

Compositional Features and Industrial Assessment of Talcose Rocks of Itagunmodi-Igun Area, Southwestern Nigeria

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Abstract

Talcose rocks from Itagunmodi and Igun areas within the Ilesa Schist Belt, southwestern Nigeria, were studied to determine their compositional affinities and industrial properties. The talcose bodies occurred as lensoid enclaves closely associated with amphibolites and quartz-mica schist. Petrographic and X-ray diffraction-aided mineralogical studies reveal that the talcose rocks are of the talc-chlorite schist variety composed predominantly of talc (average 73.63%), subordinate chlorite (average 16.08%) and accessory lizardite (average 6.5%). Total whole rock characterization of the samples using Lithium Fusion digestion revealed high mean concentrations of SiO₂ (57.53%), MgO (24.84%) and Fe₂O₃ (7.73%) with significant enrichment of Ni, Co and Cr; and low values of Ba, Rb, Sr, V, Cu and Pb. The talc-chlorite schists plotted in the peridotitic komatiite field of the Al₂O₃-(FeO + TiO₂)-MgO diagram. Water Absorption Capacity ranges from 6.25% - 8.20%, Loss on Ignition is 4.8% - 6.1% while Linear Shrinkage is 1.25% - 1.70% and firing colour is brown to dark-brown. The overall compositional features of the talcose rocks of the area, which were hitherto uncharacterized, show their suitability as raw materials for paint, coloured pottery, ceramic insulation, textile, rubber and plastic manufacture with varying beneficiation requirements. Their high trace element content however, makes them unsuitable for use in pharmaceutical and cosmetic applications.

Keywords

Talc-Chlorite Schist, Petrochemical, Physico-Chemical, Industrial Application

1. Introduction

Talcose rocks, which are alteration products of mafic and ultramafic rock units,

occur intermittently within the N-S trending Proterozoic Schist Belts that are confined to the western half of Nigeria [1] [2]. The Proterozoic schist belts are a suite of supracrustal metasediments infolded into the Nigerian Basement Complex, predominantly of pelitic to semi-pelitic composition and low-medium grade metamorphism. The Ilesa schist belt, located in southwest Nigeria, is one of such belts, hosting the Ifewara fault Zone—which divides the belt into two contrasting lithologies composed mainly of schist (of quartz, biotite, garnet and muscovite mineralogy) and gneisses; along with pelitic schists, quartzites and metabasites on the eastern and western halves respectively [3]. Talc, the essential mineral in these rocks, is an important industrial mineral with wide and varied usage. Notable occurrences of talc bodies in southwest Nigeria include Baba Ode [4], Erin Omu [5], Wonu-Apomu [6], Kumaru [7], Oke-Ila [8], Ile Ife, Ikirun and Esa Oke [9]. Talcose, tremolitic, chloritic and anthophyllitic are the four major mineralogical varieties of talc bodies identified in the Southern area [10]. A number of talcose rock occurrences have been studied for their petrology, petrogenesis [9] [11] and industrial features [12]. The talcose rocks of Itagunmodi-Igun area have, however, not been characterized in terms of their compositional properties. This study therefore involves a mineralogical, petrochemical and physical characterization of these rocks in order to elucidate their compositional characteristics and their potential as industrial raw material.

The study area is located west of Ilesa town, within latitudes $7^{\circ}30' - 7^{\circ}35'$ and longitudes $4^{\circ}37' - 4^{\circ}42'$ (**Figure 1**), covering an area of about 81 km². Six representative samples of the outcrops, collected during a geologic mapping on 1:10,000 scale, were prepared for thin section examination under the petrological microscope. Pulverized samples were analysed for elemental composition using Inductively Coupled Plasma Mass Spectrometry employing a Lithium Fusion digestion technique at Bureau Veritas Commodities Ltd., Canada. X-Ray Diffraction analysis was done at University of Poitiers, France to identify the mineral phases present, using a Philips PW 1011 model diffractometer with a scanning rate of $2^{\circ} \text{ min}^{-1} \text{ cm}^{-1}$ with a Ni-filtered Fe K-alpha radiation.

Physical tests conducted include bleaching and firing to determine colour changes, Loss on Ignition (LOI), Water Absorption Capacity (WAC), and Linear Shrinkage (LS). Pulverized samples of the rocks were made into pellets, fired at 870°C for 2 hours and bleached with dilute HCL (0.5 - 3.0 M) for 48 hours. LOI was calculated from the weight loss after heating to 1000°C. The tests were done at the Geochemistry Laboratory, University of Ibadan.

2. Field Relationship and Petrographic Features

Low to medium-grade metamorphic rocks dominated by quartz-biotite schist, with quartzite and amphibolite occur along with the talcose rocks in the study area (**Figure 2**). The study area lies west of the Ifewara Fault Zone (IFZ) [13] [14], within the Ilesa schist belt; in which talc bodies are known to be closely associated with amphibolites, quartzite and pelitic schists [9]. The talcose rocks

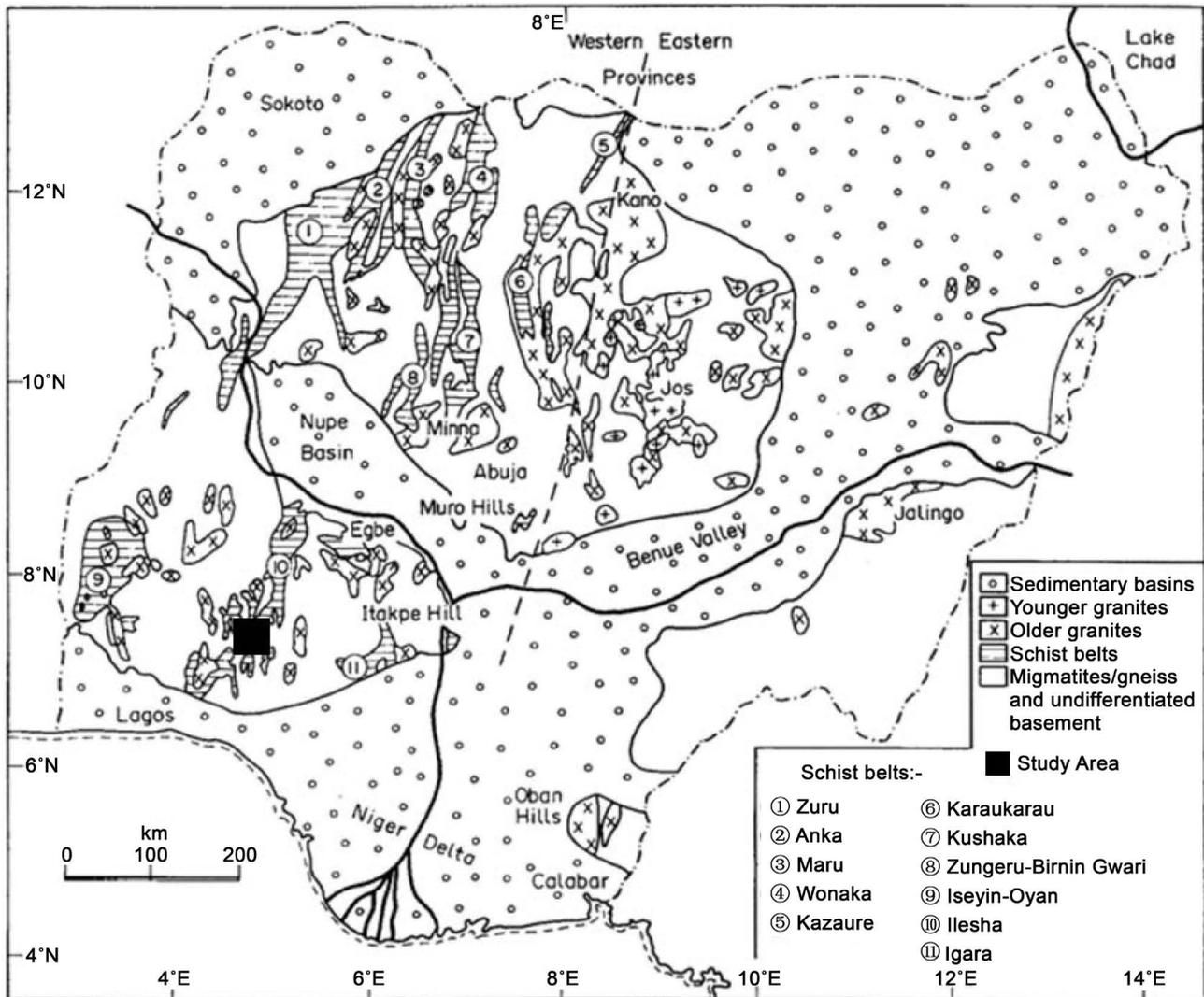


Figure 1. Location of Itaganmodi-Igun within the Proterozoic Schist Belts of Nigeria (after [15]).

occur as discontinuous lensoid enclaves within amphibolites of massive textural variety and quartz-biotite schist in the western and eastern parts of the study area respectively (**Figure 2**). This is in line with the assertion that talcose rocks of Nigeria associate closely with mafic and ultramafic rocks [9]. In the western half of the study area, they continue intermittently for a strike length of about 6 km with a north-easterly trend. They were observed occupying low lying areas within the study area, with quartzites and amphibolites forming ridges at the northwestern and central to southern parts of the study area respectively. On outcrop scale, the talcose rocks have a characteristic soapy feel, dirty-white colour and are extremely fine-grained, occurring mostly as poorly exposed outcrops (**Figure 3**). Few of the talcose rocks contain streaks of brown/rust red colouration believed to result from oxidized iron staining. These can be seen on hand specimen and thin section scales. Hand specimen samples often reveal presence of asbestiform aggregates of lizardite in a decussate textural arrangement.

