	6	1470	54		59		30		19	49	6	15	4		6
14	MG 14A	1096	25	46814	662		332		61	141	18	202	15	37	8		10
15	MG 15A	51	6	2148	63		67		30		19	32	6	12	4		6
16	MG 16 NA	188	9	7736	143		123		39		29	82	9	20	5		6
17	MG 17 NA	148	7	5252	103		97		32		22	54	7	15	4		6
18	MG 19 NA	340	11	13577	202		152		36	35	9	73	8		14		6
Standard	NIST 2710a	2194	44	45141	547		280		51	3262	56	4009	60	1445	38		17
								1% = 10,000 ppm									

Results reported in parts per million unless otherwise stated
NIST 2710a: standard reference material used, results reported in parts per million (ppm), unless otherwise stated
Results are only representative of the sample submitted to the laboratory
XRF results should be used for indicative guide purposes only for elements presented

Table 2.0

Elements	N	BACKGROUND	MED ABS DEV	AVERAGE	STDEV	MIN	MAX	THRESHOLD
Sn	18	53	53	142.89	272.46	27	1112	159
Nb	18	95.5	80.5	189.06	306.06	7	1290	256.5

4.1 Interpretation

To explain element's concentration in the earth's sampled materials and thus consider its significance in a study area, a basis of comparison is required. The average abundance of elements in the crust and soil serves that purpose in this investigation.

(a) Tin:

The distribution of tin is moderately wide within the sampled area as it was detected in 13 of the 18 samples collected. The concentration ranges from 7ppm to 1112 ppm with a mean value of 142.89 ppm and a background value of 53ppm. The threshold value being 159 ppm, indicates that there are three (3) isolated anomalous tin values (% above threshold = 16.66%) occurring within the prospect area (fig.6). Comparing the background value of tin (Sn) in soil samples of the study area (53 ppm) with the average abundance of Sn in the earth's crust (2.2ppm) and in the soil (10 ppm) after Levision, 1974, **it was observed that the abundance of Sn in this area is relatively high.** Conclusively, the anomalous values observed in the study area may be connected with placer tin deposit.

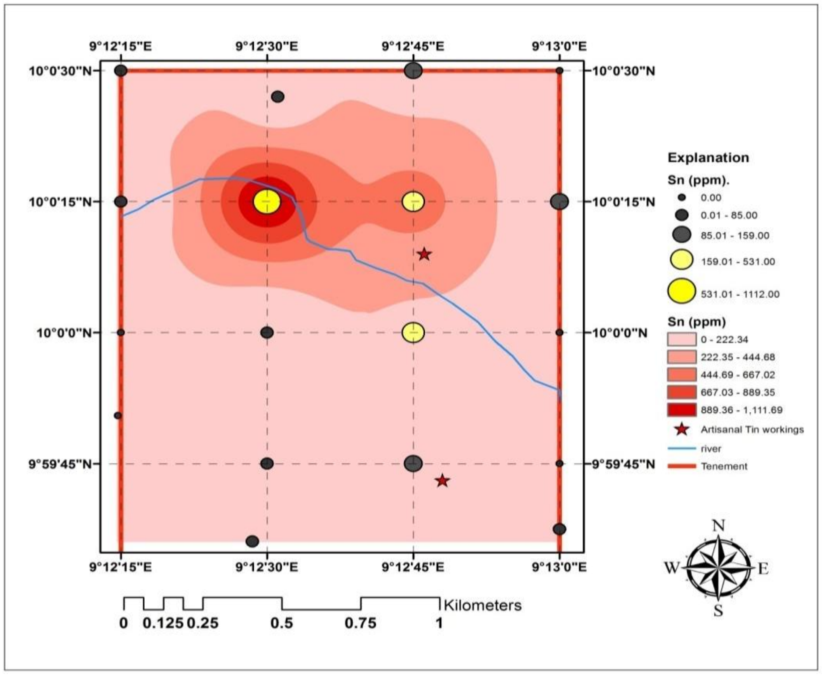

Fig: 6. showing the concentration map of Sn using the point symbol superimposed on the trend map

