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Mineralogical and Physicomechanical Characterization of Kaolinitic Clay from Moshi, Northern Tanzania for Potential Ceramic Utilization

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Abstract

Kaolin clay from Moshi, northern Tanzania has been characterized for potential ceramics productions. Clay samples taken from three different levels of the deposit were analysed by XRD and XRF. Firing experiments were carried out on experimental briquettes at a maximum temperature of 1300 °C at the rate of 100 °C/hour. The results revealed dominance of kaolinite and illite in the raw clay. The samples were composed majorly by silica (36.88–41.62%), alumina (30.83–32.40%) and hematite (9.29–12.70%). Granulometric analysis showed that the amount of clay decreased with deposit depth. The physicomechanical properties of the clay fired at the optimal temperature of 1300 °C included shrinkage (22.06–30.72%), water absorption (18.23–20.15%), bulk density (1.834–2.182 g/cm^3) and modulus of rupture (2.957–6.313 MPa). Mullite was the key component responsible for mechanical strength. Clay sample from the top level showed the best properties. The parameters were of satisfactory quality and comparable to other ceramically suitable clays. High levels of Fe_2O_3 (> 9%) could adversely affect the translucency of whitewares. These findings indicate that the investigated kaolin has potential of being used in the ceramic industry for making materials such as non-vitreous tiles, bricks and various high-temperature products that do not require high brightness specifications.

Keywords: Clay mineralogy, firing temperature, microstructure characterization, ceramic properties, Tanzanian kaolin.

Introduction

Clays are increasingly becoming important materials in the manufacturing and environmental industries. Their fine-grained nature, which gives them high plasticity and flexibility to form, allows a range of applications as raw materials in various ceramic products (Boussen et al. 2016, Semiz 2017, Temga et al. 2019). Unlike the earlier traditional uses in pottery, the current developments in science and technology have enabled new and advanced applications of the materials, including high temperature-ceramics, high-tech electronic devices, biomedical tools and even space shuttle parts (Subedi 2013, Mishra and Ningthoujam 2017, Matizamhuka 2018, Ural 2018). While the traditional uses of clays depended mainly upon the external appearance of their grains and colour, the current production of high-quality ceramics requires starting materials of specific properties as well as sophisticated sintering and vitrification techniques (Abubakar et al. 2021).

For clays of any origin, several different factors play important roles in determining the quality of the final products. These include the mineralogical content, the chemical composition, the grain features, the fired characteristics, and the quantity of impurities (Kagonbé et al. 2021). There are also some important physicomechanical properties that are usually examined for the purpose of limiting the formation of defects that may occur in the dried materials during ceramic products formation (Monsif et al. 2019). These include shrinkage, water absorption capacity, bulk density and modulus of rupture (Hammouda et al. 2015). Detailed scientific information of the source clay properties is therefore required to guarantee its suitability. Apart from this, information on the clay abundance is also important for sustaining meaningful industrial activities (Antal et al. 2017, Kagonbé et al.2021).

In Tanzania, the utilization of clay materials in the ceramic industry is not a new venture. Publications dating back to more than a decade ago examined clays from different locations around the country (Akwilapo and Wiik 2004, Akwilapo 2005, Lugwisha 2006, Lugwisha 2011, Hamisi et al. 2014, Kimambo et al. 2014, Malima et al. 2021). However, despite these efforts, it is believed that there are still some more clay reserves in various sites in the country that are not yet adequately investigated and properly documented (Lugwisha and Lunyungu 2016), one such reserve is in Katanini, Moshi District in Kilimanjaro Region. The Kilimanjaro Region in the north-eastern part of the country is regarded as having one of the most abundant mineral resources, with non-metallic minerals such as pegmatite, gypsum, magnesite and others (Mwakarukwa 1988). The rich volcanic rocks that are widely distributed at the foot of Mount Kilimanjaro, the highest volcanic mountain in Africa, characterise the area by porous basalt and clastic rocks that turn into lateritic soil through the continuous weathering and sedimentation (Little and Lee 2006). The area is conspicuously covered by clayish topsoil that was traditionally used for making red bricks (Ekosse 2010). In this experimental study, kaolin clay from different depths of the Katanini deposit is characterised, focusing on its mineralogy, chemical composition, and some physicomechanical properties. The objective was to test its potential as raw material for the ceramic industry, which play an important role in the economy of the country. To the best of our knowledge, this is the first time that the pertinence of clay from this location has been investigated. It is anticipated that this work will enlighten the understanding of the quality of the Moshi kaolin, and its applicability in various ceramic industrial uses.