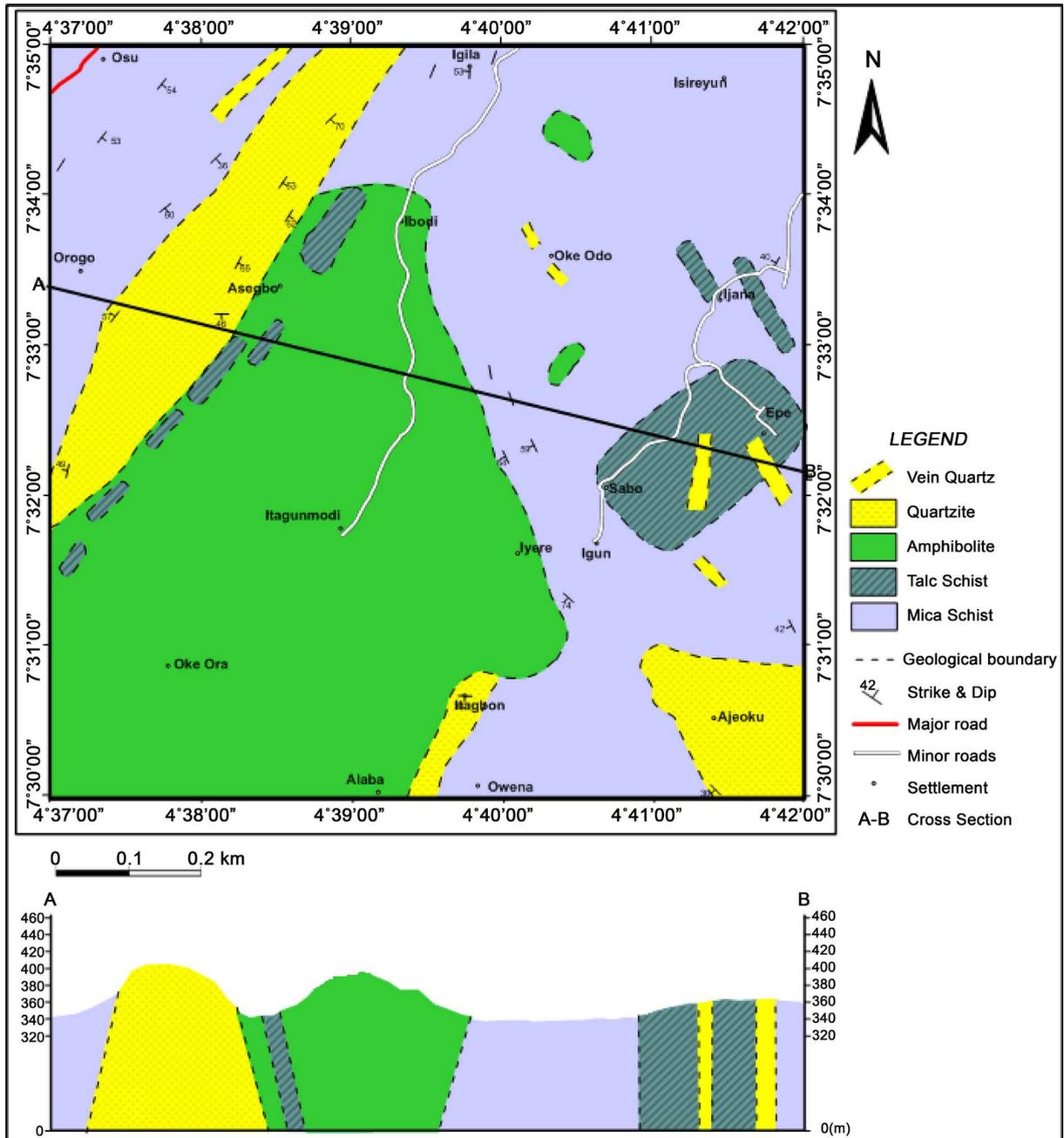


Figure 2. Geologic map of the study area.

3. Discussion

Mineralogical and elemental data of the samples were interpreted to unravel the compositional characteristics, petrogenetic affiliations of the rocks, and physico-chemical properties were investigated to determine their suitability as industrial materials.

3.1. Mineralogy

Thin section study of the rocks revealed a predominant mosaic of talc aggregates

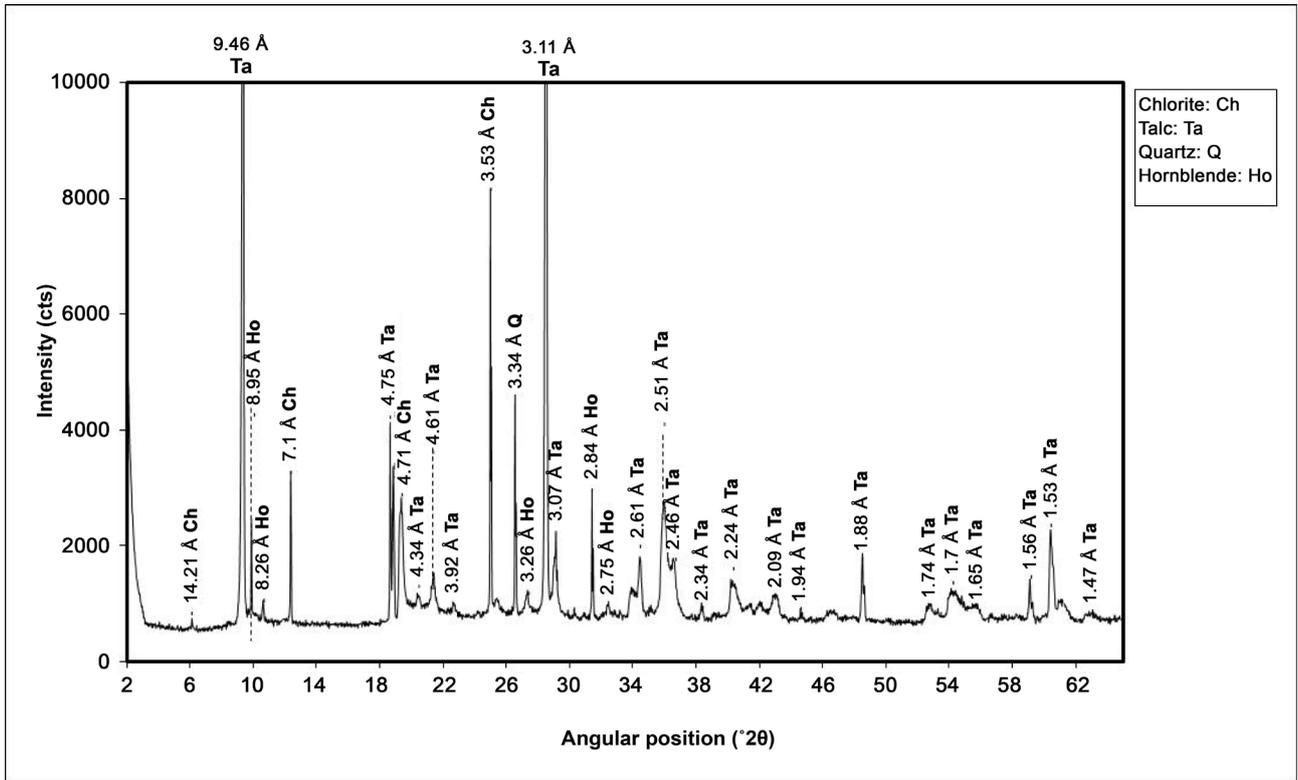


Figure 3. Talc-chlorite schist on outcrop scale and hand specimen (showing radiating lizardite grains) [Ruler length = 30 cm].