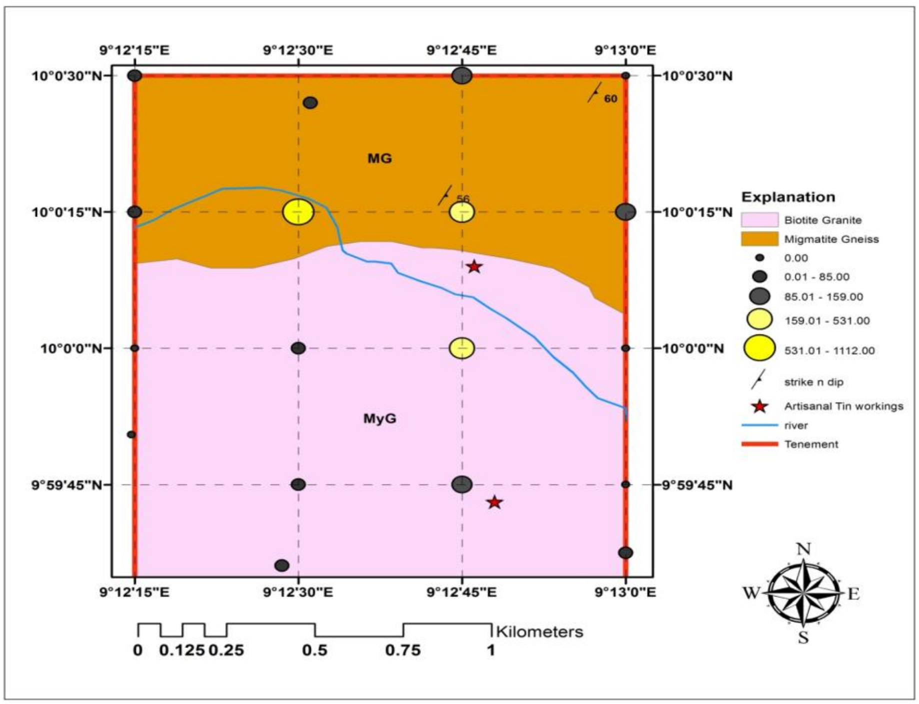

Fig. 7: Showing the concentration of Sn superimposed on the local geology

(b) Niobium:

Niobium was detected in 17 out of the 18 samples collected and showed relatively wide concentrations which range between 7.0 ppm and 1290 ppm with a mean value of 189.06 ppm. The threshold value of niobium is 256.5ppm and this value indicates that there are five (5) isolated anomalous niobium values (% above threshold = 27.77%) occurring within study area (fig.8). With a background value of 95.5 ppm, **the abundance of niobium is considered to be relatively high** in the study area when compared with the average abundance in the earth's crust (20ppm). Most of the anomalous points are underlained by the biotite granite (a member of the Mesozoic younger granite) and thus is considered to be the source of its concentration.