Materials and Methods

Sampling

The kaolin clay investigated in this study was collected from Katanini deposit located at latitude -3°16'20" north and longitude 37°18'15" east, in Moshi District, Kilimanjaro Region, Tanzania, hence the name “Moshi kaolin”. Sample collection was preceded by field observations for choice of the sampling locations and examination of the soil properties. A field area of about 2 hectares was divided into three portions of equal sizes. In each portion, samples of about 5 kg were collected from three different levels. These were the top level (coded T); the middle level (coded M), which was about 1 metre from the top level, and the lower level (coded L), which was about 2.5 metres from the top level. Apart from these, one sample was made by mixing the three original samples (T, M and L) to get a composite sample (coded X). A total of 12 samples were therefore obtained. Samples were profiled for their colour and texture according to the standard procedures (Howard 1987).

Analytical techniques

The particle size distribution was determined by granulation. Clay samples were first dried at 105 °C for 24 hours in an oven, cooled to room temperature and subjected to granulometric separation using three types of sieves, i.e., pore sizes > 63 µm; 2–63 µm and < 2 µm. The mineralogical compositions were determined by XRD, using Cu X-ray source, at wavelength 154056 Å, temperature of 25 °C, 40 kV, 40 mA energy, in the 2θ range of 2º–65º. Samples were pre-treated prior to analysis so as to remove organic materials, disaggregate the mineral particles and increase the zeta potential. The samples were treated with sodium hypochlorite solution for oxidation of organic matter, followed by three washes with sodium carbonate–sodium bicarbonate solution. This resulted into complete removal of organic matter without removing or complexing the carbonate or silica. The samples were further subjected to air-drying (24 hours) and glycolation. Glycolation was achieved by mixing with glycol liquid and standing for 24 hours for the glycol to be absorbed to the lattices so as to observe if the clay sample can absorb water and swell. The samples were also subjected to heat treatment at 550 °C for 2 hours so as to observe its behaviour when heated. The chemical composition of the clay samples before and after firing were determined by XRF, using Rh anode X-ray source and a gas-filled-proportional detector for bulk determination of major elements.

The firing test for the clay samples involved preparation of bricks using the different clay samples, i.e., the top clay (T1, T2, T3); the middle clay (M1, M2, M3), the lower clay (L1, L2, L3) and the mixture (X1, X2, X3). About 2 kg of clay sample was mixed with 500 mL of water to make clay plastic. The clay plastic was then placed in a metal mould with dimensions of 71 x 71 x 71 mm. The moulds were subsequently air-dried for 48 hours, then subjected to oven-drying at 110 °C for 24 hours. This was done so as to avoid surface cracking that might occur during firing as a result of excessive surface drying. The average amount of clay used, the amount of water used and the spillage obtained were recorded. The clay bricks were fired to the maximum temperature of 1300 °C at the rate of 100 °C/hour, then held at the maximum temperature for 24 hours and then cooled at the rate of 100 °C/hour to 600 °C. At 600 °C, the cooling rate was reduced to 50 °C/hour down to room temperature. The change of the cooling rate below 600 °C was aimed at reducing the damage of the fired moulds that would have resulted from the quartz volume change associated with its transformation at 573 °C.

Determination of the physicomechanical properties

The physicochemical properties, namely shrinkage, water adsorption, bulk density and modulus of rupture, were measured according to the American Society for Testing and Materials (ASTM) standard test method C373-88 (ASTM 2006). Shrinkage was determined experimentally by direct measurement of the brick's length (L), width (W) and height (H) using digital Vernier Calliper. The volumes of the brick before and after firing were calculated as per the formula (1):

$$V = L \text{ x } W \text{ x } H \qquad (1)$$

Shrinkage (S) was then computed using the formula (2):

$$\% \, S = \left(\frac{V_0 - V_1}{V_0}\right) \text{ x } 100 \qquad (2)$$

where V_0 and V_1 are the volumes before and after firing, respectively.