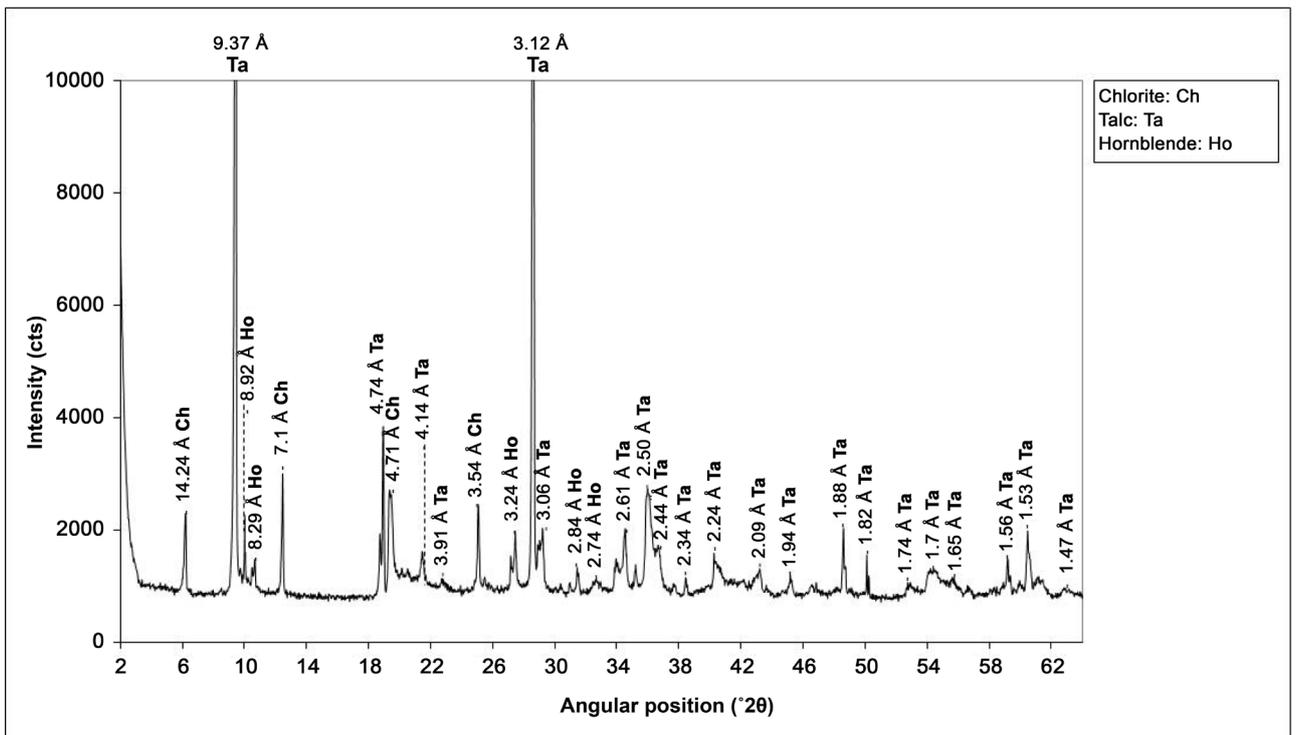
as previously observed in hand specimen. Talc and chlorite are the primary minerals in the talcose rocks, with minor occurrences of lizardite and opaque minerals observed in thin section. X-Ray Diffractograms of the rocks (**Figures 4(a)-(f)**) revealed conspicuous peaks of talc and chlorite with subordinate hornblende, lizardite and quartz; corroborating the observations obtained from the petrographic studies. Mineralogical composition in the rocks, using diffractogram peak height ratio, indicates that talc in the rocks range from 67.7% - 91.3%, occurring as mosaics of fibrous grains and constituting the groundmass; chlorite 16% - 17%; with long, greenish prismatic grains having moderate relief. Hornblende and lizardite have mean concentrations of 10.46% and 7.5% respectively, with the latter observed occurring as long, radiating grains in thin section (**Figure 5(a)**). Evidence from petrographic and X-Ray diffraction studies indicate the talcose rocks are of the talc-chlorite schist (TCS) variety. **Table 1** presents modal composition of the talc-chlorite schists. The talcose rocks in the study area contain higher percentage compositions of talc and chlorite when compared with those of Ilesa-Apomu and Oke-Ila areas. The rocks in Ilesa-Apomu and Oke-Ila contain pyrophyllite/anthophyllite and tremolite/actinolite respectively, which are absent in rocks of the study area (**Table 2**).

3.2. Chemistry

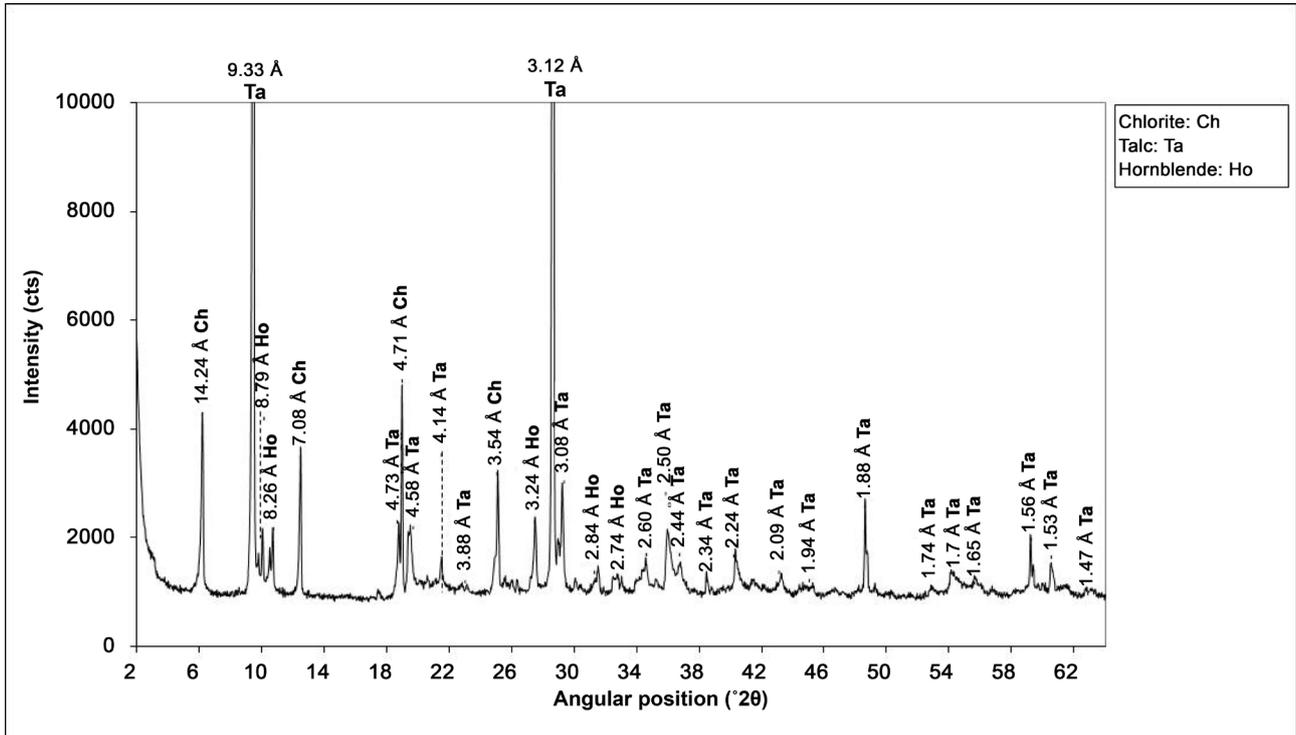
Major oxide concentration in the samples analysed include SiO₂: 55.26% - 59.15%, Al₂O₃: 1.59% - 3.30%, Fe₂O₃: 5.78% - 11.35%, MgO: 22.19% - 26.98%, CaO: 0.24-1.74% with TiO₂, MnO, Na₂O, K₂O and P₂O₅ having concentrations less than 1% (**Table 3**). Results of chemical analysis show that the talc-chlorite schists are rich in SiO₂, MgO and Fe₂O₃. The rocks show significant enrichment in Cr (1772 - 3290 ppm) and Ni (833 - 1568 ppm), and slight enrichment in Co (65 - 88 ppm) (**Table 3**). Values of other trace elements like Ba, Rb, Sr, V, Cu and Pb are generally low. Compared to the amphibolites and quartz-mica schist associated with the talcose rocks on the field, the SiO₂ concentration is the same with amphibolites but slightly lower than the schists. There is significant Al₂O₃



