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Compositional Features and Industrial Appraisal of Talcose Rocks around Arigbabu South-Western Nigeria

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Abstract
Talc bearing rocks around Arigbabu area, in the Ife-Ilesha schist belt, were studied to delineate their compositional features, petrogenesis and their suitability as industrial raw material. Systematic geological mapping was carried out to identify talcose bodies in the area; petrographic studies and X -ray Diffraction (XRD) were carried out to identify the minerals in the talcose bodies, geochemical analysis to determine elemental concentration was carried out using Inductively Coupled Plasma Mass Spectrometry (ICPMS). Samples were also subjected to firing and geotechnical test to determine its geotechnical properties. Results revealed the talc deposit are closely association with mafic - ultramafic rocks, quartzite, mica schist and granites. Petrographic and XRD studies revealed that the talcose body are composed of talc, tremolite, chlorite and anthophyllite while geochemical analysis revealed mean values of 56.02%, 25.27%, 6.6%, 2.92% and 1.13 % for SiO_2, MgO, Fe_2O_3, Al_2O_3 and CaO respectively which are comparable to other talc occurrences of southwestern Nigeria. Firing of the talc samples revealed an average Loss On Ignition (LOI) of 6.74%, average linear shrinkage value of 1.52% and mean values of water absorption capacity and pH are 10.36% and 8.08 respectively. Economic appraisal of the talc deposits indicates they are suitable as raw materials for paint, fertilizer, paper, rubber and ceramic manufacturing, subject to appropriate beneficiation.

Keywords: *Arigbabu, Industrial, Nigeria, Petrogenesis, Schist Belt, Talcose Rocks,*

Introduction

Talc, a hydrous magnesium silicate ($Mg_3Si_4O_{10}(OH)_2$) is a versatile industrial mineral commonly employed in the manufacture of ceramics, cosmetics, paper, pharmaceuticals, paint, rubber, roofing sheets, insecticides, fertilizers and a host of other products (Clarke, 1979). It belongs to a subclass of phyllosilicates and it may be formed as an hydrothermal product of basic and ultrabasic rocks (Highley, 1974; Hess, 1993).

Occurrences of talc bodies have been reported within the schist belts of the basement complex of southwestern Nigeria notably in localities around Iseyin district (Rahaman, 1973; Elueze and Awonaya, 1980; Elueze, 1982) Wonu, Apomu Area (Ige, 1982; Bolarinwa and Adeleye, 2015), Kumanu (Durotoye and Ige, 1991) and Itagunmodi-Igun area (Olajide-Kayode et al., 2019). This present occurrence, which is being reported for the first time, is an addition to the growing list of the Ife-Ilesha group of talc bodies. In this study, systematic geological mapping, petrographic studies, X-ray diffractometry, geochemical and industrial determinations of Arigbabu talcose rock was undertaken with a view to understanding the compositional characteristics so as to evaluate its economic potentials.

Methodology

Geological mapping on a scale of 1:50 000 was carried out to identify talcose bodies in the study area and determine rock association. Samples of talcose rocks were obtained and subjected to petrographic and X-Ray Diffraction (XRD) studies in order to determine the mineralogical composition. For the XRD studies, powders of 5 representative talcose rock samples were examined using a Philips- PW1011 model diffractometer and diffractograms were recorded using a scanning rate $2^0 min^{-1} cm^{-1}$ with a Ni-filtered Fe K-alpha radiation.

Eight representative talcose rock samples were pulverized and analyzed for their elemental composition using Inductively Coupled Plasma Mass Spectrometry (ICPMS) at the Bureau Veritas Minerals laboratories, Vancouver, Canada.