Water absorption (WA) is the amount of water absorbed by the dried brick sample. This was determined by first drying the brick samples in an oven at 150 °C for 24 hours and cooling them in desiccators. The dried samples were then weighed and immersed in distilled water for 24 hours at room temperature. After 24 hours of soaking, bricks were taken out, wiped with cotton cloth and weighed immediately. The WA was calculated as a percentage of the mass of the dried structure by using the formula (3):

$$WA = \left(\frac{W_2 - W_1}{W_1}\right) \text{ x } 100 \qquad (3)$$

where W_1 = weight before absorption and W_2 = weight after absorption.

The bulk density (δ) was calculated according to the formula (4):

$$\delta = \frac{m}{v} \qquad (4)$$

where m = mass of the fired brick (measured by a weigh balance) and v = volume (computed from the Vernier callipers measurements).

The modulus of rupture (MOR), which is the limit dynamical load a ceramic body is capable to withstand, was determined by using a UPD 40 tensile machine of 400 V, 50 Hz, 6 A energy and 400 kN maximum load. In this experiment, a clay brick was placed on a pan and another pan (compressor pan) was used to compress it until it collapsed. At that moment the force which made the brick to collapse was recorded. The area of the brick on which the compressor pan acted upon was determined and recorded before compression was allowed. Finally, the MOR was calculated according to the formula (5):

$$\text{MOR} = \frac{P}{S} \qquad (5)$$

where P = maximum load determined by the experiment and S = compressive area of sample (m^2).

Results and Discussion

Granulation

The results of granulometric analysis indicating the amount of clay and non-clay portions in each sample are summarized in Table 1. Sample portions with particle sizes ranging from 2 to 63 µm were regarded as clay minerals by use, while those of the particle sizes less than 2 µm were regarded as clay minerals by definition, and finally those with particle sizes greater than 63 µm were regarded as non-clay.

The grain size distribution shows that the amount of clay decreased with depth. This indicated that clay from the different levels of the deposit had significantly different textures and therefore different performances. This information is useful in determining what part of the deposit have the required properties for different applications and what modifications may be required. The fine particles feature of these clays make them highly plastic with high shrinkage and high dry strengths.

Table 1: Grain size distribution (%)

Pore size	T	M	L	X
> 63 µm	24.06	33.20	54.92	42.53
2–63 µm	67.43	57.89	40.35	51.13
< 2 µm	8.51	8.91	4.73	6.34
Clay portion	75.94	66.80	45.08	57.47
Non-clay portion	24.06	33.20	54.94	43.53

Mineralogical composition before and after firing

Figures 1 and 2 present some of the diffractograms from the XRD analysis of the clay portions of the samples before and after firing, whereas Table 2 summarizes the minerals present. Figures 1(a) and (b) show that before firing, the clay portions underwent diffraction in the measuring range 2ϴ ranging between 2^o–32^o. The diffractograms of the unfired samples showed that the main mineral groups in the clay portion before firing were kaolinite and illite.