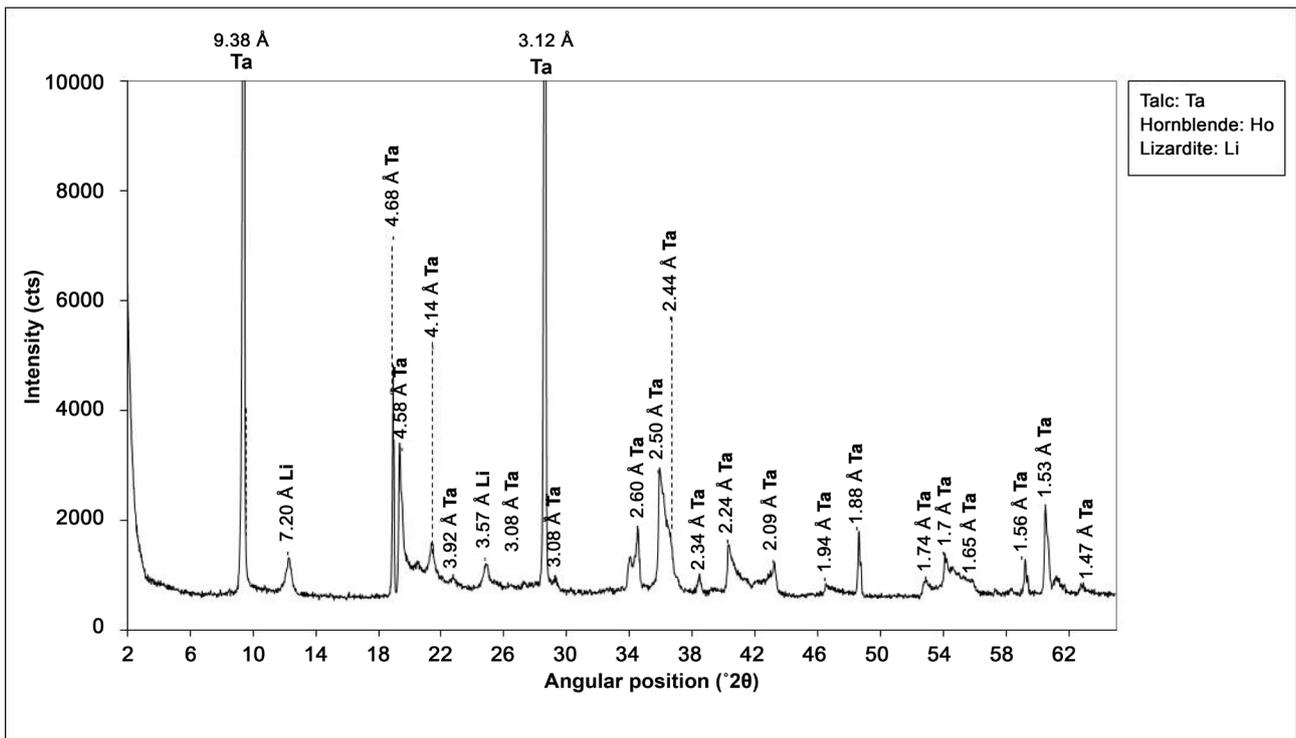
(a)



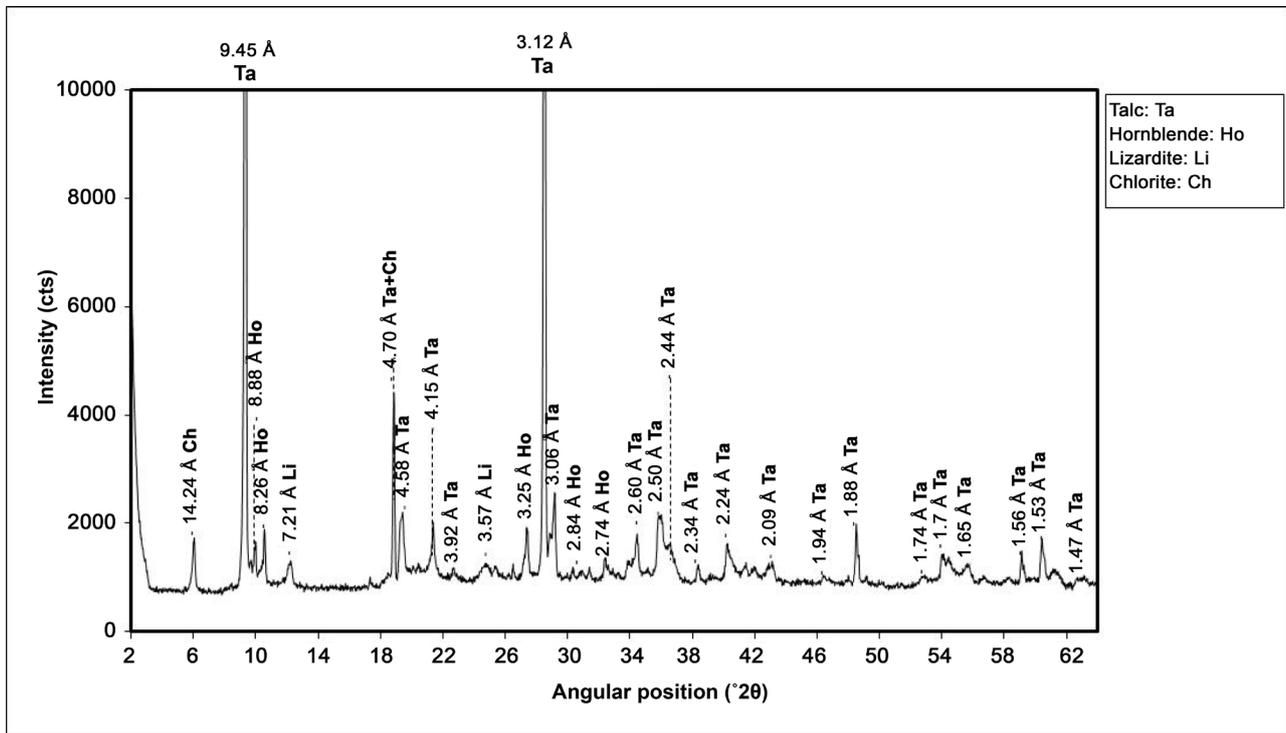
(b)



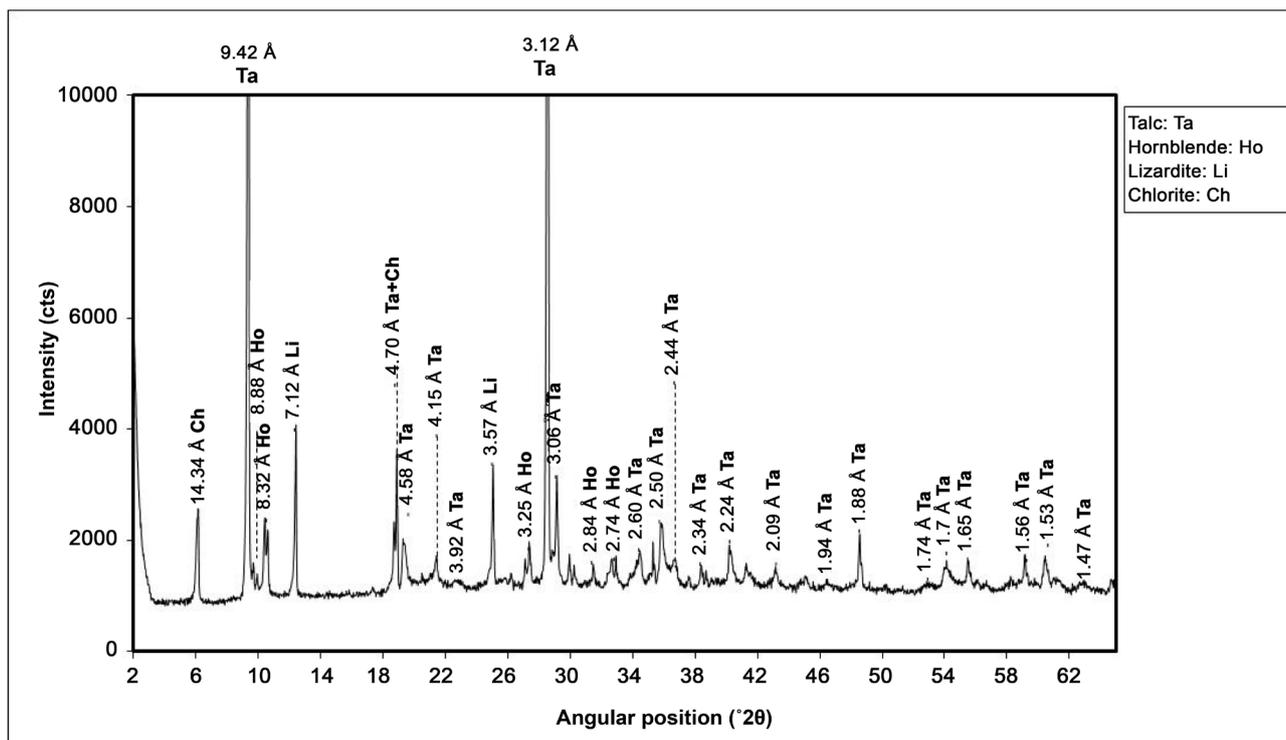
(c)