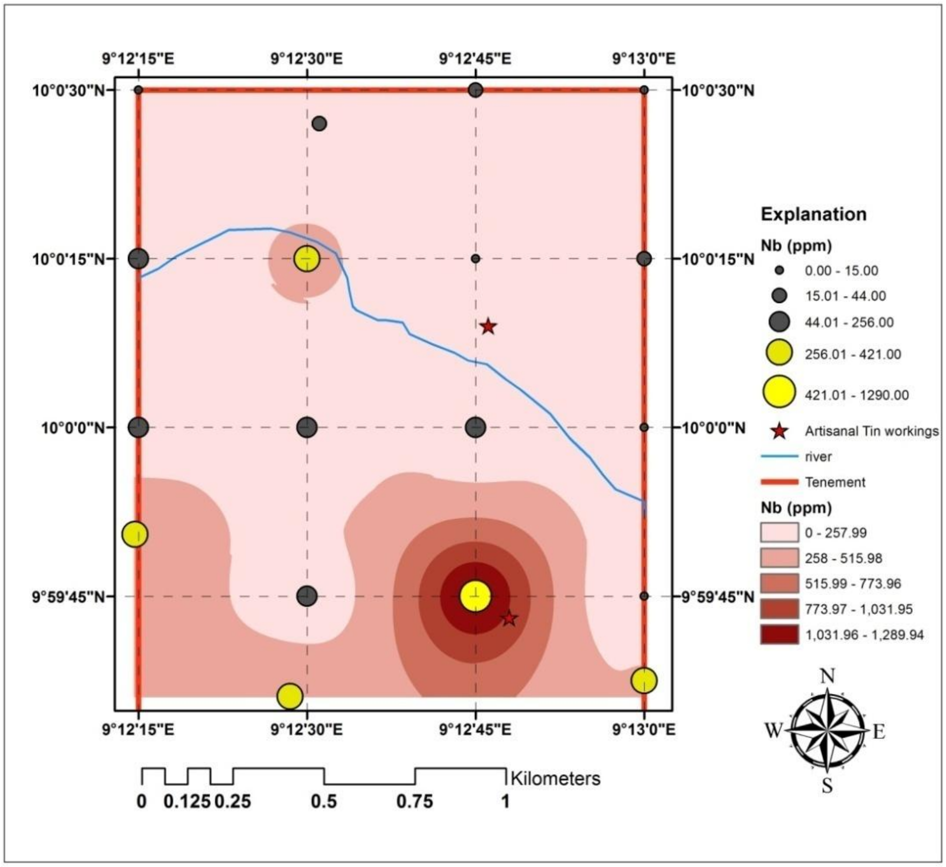

Fig: 8. showing the concentration map of Nb using the point symbol superimposed on the trend map

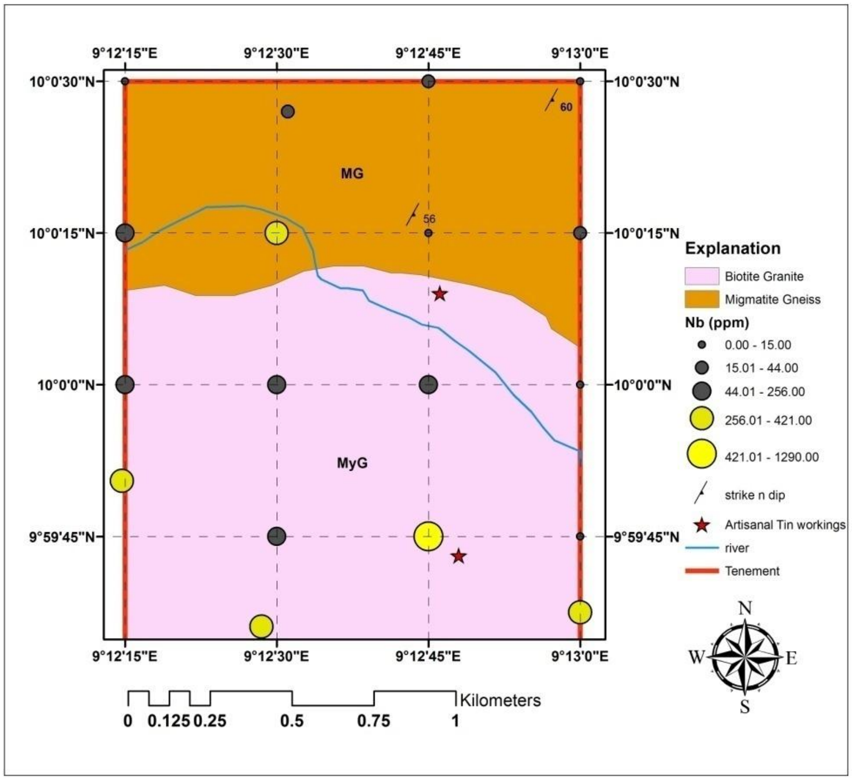

Fig: 9. showing the concentration of Nb superimposed on the local geology

5.0 Conclusion

The preliminary investigation carried out on the site involved the study of various rock units and relationship with emphasis on mineralization pattern as well as carrying out a geochemical sampling using soil as the sampling media. The basement complex of Nigeria is represented by the migmatite gneiss within the tenement and is seen to have been intruded by the biotite granite which is a member of the younger granite series of Jurassic in age.

A total of 18 soil samples and panned concentrates were taken from the accessible area with an average of 500m spacing (fig.5) between each profile and each sampling point. At each sampling point, samples were collected from three pits within a 50m radius to make a composite of that point which gives a representative sample of that area. The sampling depth varies from 0.5 to 1m depending on the thickness of the horizons.

Geochemical analysis reveals that tin concentration ranges from 7ppm to 1112 ppm with a mean value of 142.89 ppm and a background value of 53ppm. The threshold value being 159 ppm, indicates that there are three (3) isolated anomalous tin values as seen in figure 7 and comparing the background value (53 ppm) with the crustal abundance (2.2 ppm), the concentration is relatively high and this is traceable to placer tin deposit from the younger granite series.