For determination of other physical and chemical properties, sample pellets were produced in the laboratory to determine Loss On Ignition (LOI), Water Absorption Capacity (WAC), Linear Shrinkage Values (LSV), firing color and pH with the aid of a standard mechanical press. Some of the pellets were fired in the laboratory in a Muffle furnace at about 1000^0C for 24 hours and LOI was determined from the weight difference between the unfired and fired pellets. LSV

was calculated as percentage decrease in diameter after firing while WAC was estimated for each pellet as percentage weight increase after 24 hours of immersion in water. Bleaching test was carried out on the samples by soaking 2g of the pulverized powder in 5ml of 0.5, 1.0, 2.0 and 3.0M HCL.

Results and discussion

Geological Setting and Mineralogy

Geological mapping revealed talcose rocks, mica schist, quartzite, quartz schist, amphibolites, and biotite

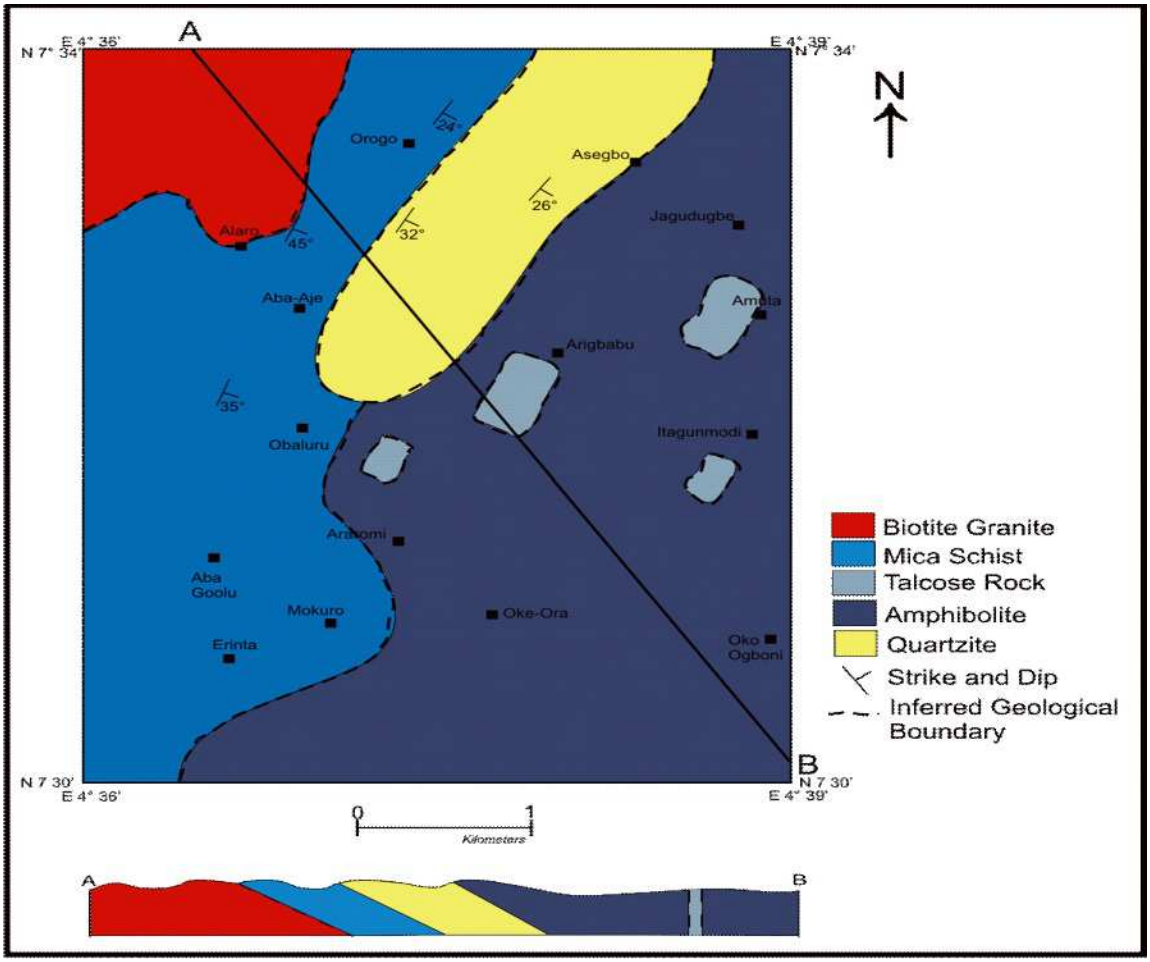

Fig. 1: Geological map of Arigbabu and environs.