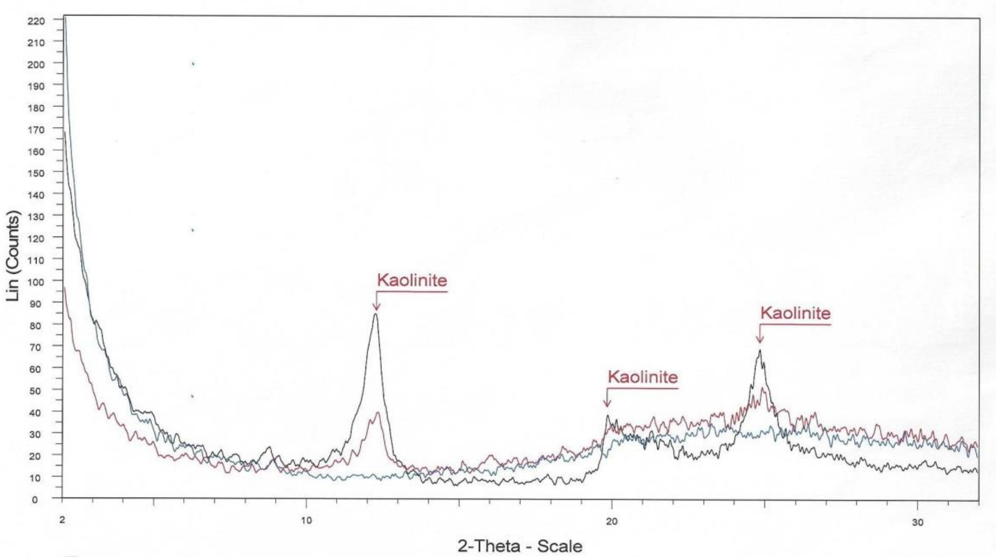

Figure 1(a): Diffractogram of sample T before firing, in the Range 2°–32°.

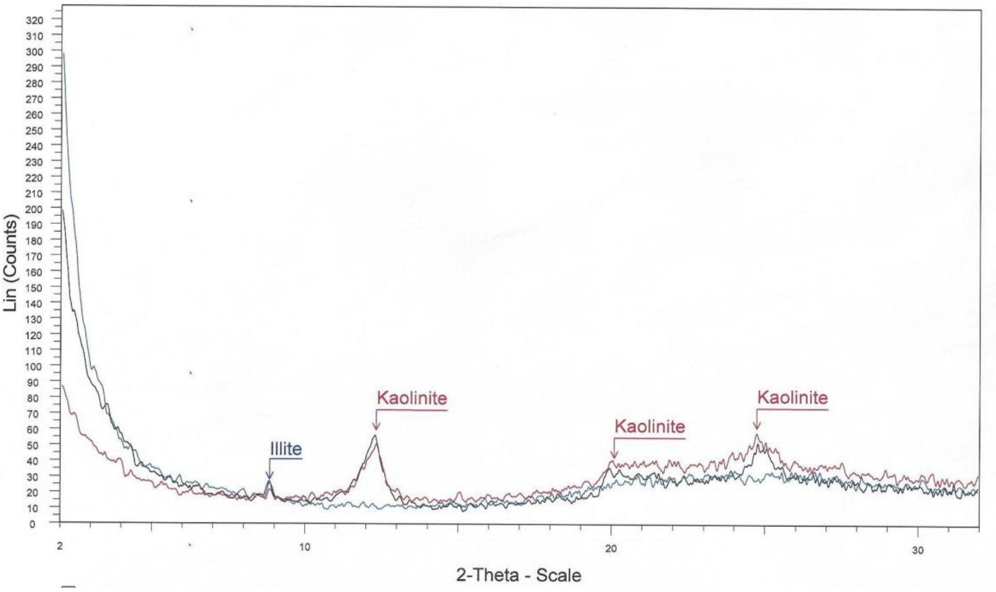

Figure 1(b): Diffractogram of sample M before firing, in the Range 2°–32°.

The X-ray diffractograms obtained after subjecting the samples to glycolating, air drying and heat treatment at 550 °C, in Figures 2(a) and (b), showed that the samples underwent diffraction in the measuring range 2Ɵ between 2°–65°. There was a collapse of the kaolinite peaks, probably because heat treatment at 550 °C swelled the mineral by dehydrating the interlayer materials thus transforming or destroying the clay minerals. However, the illite peaks showed stability under all conditions, whereas its diffractogram peaks after the three processes remained the same. This is probably because illite is a clay mineral which is not easily affected by chemical and heat treatment (Lugwisha 2011).