Recommendation

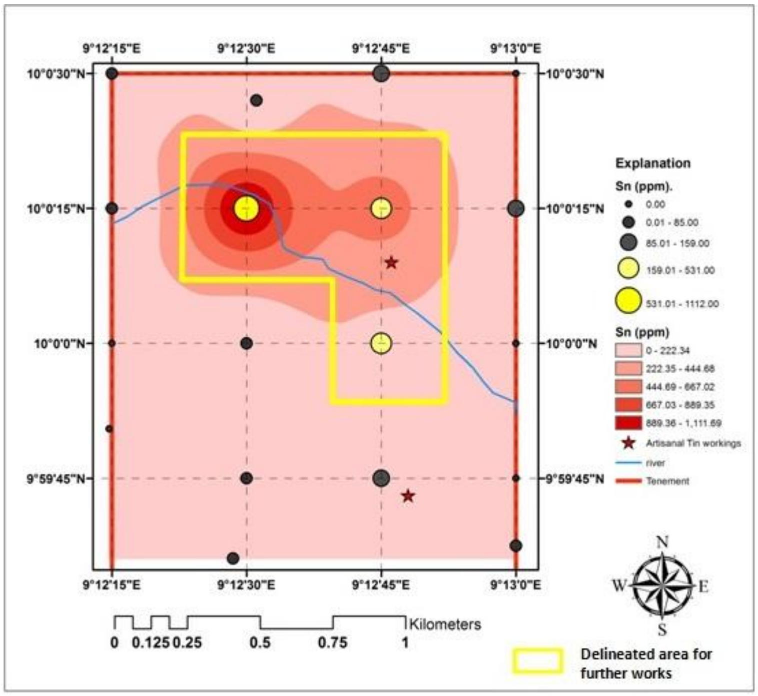

Fig.10: Showing delineated area for further exploration works.

Having carried out a proper interpretation from the result of the analysis, the area of concentration for tin has been delineated as seen in figure 10. It is therefore recommended that a systematic and detailed soil sampling be carried out at a close interval of 200m as this will avail us of the highest point of concentration which can then be followed by trenching for a run test of percentage recovery.

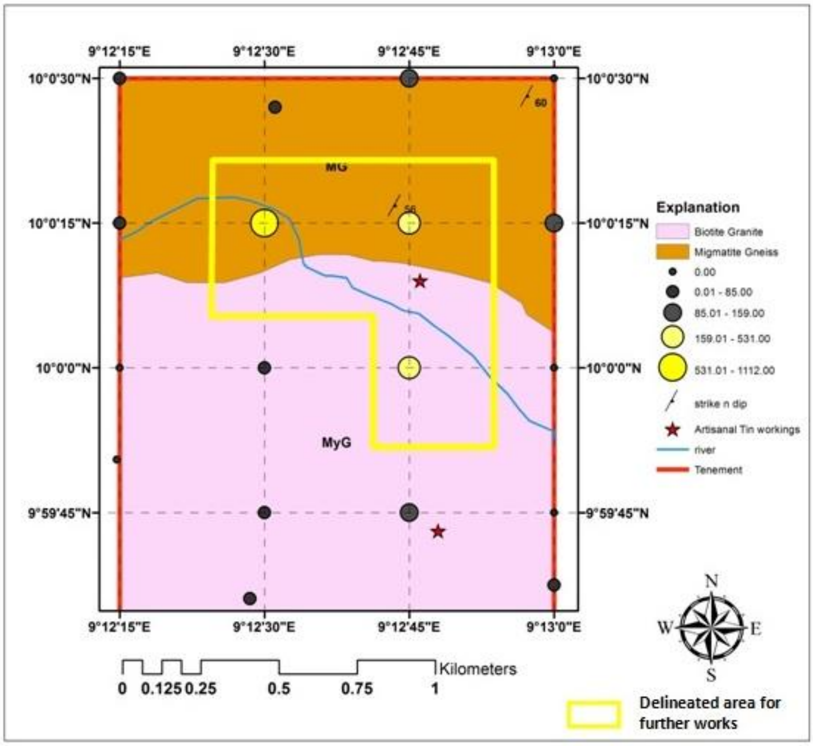

Fig.11: showing delineated area superimposed on the geology

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