granites outcrop in the Arigbagbu area (Figure 1). The talc bodies occurs as low-lying boulders, or as massive discontinuous lensoid bodies within the amphibolite complex, they are grey to whitish grey in color and are fine to medium grained with a characteristic soapy feel. Mineralogical investigation based on the thin sections study revealed that the predominant mineral in the samples is talc while tremolite, chlorite and anthophyllite occur in lower proportions (Table 1; Figure 2).

In thin section, talc appears as columnar and fibrous aggregates and as platy laths, tremolite occurs as green color prismatic grains which are sometimes acicular and it exhibits faint pleochroism with moderate birefringence. Chlorite is subordinate in occurrence to both tremolite and talc; it appears as greenish crystals with weak pleochroism. XRD results also show conspicuous peaks of talc, tremolite, anthophyllite and chlorite with high abundance of talc (30 – 70%) in all samples analyzed (Figure 3 - 4).

Geochemical results

Geochemical analysis results revealed SiO_2 ranged 51.72 – 60.83 wt. %, Al_2O_3 ranged 1.38 – 5.76 wt. %, Fe_2O_3 ranged 4.49 – 8.24 wt. %, MgO values ranged

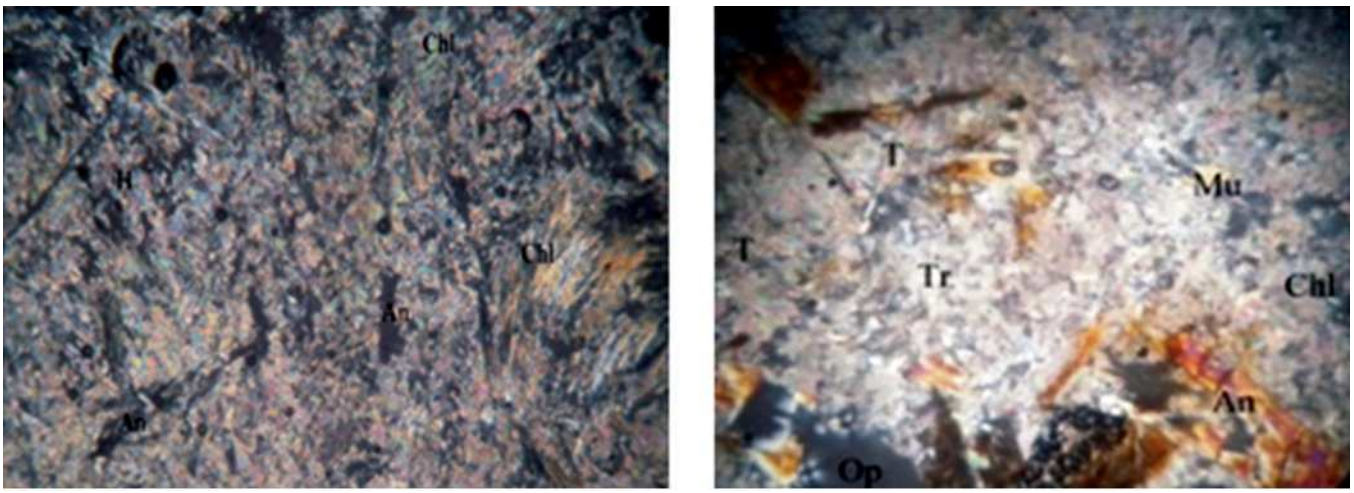

Fig. 2: Photomicrograph of Arigbabu talcose rocks in transmitted light showing talc (T), tremolite (Tr), chlorite (Chl) and anthophyllite (An).