(d)



(e)



(f)

Figure 4. Diffractograms of the study area talcose rocks depicting predominant talc and chlorite, with accessory hornblende and lizardite. (a) X-Ray Diffractogram for sample 1; (b) X-Ray Diffractogram for sample 2; (c) Diffractogram for sample 3; (d) Diffractogram for sample 4 dominated by talc and chlorite; (e) Diffractogram for sample 5; (f) Prominent talc and chlorite peaks in diffractogram for sample 6.

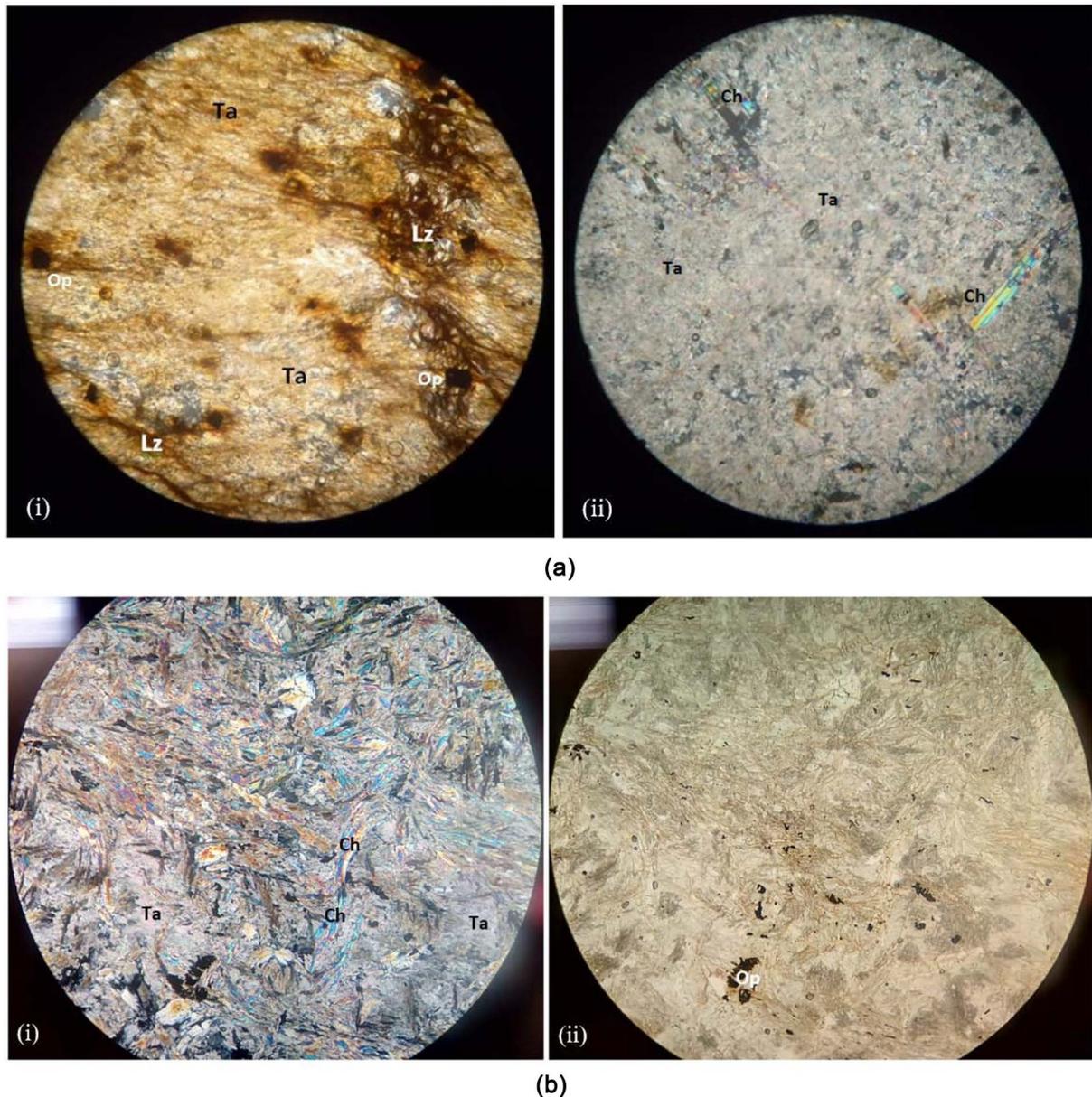


Figure 5. Talc-chlorite schist in thin section at (a) 40× and (b) 100×. (a) Photomicrograph of talc-chlorite schist showing predominantly talc with (i) lizardite and (ii) chlorite; (b) (i) Crossed nicol and (ii) plane-polarized photomicrographs of talc-chlorite schist showing inclusions of chlorite and minor opaques in a mosaic of talc.

depletion and MgO enrichment in the talc-chlorite schists (**Table 4**). Loss on Ignition in the analysed samples ranged from 4.80 - 6.10 (**Table 3**).

A comparison of the average major oxide content of the talc-chlorite schist of the study area with talcose rocks from Esie, Oke-Ila, Iseyin and other parts of southwestern Nigeria indicates that silica concentrations are comparatively similar, the magnesia in the talcose rocks of the study area is less than the other areas compared, while it has higher ferric oxide. The alumina content is less than those in talcose rocks of Oke-Ila and Iseyin (**Table 5**). Cr and Ni concentrations are higher in the talcose rocks of the study area than those of Esie, Oke-Ila and

Table 1. Modal composition of talc-chlorite schists in the study area.

Sample	Mineralogy (%)				
	Talc	Chlorite	Hornblende	Lizardite	Quartz
1	67.7	16.1	11.9	-	3.2
2	72.0	14.2	13.3	-	-
3	70.0	16.7	11.3	-	-
4	91.3	-	-	8.7	-
5	69.4	16.2	8.9	5.9	-
6	71.4	17.2	6.9	4.9	-
Mean	73.63	16.08	10.46	6.5	3.2

Table 2. Comparison of modal composition of talcose bodies in the Ilesa area, southwest Nigeria.

Minerals (%)	Itagunmodi-Igun ¹ (TCS)						Ilesa-Apomu ² (TCAS/TACS)				Oke-Ila ³ (TTCS)		
	1	2	3	4	5	6	1	2	3	4	1	2	3
Talc	68	72	70	90	69	71	30	32	21	24	58	66	81
Pyrophyllite	-	-	-	-	-	-	20	20	18	18	-	-	-
Anthophyllite	-	-	-	-	-	-	21	18	28	22	-	-	-
Tremolite/Actinolite	-	-	-	-	-	-	-	-	-	-	18	20	10
Chlorite	16	14	17	-	16	17	14	15	16	20	22	12	8
Hornblende	12	13	11	-	8	6	-	-	-	-	-	-	-
Lizardite	-	-	-	9	6	4	-	-	-	-	-	-	-
Clinocllore	-	-	-	-	-	-	14	14	16	14	-	-	-
Others	4	1	2	1	1	2	1	1	1	2	2	2	1

¹This Study (TCS—talc-chlorite schist); ²[9] (TCAS/TACS—talc-chlorite-anthophyllite schist/talc-anthophyllite-chlorite schist); ³[8] (TTCS—talc-tremolite-chlorite schist).

Table 3. Summary of major and trace element content of Itagunmodi-Igun talc-chlorite schists.

