Conventional and modern techniques for the analysis of some Sudan clays

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Abstract

This study was conducted to determine the main elements contents of clay samples collected from different parts of Sudan (Omdurman, Marawi, Blue Nile, Kosti, Umm Ali and Portland cement) using gravimetric and volumetric techniques as classical chemical analysis and compare the results obtained to the X-ray fluorescence as a physical method of analysis adopted recently. The results obtained from chemical analysis were as follows: losses on ignition were in the range 1.06 to 24%; SiO_2 were in the range 20-70%; Al_2O_3 9-33%; Fe_2O_3 0.05-9.40%; MgO 2-10%; CaO 0.6-61.07; K_2O, 0.1-3.6% and Na_2O 0.11-4%, depending upon the type of soil whether koalinite, montmorillonite or illite. The XRF analyses showed some agreement to chemical analysis in a loss on ignition, Fe_2O_3, Al_2O_3 and CaO, however, differ in K_2O, Na_2O, SiO_2 and MgO.

Keywords: Sudan clay, analysis, Chemical, XRF.

Introduction

Clay according to the definition put forward by the American Ceramic Society, is a fine grained rock; when crushed properly the powder becomes plastic when wet, leather hard when dry, and on fire is converted to permanent rock–like mass; it is essentially hydrated aluminum silicate [1, 2].

Clay minerals occur in all types of sediments and sedimentary rocks and a common constituent of hydrothermal deposits [1]. It has long been recognized that quantitative knowledge of the clay mineral assemblage an its alteration with depth yield valuable information on the pedogenetic history of a given soil [3]. Recently, more urgent matters add impetus to attempts to quantity clay minerals in soils. In this contribution, various tests and studies were carried out on clay deposits at different part of the Sudan to appraise their industrial suitability for the manufacturing of cement and bricks like the kaolinite clay, kaolinite clay with miner illite and montmorillonite [4]. Black-belt soils have developed from base-rich parent materials and are dominated by montmorillonitic clay, black cotton soil which occurs in many areas in the Sudan mainly along the rivers [4, 5].

Minerals can be classified into three groups: native elements, silicate minerals and non silicate minerals. The silicate minerals are the most abundant group of minerals. In many silicate minerals Si^{+4}ions are replaced by Al^{+3} ions within the silicate tetrahedral; this replacement produces aluminosilicates [1]. Silicates are conveniently classified according to the way in which SiO_4 or AlO_4 are linked together and the more important silicates structures are:

*Ortho silicates, containing discrete $(SiO_4)^{-4}$ ions,

* Silicates with $(Si_2O_7)^{-6}$ ions,

*Silicates with cyclic $(SiO_3)_n^{-2n}$ ions,

*Silicates with layer structure clay minerals and micas,

*Silicates with frame work structures-feldspars and zeolites.

Clay minerals are a number of groups of minerals with certain characteristic properties [6]. Clays are composed mainly of silica, alumina and water frequently with appreciable quantities of iron, alkalies and alkali earths [7]. Some data for the chemical composition of the clay fraction -(SiO_2 ,Al_2O_3, Fe_2O_3, TiO_2 , CaO, MgO, K_2O, Na_2O)- have been obtained, the composition of the clay shows a very wide variation [8].

The sample to be analyzed has been obtained in solution, the constituent to be determined must be often first to be separated from the other components by precipitation methods and then determination of the interest element by gravimetric or volumetric procedures [9]. Flame photometry, is now used mainly for the analysis of alkali metals (sodium and potassium), which is one of the most rapid and sensitive techniques for qualitative analysis [10]. X- Ray fluorescence (XRF) is the processes usually lead to determination of elements in sample [11, 12]. The conventional analysis of the gravimetric, volumetric of the clays will be linked to their chemical analysis using XRF as modern techniques.

The objective of this study was to determine the main elements contents of clay samples collected from different parts of Sudan using some conventional and modern techniques of analysis.

Materials and methods

Sample collection

Clay samples were collected from different parts of Sudan: Omdurman jurdiga, Merkhiyat, Marawi, Blue Nile, Kosti, Umm Ali, and the Portland cement from Industrial Research and Consultancy Center (IRCC). Samples were dried to 105 ^{0}C, thereafter ground into fine-powdered and passed through a 2 mm sieve and kept in clean dray sample bottles for subsequent analysis.

Analytical methods

Five grams of each powdered sample were weighed using a dry picnometer, then moistured with toluene and shaken for one hour. The picnometer was completed with toluene and weighed. Clays were analyzed using standard methods of gravimetric, volumetric and spectro-photometric procedures. By gravimetric analysis, loss on ignition, silica, combined oxides, calcium oxide and magnesium oxide were determined. Determination of potassium and sodium in clays was achieved using a flame photometry (Model AFP100, Biotech Engineering Management Company Ltd. India). X-ray fluorescence analysis was performed with (A Aios, XRF, PANalytical 2005 Cairo, Egypt), using an automatic bead preparation for determination for the major element, pressed pellets for the trace element determinations. Atomic absorption spectroscopy (AAS) was recorded using (AA-6800 Atomic Absorption Spectrophotometer Shimadzu – Japan). The fine clay fraction for each samples were treated with 2.5% acetic acid, in order to determine trace elements.