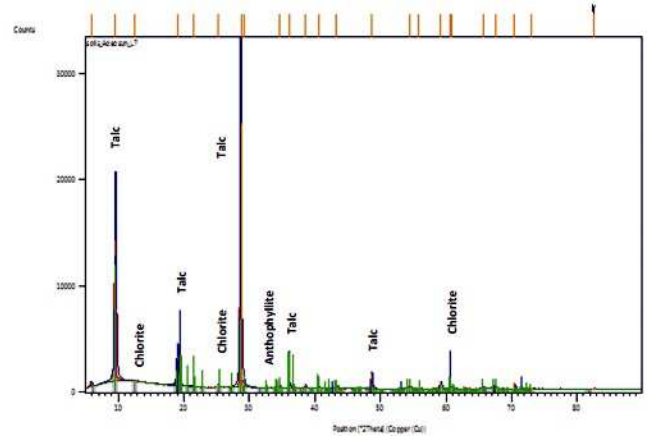

Fig. 3: X-ray diffractogram for talcose rock of Arigbagbu showing abundance of talc and minor proportions of chlorite, anthophyllite and chlorite.

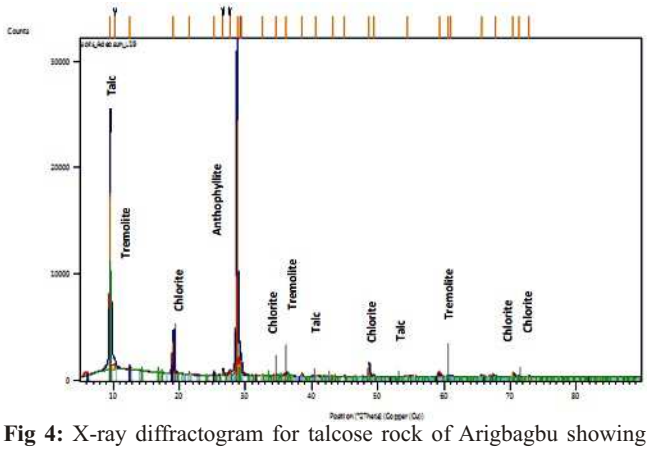

Fig 4: X-ray diffractogram for talcose rock of Arigbagbu showing abundance of talc and minor proportions of chlorite, tremolite, anthophyllite and chlorite.

23.98 – 27.37, CaO values ranged 0.04 – 2.86 wt. % while TiO_2 values ranged 0.03 – 0.08 wt. %. Selected trace elemental concentration (ppm) varied as follows: 6 – 38; 1171 – 1547; 77 – 117; 0.4 – 49.2; 2.1 – 29.3; 19 – 60; 1.5 – 9.9 and 0.4 – 5.9 for Ba, Ni, Co, Rb, Sr, V, Zr and Y respectively with mean values (ppm) of 24, 1375, 86, 11, 13, 40, 5, and 3 for Ba, Ni, Co, Rb, Sr, V, Zr and Y respectively (Table 2).

Table 1: Modal composition of Arigbabu talcose rocks

Minerals (%)	T2	T3	T5	T7
Talc	50	25	25	40
Tremolite	13	20	5	20
Actinolite	7	15	-	-
Anthophyllite	20	-	25	20
Hornblende	-	15	10	-
Chlorite	10	15	30	10
Musovite	-	-	-	5
Opaque	-	5	-	5
Others	-	5	5	-
Total	100	100	100	100

The Arigbagbu talcose rock samples plot close to the talc field on the CaO-SiO_2-MgO ternary plot; on the Al_2O_3 vs. $FeO/(FeO + MgO)$ and the Al_2O_3-$(FeO + TiO_2)$ - MgO ternary diagram, they plot within the peridotitic komatiite and komatiite field which implies the talcose rocks are likely derivatives of an ultramafic mantle derived extrusive rock (Figure 5-7).