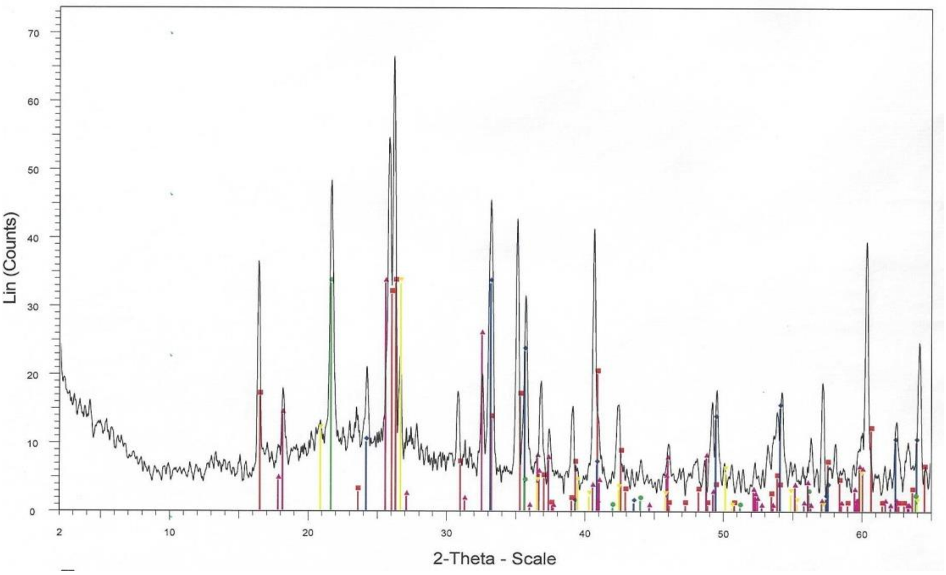

Figure 2(a): Diffractogram of sample T after firing, in the range 2°–65°.

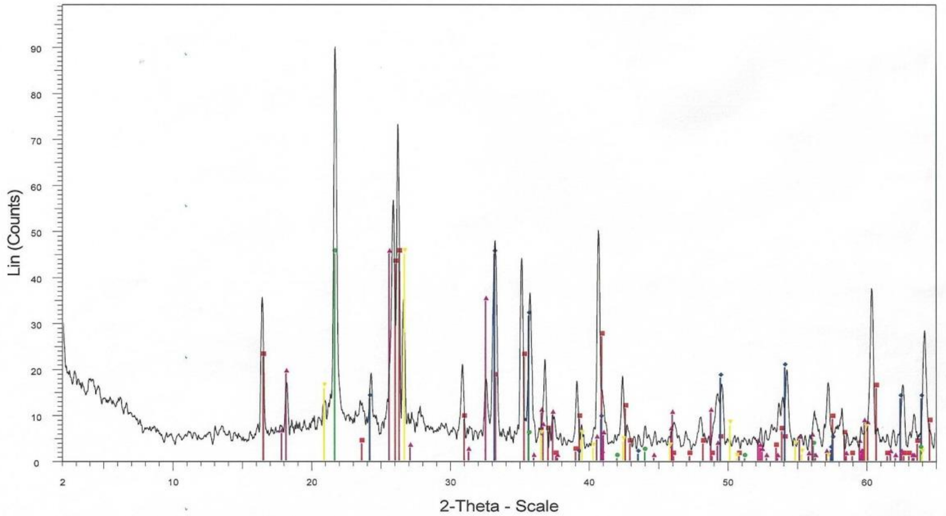

Figure 2(b): Diffractogram of sample M after firing, in the range 2°–65°.

The fired bodies were found to consist of mullite, hematite, silicon oxide, cristobalite, pseudobrookite and quartz, in all the samples. This shows that minerals present in the clay before firing (kaolinite and illite) disappeared completely after firing. During firing, a series of chemical reactions take place, leading to transformations of minerals from one form to another. Kaolinite was dehydroxylated between 500 °C and 600 °C yielding amorphous metakaolinite and silica; and above 950 °C, the metakaolinite was converted to mullite and some cristobalite (Chen et al. 2004). This was also established by Chargui et al. (2018) who found that the decomposition of kaolinite in metakaolinite takes place between 400 °C and 630 °C, and the gradual collapse of metakaolin promoted the formation of nanoscale crystals of mullite, in addition to formation of free amorphous silica.

Table 2: Mineralogical compositions before and after firing

Sample	Clay portion before firing	Clay portion after firing
T	Kaolinite	Mullite, Hematite, Silicon oxide, Cristobalite, Pseudobrookite, Quartz
M	Kaolinite and Illite	Mullite, Hematite, Silicon oxide, Cristobalite, Pseudobrookite, Quartz
L	Kaolinite and Illite	Mullite, Hematite, Silicon oxide, Cristobalite, Pseudobrookite, Quartz
X	Kaolinite and Illite	Mullite, Hematite, Silicon oxide, Cristobalite, Pseudobrookite, Quartz