Oxide (%)	1	2	3	4	5	6
SiO ₂	58.49	55.26	58.26	55.28	58.76	59.15
TiO ₂	0.03	0.08	0.10	0.34	0.06	0.07
Al ₂ O ₃	1.59	2.94	3.30	2.86	2.64	2.27
Fe ₂ O ₃	5.78	8.52	7.15	11.35	6.99	6.60
MnO	0.11	0.10	0.04	0.21	0.09	0.11
MgO	26.98	25.72	23.93	22.19	25.17	25.02
CaO	0.24	0.77	0.11	1.74	0.47	0.50
Na ₂ O	0.10	0.03	0.02	0.03	0.03	0.02
K ₂ O	0.08	BDL	0.04	0.02	BDL	0.02
P ₂ O ₅	0.03	BDL	0.01	0.03	BDL	0.02
LOI	5.60	5.50	6.10	5.00	4.80	5.30

Continued

Sum	99.54	99.55	99.60	99.58	99.56	99.57
Trace elements (ppm)						
Ba	17	24	8	38	16	19
Co	79	72	65	88	86	65
Cr	1772	3290	2551	2633	2189	2483
Cu	3	19	17	70	11	35
Ni	1568	1328	1097	833	1532	1117
Pb	0.7	0.2	2	0.5	0.4	0.5
Rb	10	0.3	2	0.8	0.7	2
Sr	8	10	5	35	6	7
V	33	39	60	65	45	44
Zn	6	17	9	19	12	34

Table 4. Comparisons of elemental concentrations in talc-chlorite schists with associated amphibolite and quartz-mica schist.

Major Oxides (%)	Talc-chlorite schist		Amphibolites		Quartz-mica schist	
	Mean	Range	Mean	Range	Mean	Range
SiO ₂	57.53	55.26 - 59.15	55.11	49.67 - 67.19	63.65	50.05 - 67.46
TiO ₂	0.11	0.03 - 0.34	1.15	0.72 - 1.36	0.98	0.82 - 1.35
Al ₂ O ₃	2.60	1.59 - 3.30	13.26	12.13 - 15.16	14.60	12.17 - 15.31
Fe ₂ O ₃	7.73	5.78 - 11.35	9.73	6.29 - 11.15	7.48	6.19 - 11.13
MnO	0.11	0.04 - 0.21	0.17	0.10 - 0.20	0.12	0.10 - 0.20
MgO	24.84	22.19 - 26.98	6.06	1.64 - 7.24	2.93	1.60 - 7.21
CaO	0.64	0.11 - 1.74	7.98	1.50 - 10.96	3.52	1.51 - 10.32
Na ₂ O	0.04	0.02 - 0.10	1.40	1.00 - 2.33	1.80	1.01 - 2.08
K ₂ O	0.03	0.01 - 0.08	2.18	0.66 - 6.66	2.26	1.12 - 2.71
P ₂ O ₅	0.02	0.01 - 0.03	0.37	0.11 - 1.09	0.16	0.10 - 0.20
Trace Elements (ppm)						
Ba	20	8 - 38	840	238 - 2732	567	417 - 638
Co	76	65 - 88	3	1 - 7	21	13 - 43
Cr	2486	1772 - 3290	266	90 - 320	145	70 - 330
Cu	26	3 - 70	34	22 - 41	26	21 - 46
Ni	1246	833 - 1568	81	29 - 102	48	27 - 100
Pb	0.72	0.2 - 2	16	3 - 25	7	3 - 19
Rb	2	0.3 - 10	76	17 - 242	81	28 - 101
Sr	12	5 - 35	556	216 - 916	293	214 - 560
V	48	33 - 65	207	100 - 263	139	96 - 261
Zn	16	6 - 34	39	20 - 52	46	40 - 52

Table 5. Comparison of elemental composition of Itagunmodi-Igun talc-chlorite schists with talcose rocks from other parts of Nigeria.

Oxides (%)	This study		Esie ¹		Oke-Ila ²		Iseyin (TTCS) ³		SW Nigeria (TTAS) ⁴	
	Mean	Range (n = 6)	Mean	Range (n = 12)	Mean	Range (n = 40)	Mean	Range (n = 10)	Mean	Range
SiO ₂	57.53	55.26 - 59.15	56.21	50.48 - 58.30	52.30	44.82 - 56.52	54.70	53.61 - 55.35	55.01	46.82 - 55.37
Al ₂ O ₃	2.60	1.59 - 3.30	1.66	0.50 - 5.54	3.14	2.66 - 5.49	3.54	1.86 - 4.84	2.52	1.19 - 2.86
Fe ₂ O ₃	7.73	5.78 - 11.35	6.90	5.23 - 10.63	5.22	5.03 - 8.84	6.50	5.75 - 7.25	4.50	3.20 - 4.50
MnO	0.11	0.04 - 0.21	0.10	0.03 - 0.18	0.18	0.12 - 0.20	0.16	0.10 - 0.25	0.05	0.04 - 0.13
MgO	24.84	22.19 - 26.98	29.71	26.09 - 31.35	26.98	20.54 - 28.15	27.20	22.06 - 30.38	30.04	29.13 - 32.04
CaO	0.64	0.11 - 1.74	0.16	0.04 - 0.37	7.40	6.28 - 8.66	4.43	2.76 - 5.32	1.50	0.41 - 4.47
Na ₂ O	0.04	0.02 - 0.10	0.16	0.12 - 0.25	0.05	0.03 - 0.08	0.22	0.16 - 0.32	0.01	0.01 - 0.02
K ₂ O	0.03	0.01 - 0.08	0.03	0.01 - 0.12	0.03	0.01 - 0.05	0.03	0.01 - 0.06	0.02	0.01 - 0.02
P ₂ O ₅	0.02	0.01 - 0.03	0.02	0.01 - 0.03	0.02	0.01 - 0.05	0.02	0.02 - 0.02	0.06	0.05 - 0.13
LOI	5.38	4.80 - 6.10	4.63	3.90 - 6.07	4.54	3.75 - 5.20	2.99	1.82 - 4.88	6.00	3.60 - 5.41
Sum	99.57	-	99.60	-	99.86	-	97.99	-	99.71	-
Trace Elements (ppm)										
Co	76	65 - 87.9	70	42 - 81	66	52 - 79	71	52 - 80	-	-
Cr	2486	1772 - 3290	1969	1330 - 2690	1629	608 - 2310	826	806 - 897	2000	-
Ni	1246	833 - 1568	1370	637 - 1870	774	639 - 979	1278	1034 - 1702	1500	-
Zn	16	6 - 34	1120	66 - 182	78	81 - 96	69	58 - 82	-	-

¹[11]; ²[8]; ³[16]; ⁴[17].

Iseyin, while Zn and Co concentrations are less. The relative chemical mobility of Na, Ca and K during secondary alteration processes [9] is visible in strong depletions of oxides of these elements relative to amphibolites and quartz-mica schists having field relationships with the talcose rocks.

The low values of Ba, Sr and Rb are probably due to their chemical instability during secondary alteration processes [9]. Cr and Ni are chemically immobile, even under hydrothermal alteration conditions, and this explains their enrichment in the talcose rocks in the study area. Zr and Sr also have low values in the talcose rocks likely due to the absence of mineralogical phases in the rock to host them.

On the Al₂O₃-(FeO + TiO₂)-MgO plot of [18], the talc-chlorite schist plot in the peridotitic komatiite field (Figure 6). This assertion is supported by the low concentrations of aluminium and potassium oxides, and the high magnesium content in the rocks (Table 3). The talcose bodies were therefore, most likely metamorphosed from a komatiite; an ultramafic mantle-derived volcanic rock. The talcose rocks also plot within the komatiitic field on [19] Al₂O₃ vs. FeO/(FeO + MgO) plot (Figure 7). All the samples plot close to the talc field in the CaO-SiO₂-MgO plot (Figure 8).