SiO_2 value is similar to the Baba - Ode talc tremolite-actinolite schist and talc-tremolite/ actinolite schist of southwestern Nigeria (Elueze, 1982; Elueze and Ogunniyi, 1985; Okunlola, et al, 2002). However, Arigbagbu talcose rocks contains lower mean SiO_2 concentration compared slightly to Erin-Omu talcose rock and Igbo-Agbon talcose rocks of Iseyin district (Bolarinwa, 2001; Ayemo, 2003; Okunlola and Anikulapo, 2006). Al_2O_3 and CaO mean concentration are 2.92% and 1.13% respectively, the values are higher than Al_2O_3 and CaO concentration of Erin-Omu talc and

Table 2: Elemental composition of Arigbabu talcose rocks

Oxides	T1	T2	T3	T4	T5	T6	T7	T8	Mean
SiO_2	59.97	58.7	53.68	60.83	59.86	51.57	51.72	51.84	56.02
Al_2O_3	1.44	1.38	5.76	1.4	1.76	3.88	3.88	3.85	2.92
Fe_2O_3	4.49	6.44	8.24	4.72	4.5	8.08	8.15	8.19	6.6
MgO	26.52	25.47	23.98	26.75	27.37	24.04	24.07	23.99	25.27
CaO	0.06	0.18	0.07	0.04	0.04	2.86	2.91	2.85	1.13
Na_2O	0.1	0.09	0.03	0.09	0.03	0.06	0.05	0.05	0.06
K_2O	0.18	0.32	0.02	0.07	0.01	0.03	0.03	0.04	0.09
TiO_2	0.03	0.03	0.08	0.03	0.04	0.08	0.07	0.09	0.06
P_2O_5	0.02	0.04	<0.01	0.02	<0.01	0.05	0.05	0.05	0.03
MnO	0.05	0.1	0.14	0.07	0.03	0.17	0.17	0.17	0.11
Cr_2O_3	0.272	0.248	0.47	0.23	0.23	0.45	0.449	0.443	0.35
LOI	6.2	6.4	6.9	5.1	5.5	8.1	7.9	7.8	6.74
Ba	18	17	20	21	6	37	38	38	24.38
Ni	1486	1404	1522	1533	1547	1167	1174	1171	1375.5
Sc	4	9	6	4	2	13	13	13	8
Co	77.8	74.6	117.4	77.2	76.5	87.1	89.7	88.5	86.1
Cs	22.6	54.6	0.8	6.8	0.2	<0.1	<0.1	<0.1	10.63
Ga	1.3	1.5	7.3	1.3	2.2	3.6	3.4	3.5	3.01
Hf	<0.1	<0.1	0.2	<0.1	0.1	0.3	0.2	0.3	0.14
Nb	<0.1	<0.1	4.3	<0.1	<0.1	1.7	1.6	2.2	1.23
Rb	23.4	49.2	1.1	8.3	0.4	1.6	1.1	2.6	10.96
Sr	3.8	7.6	2.7	3	2.1	28.1	28.5	29.3	13.14
V	34	26	60	19	19	58	54	53	40.38
Zr	2.6	1.5	4.7	1.8	4	9.5	8.6	9.9	5.33
Y	0.4	0.8	3.5	0.6	1	5.9	5.8	6.2	3.03