Chemical composition

The data obtained from chemical analysis of the kaolin samples are summarized in Table 3. It shows that silica is ranked first in amount (36.88–41.63%) followed by alumina (30.83–32.40%) and ferrous oxide (9.29–12.70%), while sulphates (0.09–0.15%) and chlorides (0.06–0.07%) were the least in amounts. From these data, it is also shown that the concentrations of minerals had almost the same trend in decreasing order among the three levels, i.e., top, middle and low. The concentrations of silica and alumina agreed with the kaolinite contents of the samples, where in all samples, silica was ranked first and alumina was ranked second in abundance followed by hematite, while chlorides and sulphites were the least. The contents of silica and alumina were below the theoretical values for pure kaolin, of 46.55% SiO_2, 39.49% Al_2O_3 and Loss-on-Ignition (LOI) of 13.96% (Kimambo et al. 2014). However, kaolin is rarely found in pure form in nature.

Table 3: Chemical composition of the clay portions

Component (% wt)	T	M	L	X
SiO_2	41.63	41.40	36.88	40.10
Al_2O_3	31.60	30.83	31.90	32.40
Fe_2O_3	9.29	9.90	12.70	11.60
TiO_2	2.48	2.37	2.29	2.25
CaO	0.58	0.40	0.30	0.65
MgO	0.39	0.35	0.36	0.37
K_2O	1.28	1.00	0.79	1.24
Na_2O	0.40	0.20	0.24	0.46
MnO	0.19	0.21	0.48	0.43
Cr_2O_3	0.01	0.14	0.01	0.01
ZrO_2	0.22	0.19	0.15	0.15
P_2O_5	0.59	0.65	0.65	0.60
SO_3	0.15	0.13	0.09	0.15
Cl	0.07	0.07	0.06	0.07
LOI	9.12	12.16	13.10	9.43
Total	**100**	**100**	**100**	**100**

The results also showed relatively low content of four alkali oxides, i.e., CaO, MgO, K_2O and Na_2O. The presence of relative low content of CaO (< 1%) indicates that the clay found in this deposit is non-calcareous. Some researchers found this to have an advantage of favouring the formation of anorthitic plagioclase during firing, which prevents shrinkage of the finished products (Masheane et al. 2018). The losses on ignition (> 9%) were associated with the presence of clay minerals, hydroxides and organic matter. The chemical composition of the Moshi kaolin clay in this study differs from those of other locations in Tanzania such as Chimala (Akwilapo and Wiik 2004), Pugu (Lugwisha

2006) and Malangali (Malima et al. 2021), in terms of low composition of SiO_2 and Al_2O_3 and significantly high composition of Fe_2O_3. This high content of Fe_2O_3 will be the main setback of clay from this deposit as it has the potential to adversely affect the translucency and colour of the finished ware. Studies have established that the degree of whiteness of ceramic products originating from naturally occurring clays depend on the usage of raw materials containing low levels of colouring impurities such as Fe_2O_3 and TiO_2. The recommended content for the two oxides for whiteware products is > 1.0% (Cheng et al. 2012). The levels of these oxides can, however, be reduced by appropriate means to give a relatively cleaner product that could be appropriate for other types of whiteware products. The clay material from this work would therefore be suitable for ceramics that do not require high brightness specifications.

The results on the subsequent effects of firing on the three components of SiO_2, Al_2O_3 and LOI, are summarized in Table 4. It was observed that upon firing, the organic matter content disappeared completely. This is to be expected since organic matters were burned off to form ashes. The amounts of both silica and alumina decreased by different percentages ranging from 7 to 13%. This was due to the transformations that occurred, leading to the formation of mullite and cristobalite, as explained by the XRD results. Mullite ($3Al_2O_3.2SiO_2$) is a combination of silica and alumina, therefore during firing, silica is combined with alumina to form mullite through a solid-state reaction, hence their amounts decreased.

For the present clay samples, Fe_2O_3, MnO and LOI were the limiting parameters because they have a potential to impart colour to the ceramic body (Akwilapo and Wiik 2004). Manganese oxide has been found to cause staining to articles made from clays, with colour of the stains ranging from medium brown to dark brown or black. Hematite is reddish, so it imparted reddish colour to the fired product. LOI which were mostly organic matter imparted a dark colour to the raw material. Therefore, these three components were responsible for the brown colour of the bricks under the study. They were used as flux for the purpose of lowering firing temperature of the batch.