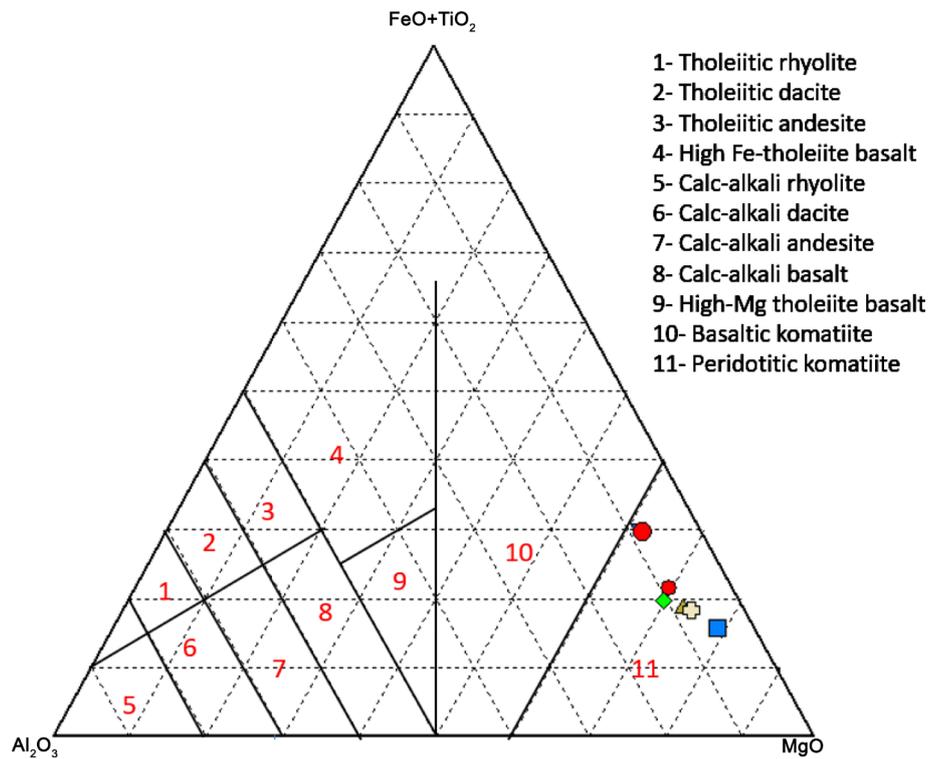


Figure 6. Plot of Itaganmodi-Igun talc-chlorite schist on Al_2O_3 -($FeO + TiO_2$)- MgO plot of [18].

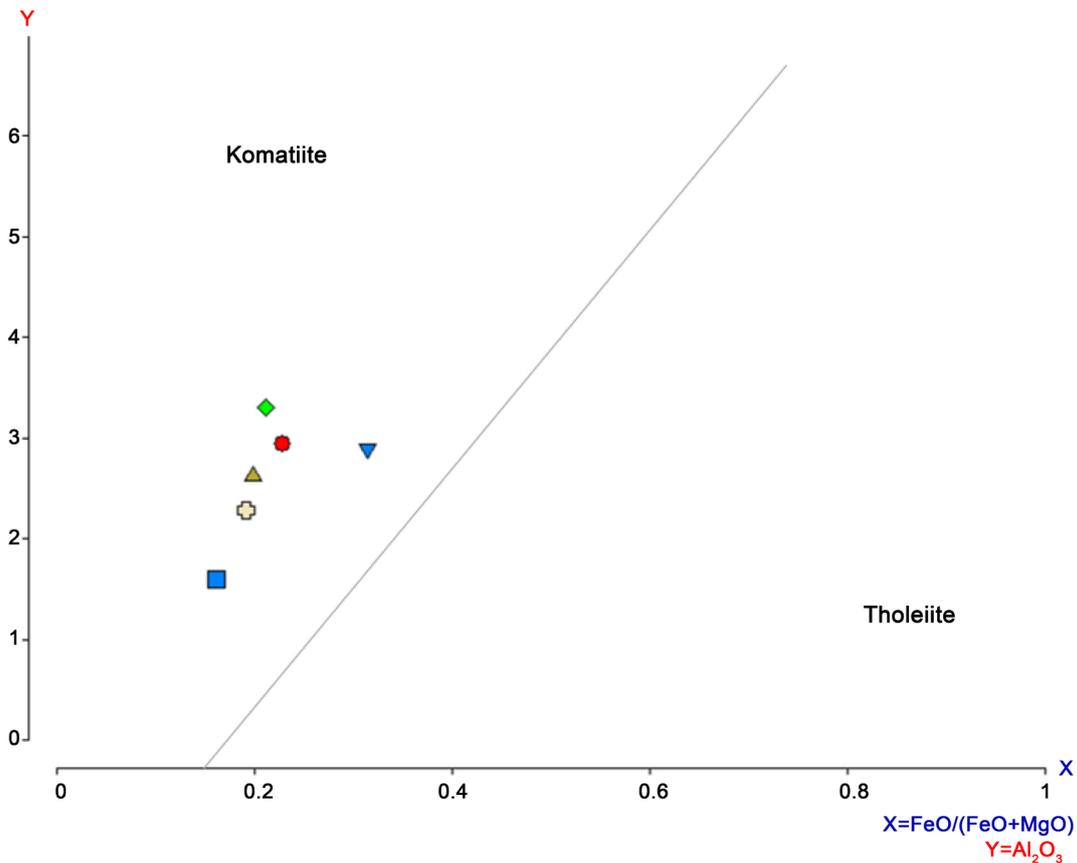


Figure 7. Al_2O_3 vs. $FeO/(FeO + MgO)$ plot of [19].

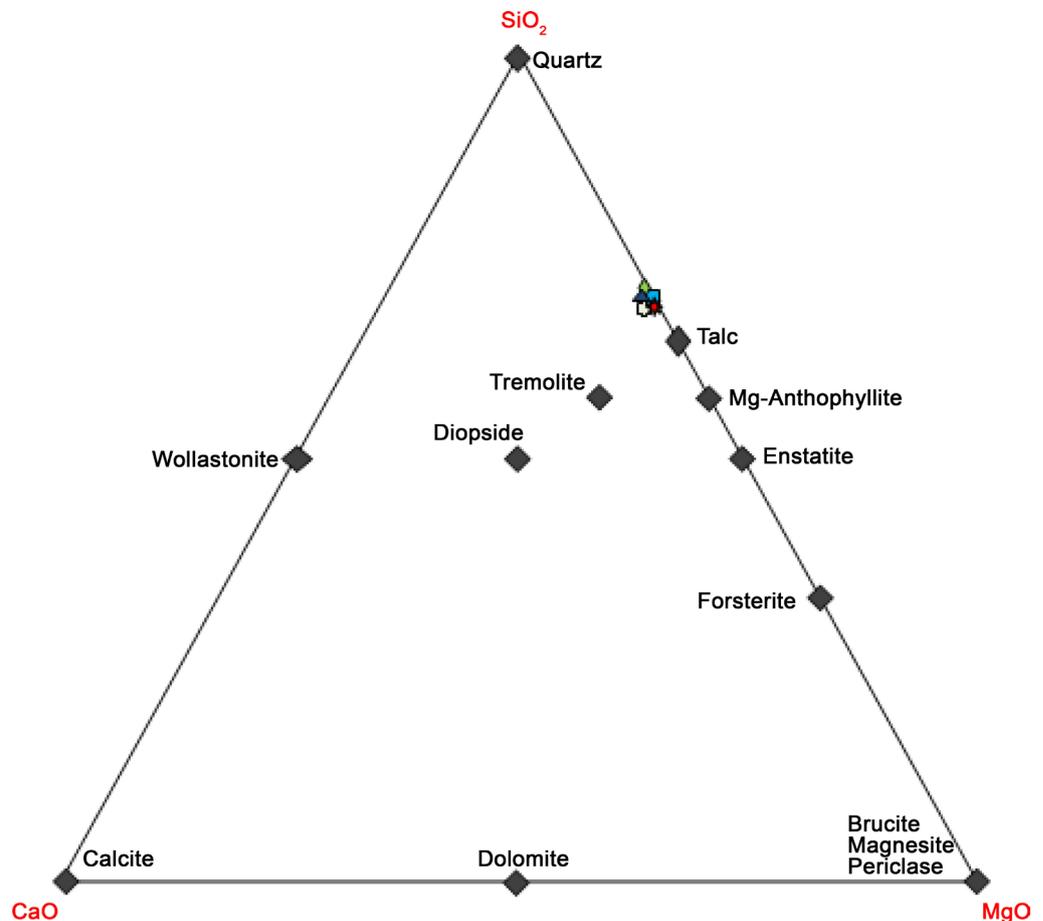


Figure 8. CaO-SiO₂-MgO plot for Itagun-Igun talcose rocks.

3.3. Industrial Appraisal

Talc, as an industrial mineral, has found application in the manufacture of various products such as ceramics, cosmetics, rubber, roofing sheets, paper, pharmaceuticals, paint and insecticides [20]. The suitability of talc for industrial application is largely a function of its physico-chemical properties.

Pulverized samples of the talc-chlorite schist were made into pellets and fired at 870°C for 2 hours to determine Linear Shrinkage (LS), bleached with dilute HCL for 48 hours and then submerged in water for 24 hours. LOI was calculated from the weight lost after heating to 1000°C. Water Absorption Capacity (WAC) was estimated by determining the percentage volume increase after soaking the pellets in water, while the reduction in diameter of the fired pellets compared to the unfired ones gave their LS values. WAC for the samples ranged between 6.25 and 8.20%, LS: 1.25% - 1.70%, and LOI: 4.80 - 6.10. Powders of the talc-chlorite schists bleached from grey and light brown to brown and dark brown (Table 6).