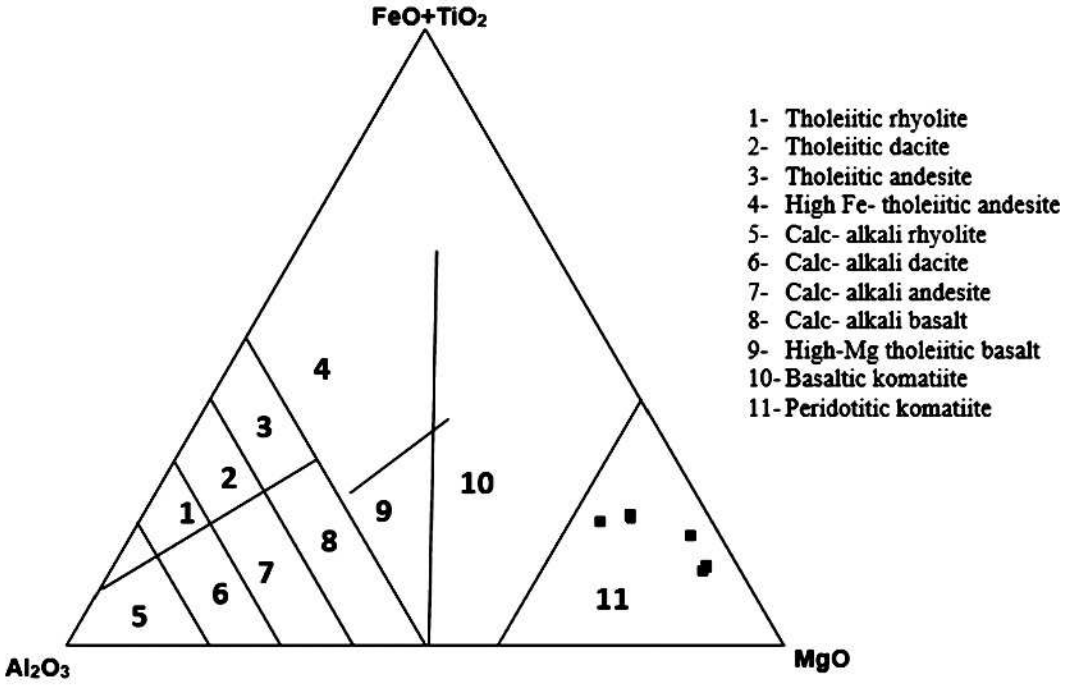

Fig. 5: Plot of Arigbagbu talc-chlorite schist on Al_2O_3 - (FeO + TiO_2)-MgO plot of Jenson, (1976)

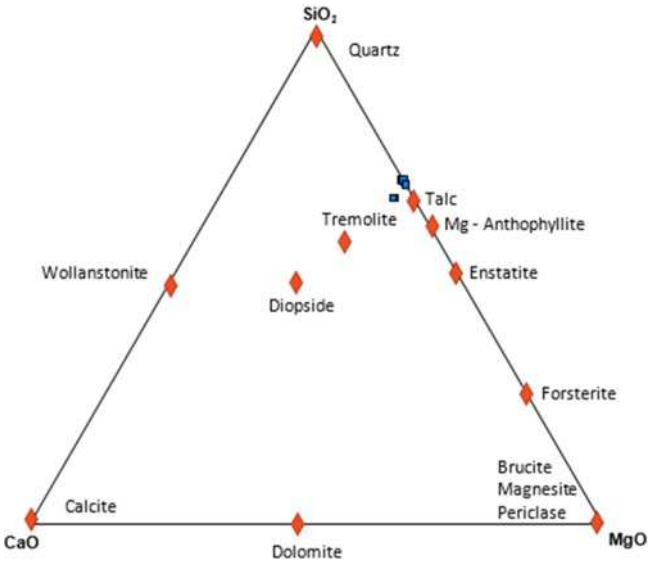

Fig. 6: CaO-SiO_2-MgO plot for Arigbagbu talcose rocks.

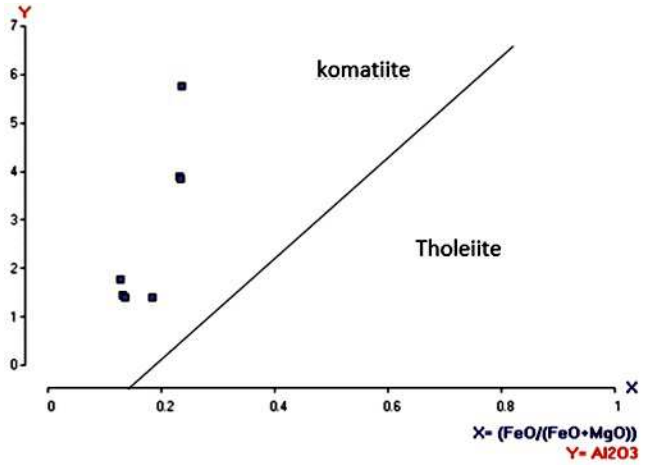

Fig. 7: Al_2O_3 vs. FeO/(FeO + MgO) plot of Naldrett and Cabri, (1976)