Results and discussion

Density of clay samples in this study was determined as specific gravity, Table 1. Soil particles which contain a high content of quartz, the specific gravity is usually about 2.7 [13]. The true density of all the clay minerals is much the same, with values in the range from about 2.5-2.8 [14], this range is distinct in the samples that have been analyzed.

Table 1. The density value of clay samples from different parts of Sudan.

Sample	Density
Merkhyiat kaolinite	2.57
Marwi kaolinite	2.57
Omdurman jurdiga	2.43
Blue Nile clay	2.18
White Nile clay	2.53
Umm Ali montmorillonite	2.51
Portland cement	2.23

The technique chosen to analyze a sample for a particular element depends upon a number of factors, since no one, technique is ever likely to be completely free of bias. The frequency of use of selected analytical techniques for the determination of elements includes X-ray fluorescence analysis and atomic absorption spectrometry are the most widely used techniques for the determination of the major and minor elements respectively (excluding P_2O_5, which cannot be determined by AAS and H_2O^+ which cannot be determined by either AAS or XRF). Chemical procedures are also extensively used in the determination of selected major elements including SiO_2, TiO_2, Al_2O_3.

Flame photometry is used quite extensively for determination of Na_2O and K_2O presumably to complement wet chemical procedures used in the determination of the other major elements. The components which could be determined gravimetrically are SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O and K_2O, H_2O^+ and CO_2.

Precipitation gravimetric analysis is still providing liable means for assessing the accuracy of other methods of analysis or verifying the composition of standard reference materials. The loss on ignition which is a measure of organic matter content and other combustible fractions, chemically, combined water and CO_2 have a mean percentage of 13.08% [15], this low moderate value could be attributed to the absence of carbonates rock [16], but in samples (jurdiga) the loss on ignition is relatively high because this sample has H_2O and CO_2.

In wet chemical analysis by gravimetric techniques; the results of kaolinite in sample of Merkhyiat and Marwi, Table 2, the variations in composition of one type of clay appear to be primarily related to the geological setting. The variation between results of chemical analysis of one type of clay is large, but it is composite of all the error inherent in any analytic analysis: operator, instrument, method, beneficiation, sampling but according to the American Society for Testing and Materials (ASTM International), it is in the range.

The data given by XRF shows that alumina and silica oxide are present in major quantities while other minerals are present in trace amount, Table 3. This confirms the chemical analysis of clays in jurdiga sample, Na_2O suggest the clays are most probably non expandable swelling and low feldspar content [17]. Results show the predominance of SiO_2 and Al_2O_3.

Table 2. Chemical analysis results of clay samples collected from different parts of Sudan.

Sample	Gravimetric and titremetric analysis (% mass)						Flame photometer (% mass)	
	Loss on ignition	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O	Na_2O
Merkhyiat kaolinite	6.67	70.55	16.67	0.05	1.88	0.602	0.45	0.97
Marwi kaolinite	1.66	50.50	33.05	0.01	2.03	0.55	0.58	0.11
Omdurman jurdiga	18.92	40.55	8.72	9.40	9.93	5.78	3.61	0.09
Blue Nile clay	15.06	42.07	27.18	0.40	8.77	3.87	1.23	0.53
White Nile clay	23.69	35.17	9.76	4.66	7.14	13.79	1.17	3.93
Umm Ali montmorillonite	1.36	55.6	17.88	4.76	2.56	5.06	0.56	0.74
Portland cement	1.06	19.64	8.73	3.50	3.77	61.44	0.16	0.55

Table 3. XRF analysis results of clay samples collected from different parts of Sudan.

Constituent (wt. %)	Clay sample						
	Merkhyiat kaolinite	Marwi kaolinite	Omdurman jurdiga	Blue Nile clay	White Nile clay	Umm Ali montmorillonite	Portland cement
SiO_2	72.31	55.41	46.55	49.11	41.03	59.25	20.72
TiO_2	1.17	1.69	0.96	2.78	0.75	1.21	0.32
Al_2O_3	17.80	28.80	10.42	16.47	9.48	1.62	5.36
$Fe_2O_3^{lot}$	0.88	1.93	6.44	14.41	5.55	5.24	4.50
MgO	0.05	0.13	4.75	1.73	4.31	0.99	0.50
MnO	-	-	0.11	0.22	0.16	0.06	-
CaO	0.13	0.23	5.86	3.63	14.50	5.37	61.40
Na_2O	0.05	0.07	4.98	0.89	1.79	0.30	0.23
K_2O	0.37	0.54	3.34	0.95	0.99	0.56	0.26
P_2O_5	0.04	0.06	0.28	0.26	0.03	0.04	0.32
SO_3	0.04	0.05	0.46	0.10	0.22	0.08	2.84
Cl	0.10	0.11	0.57	0.10	0.12	0.31	0.10
F	-	-	0.09	-	-	-	-
L. O. I	7.00	10.80	15.01	9.14	20.79	11.88	3.30

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