A comparison of industrial properties of talcose rocks of the study area with those of other parts of south western Nigeria indicates that the WAC values for rocks from the study area are lower than those from Wonu-Apomu, Erin-Omu, Iseyin and Baba Ode; but higher than Oke-Ila area. The range of LS value of the

other areas are wider than those of the study area, while the LOI are comparable with talcose rocks in Iseyin and Wonu-Apomu (**Table 7**). Average talc composition in the Itagunmodi-Iguntalc-chlorite schist is comparable to industrial and pharmaceutical grade Luzenac talc deposit in France [21] but significantly higher than the talc composition of Lumphurm [22] and Pitchbury [23] textile-, and rubber-grade talc deposits respectively. Mean chlorite compositions in the Pitchbury, Lumphurm and Itagunmodi-Igun talcose bodies are approximately the same (**Table 8**).

Table 6. Physical properties of talc-chlorite schists of the study area.

Parameter/Sample	1	2	3	4	5	6	
WAC (%)	-	6.25	6.30	8.14	8.20	5.35	
LS (%)	-	1.70	1.40	1.25	1.25	1.60	
LOI (%)	-	5.5	6.1	5.0	4.8	5.3	
Colour	Unfired	-	Light brown	Grey	Light brown	Light brown	Dark grey
	Fired	-	Dark brown	Brown	Dark brown	Dark brown	Dark brown

Table 7. Comparison of physical properties of talcose rocks in the study area with other parts of SW Nigeria.

Parameter	Present study	Wonu-Apomu/Ilesa ¹	Erin-Omu ²	Iseyin ³	Oke-Ila ⁴	Baba-Ode ⁵
WAC (%)	5.35 - 8.20	8.05 - 10.00	13.25 - 16.25	6.96 - 11.65	4.21 - 5.80	15.14 - 18.25
LS (%)	1.25 - 1.70	2.33 - 4.40	1.01 - 1.81	0.25 - 2.0	2.45 - 3.50	1.01 - 1.52
LOI (%)	4.8 - 6.1	4.21 - 5.27	2.87 - 4.11	1.45 - 6.03	3.75 - 5.28	4.25 - 4.41
Colour	Unfired	L/Brown-grey	Green/brown/grey	-	-	-
	Fired	Brown-D/Brown	Red/yellow/cream	-	-	-

¹[9]; ²[5]; ³[16]; ⁴[8]; ⁵[4].

Table 8. Comparison of mineralogical composition of Itagun-Igun talcose rocks with industrial grade talcose deposits.

Minerals (%)	This study								Reference samples			
	1	2	3	4	5	6	Range	Mean	A	b (i)	b (ii)	C
Talc	68	72	70	90	69	71	68 - 90	73	41	65	91	43
Pyrophyllite	-	-	-	-	-	-	-	-	-	-	-	-
Anthophyllite	-	-	-	-	-	-	-	-	4	-	-	6
Tremolite/Actinolite	-	-	-	-	-	-	-	-	31	-	-	33
Chlorite	16	14	17	-	16	17	14 - 17	16	12	6	1	13
Hornblende	12	13	11	-	8	6	6 - 12	10	-	-	-	-
Lizardite	-	-	-	9	6	4	4-9	6.3	-	-	-	-
Muscovite	-	-	-	-	-	-	-	-	2	-	2	-
Dolomite	-	-	-	-	-	-	-	-	-	15	3.5	1.7
Others (opaques, quartz)	4	1	2	1	1	2	1-4	1.8	4	3	-	3.5

^aLumphurm Deposit; Textile grade [22]; ^bLuzenac Talc; (i) Industrial grade (ii) Pharmaceutical grade [21]; ^cPitchbury Talc, Rubber grade [23].

Talc is a versatile industrial mineral useful in the manufacture of paints, cosmetics, pharmaceuticals, detergents and agricultural products. Talc, when used as a cement substitute, has less energy-intensive production requirement than Portland Cement and absorbs far more carbon dioxide as it hardens, thereby leaving a negative carbon footprint.

On the ISO Quality Specification for talc [24], the talcose rocks of the study area fall in Types C and D for wt% talc content (with values ranging from 68% - 91%), and Type A for wt% LOI at 1000°C (with values 4.8% - 6.1%).

When fired, the talcose rocks are brown to dark brown in colour, making them suitable as materials for insulation ceramics and in coloured pottery, but not as white wares and enamels as these require a white firing colour and an average of 6% CaO [25] [26]. The maturing temperature of the talc could be improved as a result of the presence of aluminium-rich chlorite, thereby increasing its usability for ceramic manufacture. Also, the absence of iron minerals in the talc schists is advantageous as they are known to cause spotting in ceramics [6]. They will also find use in the manufacture of plastics, textiles, paint, rubber and roofing materials [25] [26] [27] [28].

Paint manufacture requires an Al₂O₃ composition of ca 2%, MgO + SiO₂ (ca. 75%) and LOI (4% - 8%) [25] [26]; all criteria which the talcose rocks of the study area satisfy. For rubber manufacture, useful talc raw material will have no gritty particles and be composed of low MnO and CaO values [25] [26]. The talc-chlorite schists are very fine when pulverized and have low concentrations of CaO and MnO (Table 3). However, they are unsuitable for paper manufacture as the requirements include white colour, fine grain, no mica content and very low Fe₂O₃ and CaO contents [28]. The talc-chlorite schists have high Fe₂O₃ content and are brown to dark brown in colour post-bleaching. They also do not meet the criteria for refractory materials [29], as their Fe₂O₃ and SiO₂ contents are too high. To be desirable as raw material for the improvement of the rigidity and stability of rubber at high temperature during polypropylene plastic manufacture, talc raw materials should have low specific gravity, fine particle size distribution, softness and good colour [28]. The talcose rocks of the study area meet most of these criteria and will be useful if well processed. To be used in textile manufacture, talc raw materials are required to be free of hard/gritty particles (e.g. calcite, quartz), smooth, greasy, have good colour and moisture content < 0.3%. Though the talc deposits in the study area are essentially free of gritty particles, are smooth and greasy; its colour may restrict its use to certain textile types/varieties. They should also be properly processed to remove potential impurities like chlorite and hornblende.

Although the talc content in the talc-chlorite schists of the study area are comparable with that of the Luzenac pharmaceutical grade talc deposit [21], due to the elevated concentrations of trace elements (Ba, Co, Cr, Cu, Ni, Pb, Rb, Sr, V and Zn) in the talcose rock, which far exceed minimum risk levels prescribed by the Agency for Toxic Substances and Diseases Registry ([30]; Table 9), they

Table 9. Comparison of trace element content of talc-chlorite schist with Recommended Daily Allowance of trace elements.

Trace Elements (ppm)	Mean	Range	MRL (ppm) ¹
Ba	20	8 - 38	0.2
Co	76	65 - 88	0.01
Cr	2486	1772 - 3290	0.005
Cu	26	3 - 70	0.01
Ni	1246	833 - 1568	$2 * 10^{-7}$
Pb	0.72	0.2 - 2	No safe threshold
Rb	2	0.3 - 10	-
Sr	12	5 - 35	2
V	48	33 - 65	0.01
Zn	16	6 - 34	0.3

¹[30].

are unsuitable as raw materials in the production of pharmaceutical and cosmetic products. They are however useful, if beneficiated, as industrial grade talc raw materials.

4. Conclusion

Talc-chlorite schists from Itagunmodi-Igun areas of the Ilesa schist belt contain talc and chlorite as major minerals, with accessory lizardite, hornblende and quartz. Results of chemical analyses indicate that the rocks are high in SiO₂ and MgO, with significant enrichments of Co, Cr and Ni. They plot within the komatiite field and are believed to derive from a peridotitic komatiite protolith. A comparison with talcose rocks from other parts of the Ilesa schist belt and southern Nigeria reveals similar silica content, lower magnesia and alumina, and higher ferric oxide components. They also compare favourably in talc composition with talc deposits from Luznac, France and in chlorite content with Lumpfurm and Pitchbury talcose bodies. The mineralogical composition and physico-chemical properties of the talc-chlorite schists make them suitable as raw material for paint, absorbent, coloured pottery, ceramic insulation, textile, rubber, plastic and roofing sheet manufacture with varying beneficiation requirements. The relatively high concentration of trace elements like Cr, Cu, Ni, Pb and Zn however disqualifies them for use in pharmaceutical and cosmetic applications. The study has contributed to increased knowledge of the petrochemistry and petrogenesis of talcose bodies within the Nigerian schist belts (Ilesa in particular) and geology of the Basement Complex in general. Further work could involve an estimation of the tonnage of the talc deposit and the economic viability of mining it.

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