Baba-Ode talc tremolite- actinolite schist but lower than that of Iseyin (Elueze, 1982; Elueze and Ogunniyi, 1985). Fe_2O_3 mean concentration is 6.60% and this is comparable to Baba-Ode tremolite talc ca. 6.61%), lower than that of Erin-Omu talcose rock and higher than Iseyin talc tremolite- chlorite schist and Baba-Ode talc tremolite- actinolite schist. Average MgO concentration of the talcose rock (25.27%) is lower than that of other talc bodies in the southwestern part of Nigeria except the Igbo-Agbon talc bodies (Table 3).

Arigbagbu talcose rocks is also characterized by higher average Co concentration (86ppm) compared to 62ppm in Erin-Omu talcose rocks (Okunlola and Anikulapo, 2006); 71 ppm in Iseyin tremolite talc chlorite schist (Elueze and Awonaiya, 1989) and 66ppm in the Oke- Ila talc (Bolarinwa, 2001). The Ni content of the talc body (1375 ppm) is lower than values of 1500 ppm recorded for talc-tremolite actinolite schist of southwestern Nigeria, (Elueze, 1982; Elueze and Ogunniyi, 1985).

Physical and Industrial Assessment

Results of physical and chemical test revealed pH values ranged 8.07 – 8.10, LOI varies from 5.1 to 8.1; the Fired Shrinkage Value (FSV) ranged 1.25 to 1.71% and Water Absorption Capacity (WAC) ranged 8.10-16.15 % (Table 5). The high water absorption capacity suggests that the talc samples are more porous compared to the Iseyin and Ilesha varieties but the reduction of porosity may be effectively achieved through blending of talc with calcite.

Colour varies from grey to whitish grey before firing,

Table 3: Comparison of Arigbabu talcose rock composition with similar rocks from other location

	A		Erin-Omu		Iseyin		Baba-Ode		Wonu-Apomu	
SiO_2	56.02	51.57-60.83	59.72	57.84-61.76	54.7	53.61-55.35	52.01	49.15-54.65	55.62	51.23–61.15
Al_2O_3	2.92	1.38-5.76	1.65	0.85-2.91	3.54	1.86-4.84	3.82	3.18-4.61	2.74	0.77–4.3
Fe_2O_3(t)	6.6	4.49-8.24	7.34	5.65-8.34	6.5	5.75-7.25	6.61	6.15-7.11	6.43	3.75–8.34
MnO	0.11	0.03-0.17	-	-	0.16	0.10-0.25	0.17	0.15-0.18	0.19	0.05–0.48
MgO	25.27	23.99-27.37	26.87	24.72-29.06	27.2	22.06-30.38	26.25	24.12-28.81	29.15	27.89–30.06
CaO	1.12	0.04-2.86	0.06	0.042-0.08	4.43	2.76-5.32	6.17	5.91-6.80	1.71	0.05–3.17
Na_2O	0.06	0.03-0.10	0.02	0.01-0.03	0.22	0.16-0.32	0.07	0.05-0.08	0.04	0.01–0.11
K_2O	0.08	0.01-0.18	-	-	0.03	0.01-0.06	-	-	0.03	0.01–0.11
TiO_2	0.05	0.03-0.09	0.15	0.07-0.36	0.18	0.17-0.21	0.58	0.31-0.52	0.16	0.02–0.2
P_2O_5	0.03	<0.01-0.05	-	-	0.02	0.02-0.02			0.02	0.01–0.03
LOI	6.7	5.1-8.1	3.82	2.87-4.11	2.99	1.82-4.88	3.66	3.51-3.91	4.58	4.21–4.81
Co	86	74-117	62	56-70	71	52-80			62	48–82
Cr	-	-	1229	428-1699	826	806-897			63	45–94
Ni	1375	1167-1547	1029	915-1110	1278	1034-1072			57	25–85
Zn	-	-	58	49-69	69	58-82			-	-