Table 4: Amounts of silica, alumina and organic matter before and after firing (% wt)

Sample	Component	Before firing	After firing
T	SiO_2	41.63	34.00
	Al_2O_3	31.60	17.80
	LOI	9.12	0
M	SiO_2	41.40	32.20
	Al_2O_3	30.83	18.90
	LOI	12.16	0
L	SiO_2	36.88	27.10
	Al_2O_3	31.90	18.00
	LOI	13.10	0
X	SiO_2	40.10	30.80
	Al_2O_3	32.40	18.60
	LOI	9.43	0

Physicomechanical properties

Shrinkage

The percentage shrinkage of the brick samples from the four clay samples in this study are displayed in Table 5. It shows that the bricks made from the top clay had the lowest shrinkage (22.06%), followed by the mixed sample, whereas the middle and lower clays had almost similar shrinkage.

Table 5: Shrinkage of brick samples

Sample	V_0 (cm^3)	V_1 (cm^3)	S (cm^3)	% S
T	323.2	251.9	71.3	22.06
M	305.6	216.7	88.9	29.09
L	326.8	231.9	94.9	29.04
X	362.2	263.6	98.6	27.22

In this study, the amount of shrinkage was attributed to the amount of fluxes present in clays, which were Fe_2O_3, MgO, CaO, and K_2O as presented in Table 3. Shrinkage was also attributed to the release of the water of crystallization and decomposition of the kaolinite and illite. As previously presented in Table 2, the top clay was found to contain only kaolinite whereas the middle and lower clay contained kaolinite and illite. Kaolinite has a low shrink capacity, thus gives lower shrinkage during drying and firing (Akwilapo 2005). Other researchers found that Illite released water vapour, sulphur dioxide (SO_2) and carbondioxide (CO_2) when heated at up to 1150 °C, therefore resulting into higher shrinkage (Lugwisha 2011). Another possible cause of the variations in shrinkage between the brick samples was the difference in the amount of organic matter contained before firing (LOI). There was a direct variation between LOI and the brick volume shrinkage.

Organic matter has potential to produce reducing conditions during furnace firing due to its rapid combustion. Noticeable changes occurred during firing, at 500 °C a slight expansion occurred followed by modest shrinkage up to 900 °C, probably caused by loss of moisture content. Rapid shrinkage then occurred between 900 °C and 1200 °C, when the volume remains constant. When compared to kaolin clays from other Tanzanian deposits, Katanini kaolin clay showed high shrinkage (22%- 30%) than the Pugu kaolin clay which had 3% shrinkage (Akwilapo 2005). Shrinkage control is an important criterion in products manufacturing because excessive shrinkage causes the deformation of the items during firing (Das et al. 2005).

Water absorption

The results in Table 6 show that water absorption in the clay samples ranged between 18.23 and 20.15 wt %. Bricks made from sample L had the highest water of absorption whereas those made from sample T had the lowest. These results are comparable to the range reported in the literatures of 16.77 to 30.50 wt % (Kumari and Mohan 2021). However, these values are higher than those reported from other Tanzanian locations (e.g., Kimambo et al. 2014). The differences were attributed to the higher amount of organic matter, which disappear during firing and consequently created pore spaces that accommodated the water molecules. This can be explained by the amount of organic matter burned off during firing (LOI), which occur at about 900 °C where the organic and inorganic materials were burned off. When these materials were burned, they created channels and pores within the body of the bricks due to liberation of gases.

Another reason for the variations in water absorption between the clay samples from the different deposit depths was the grain sizes. It has been established that smaller particle have lower permeability because of the less space between them. This has the effect of causing a lower porosity, and slower travel through them (Kumari and Mohan 2021). In this study, the clay sample T had the highest percentage of particles in the range 2–63 µm as was shown in Table 1. The range of water absorption found in this study is not desirable for products that require low water absorption capacity such as porcelain tiles. It can be applicable for products in which technical standards allow water absorption higher than 10% such as non-vitreous tiles.

Table 6: Water absorption of brick samples

Sample	W_1 (kg)	W_2 (kg)	Absorbed (kg)	%Absorption
T	0.462	0.565	0.103	18.23
M	0.430	0.530	0.100	18.87
L	0.440	0.551	0.111	20.15
X	0.486	0.601	0.115	19.13

Bulk density

The results for density measurements of bricks made from the four clay samples in this study are summarized in Table 7. It shows the density range of 1.834–1.984 g/cm^3, with bricks made from the sample T having the lowest density, while those from sample M have the highest. These results were within the established refractory standards for fireclay of 1.70–2.30 g/cm^3 (Amkpa et al. 2017). The results were also comparable to those found in clays from other locations such as Pugu, Tanzania (Kimambo et al. 2014), Lesotho (Masheane et al. 2018), Alkaleri, Nigeria (Amkpa et al. 2017), and western Tunisia (Jemaï et al. 2015) and that were established to be suitable for ceramic applications. The bulk density of clay samples in this study had a direct relationship with the grain size and the firing temperatures. The maximum bulk density for the brick samples were found to be at the optimal temperature of 1300 °C.

As reported in other studies, bulk density reaches its maximum at the temperature where there is enough liquid phase to block the open porosity (Akwilapo and Wiik 2004). It was expected therefore, that bulk density would vary directly with the relative amount of alumina present in the clay sample. This is because during firing, alumina is responsible for the formation of glass phase which fills the pores (Akwilapo and Wiik 2004).

Table 7: Densities of the brick samples

Sample	Mass (gm)	Volume (cm^3)	Density (g/cm^3)
T	462	251.9	1.834
M	430	216.7	1.984
L	440	231.9	1.897
X	486	263.6	1.844

Modulus of rupture

The test results for the brick samples' modulus of rupture were in the range 2.957–5.838 MPa. These results were used to determine the flexural strength of the bricks. It was found that bricks made from the lower clay had the least MOR, while those made from the top clay had the highest. This was associated with the amount of clay portions, where brick samples with higher amount of clay portion showed greater flexural strength than those with less. This was also established by Okey (2022) who compared the MOR of three clay samples from south-eastern Nigeria with their particle size distributions and found that a high proportion of the larger sized particles lowered the modulus of rupture of the clay.

The variation in MOR was also associated with the amount of ferrous oxide, which has a tendency of decomposing and causing bloating. In some cases, bloating was viewed to be caused by expulsion of oxygen coming from the decomposition (Akwilapo 2005). The MOR values obtained in this study were lower than those reported in literature for kaolin clay, which range between 10.7 and 29.3 MPa (Kimambo et al. 2014). Fired bodies with higher modulus of rupture are expected to have greater flexural, compressive, and tensile strengths, with superior hardness, and improved wear resistance (Kumari and Mohan 2021).

The MOR was also found to increase with the increase in the amount of mullite. The two were found to vary directly as shown in Table 8. This was in agreement with the results obtained by other researchers (Maldhure et al. 2015). In other studies, it was established that mullite phase dispersed in the glassy phase limited and stopped the intergranular crack propagation, hence increased the value of the MOR (Aguilar-García et al. 2014). Some researchers even suggested adding synthetic mullite to porcelain stoneware to enhance mechanical properties (Zanelli et al. 2004).

Table 8: Relationship between the mullite content and MOR

Sample	Mullite content	MOR (MPa)
T	86	5.838
M	75	4.436
L	59	2.957
X	67	3.624

Conclusions

Kaolin clay from Katanini deposit in Moshi, Kilimanjaro region, northern Tanzania was systematically characterized for the first time. The results confirmed that the locally available clay can be used as a raw material for various ceramic products. In this investigation, the clay samples were found to be mainly composed of silica (36.88–41.62%), alumina (30.83–32.40%) and hematite (9.29–12.70%). At a firing temperature of 1300 °C, the clay was found to have met the required standard with respect to percentage shrinkage, water absorption capacity, bulk density and appreciable modulus of rupture. Clay sample taken from the top layer of the deposit was of the best quality in terms of the lowest shrinkage, the lowest water absorption, the highest fracture strength, and the lowest likelihood of staining. There is therefore a possibility of improving the properties and the firing conditions of this clay for optimizing its applicability in the growing ceramic industry in the country.

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Declaration of interests

The authors declare that they have no competing or conflicting interests regarding this paper.

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