A: This study
B: Erin-Omu (Okunlola and Anikulapo, 2006)
C: Iseyin (Elueze and Awonaiya, 1989)
D: Baba – Ode (Okunlola, et al, 2002)
E: Wonu – Apomu (Bolarinwa and Adeleye, 2015)

and from whitish to grey and light brown on firing with some samples retaining their whitish colour and this may promote their suitability for industrial applications. Application of HCl to samples revealed the possibility of colour improvement with increase in concentration of HCl. Color can be upgraded using 3.0M and 2.0M of HCl while 1.0M HCl moderately bleached and improved the colour.

The usefulness of talc as industrial raw materials is dependent on certain specifications which are based on their physical characteristics and chemical/ compositional features. In the production of wall/floor tiles, white wares and enamels, talc acts as an additive to promote translucency and to increase toughness of the product. Mitchell, (1975) specified a good firing colour (white) and an average CaO concentration of 6%. The

Table 4: Physical tests results of the Arigbagbu talcose rocks

	1	2	3	4	5	6	7	8	Mean	Range
pH	8.07	8.07	8.07	8.12	8.10	8.07	8.05	8.10	8.08	8.05-8.12
WAC (%)	9.23	8.10	8.12	6.25	6.50	14.22	14.31	16.15	10.36	8.10-16.15
FSV (%)	1.25	1.25	1.25	1.75	1.75	1.55	1.65	1.71	1.52	1.25-1.71
LOI (%)	6.2	6.4	6.9	5.1	5.5	8.1	7.9	7.8	6.74	5.1-8.1

Arigbabu talcose rock samples do not meet the specifications for this purpose as the CaO concentration is below 6%. However, they meet the requirements for use as fillers in the production of rubber goods because of their off colour, silica and magnesia contents which is greater than 75% and low MnO and CaO content (1.24%) (Severinghus, 1975).

The Fe_2O_3 content is marginally high for the Arigbabu talc to be used as extenders in paints and magnetic separation of iron-oxide would significantly improve the quality of the talc. Average Al_2O_3 concentration of 2.92% can also promote the maturation temperature and suppress shrinkage.

Textural features are also important in industrial assessment of talc deposits. Arigbabu talc is glossy but flaky and therefore desirable for the production of roofing tiles and cosmetics. Furthermore, Arigbabu talc can be used in textile industries as mpurities such as quartz and calcite which limits talc use in textile application are absent from Arigbabu Talc. Firing of the Arigbabu pellets to a temperature of about 1100°C yielded refractory products with more than 6% loss on ignition, 1.52% shrinkage and 10.36% water absorption capacity. The Arigbabu pellets, after firing at 1100^0C did not bloat or crack. Heating may have also increased the volumes of the solid phases, which could partly inhibit shrinkage due to porosity reduction. The high water absorption capacities indicate low vitrification and thermal resistance, which is desirable in refractory production and reduction of porosity may be effectively achieved by the addition of calcite to talc.

Conclusion

Mineralogical compositions based on petrographic and X-ray diffraction results revealed Arigbabu talcose rocks are associated with amphibolites and they contain talc, tremolite, chlorite, actinolite and minor proportions of anthophyllite. Based on the shrinkage value, Arigbabu talc may find usage as porcelains raw material for which zero to low firing shrinkage is appropriate.The overall assessment indicate that Arigbabu talcose rocks could be economically viable especially after undergoing appropriate process of beneficiation and utilized as raw materials in the production of rubber, paints, refractory and textiles but may not be fully suitable as raw materials in high grade ceramics because of its low CaO content.

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