

Preliminary geological and geochemical study of clay at Al-Harur area, Abyan governorate, Yemen

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Abstract

The area of study comprises about 1284400 m² of Al-Harur village, which is located between latitudes 13° 13' 54.9" and 13° 14' 8" north and longitudes 45° 11' 38.5" and 45° 12' 30" east , in Abyan Governorate .Geologically, the main area is composed of Loess – Loam deposits of Upper Pleistocene to Holocene age.

Field works of Geological mapping ,Geological logging and description of pits accompanied by systematic sampling for chemical full silicate analysis was done .

The mineralogical and chemical analysis of clay revealed the presence of montmorillonite as the main constituent of clay .The results of the study showed the suitability of Clay for the production of cement.

Key words: Geology, Geochemistry, Clay , Al-Harur, Abyan .

Introduction

Clay is a raw material which has an amazing variety of uses and properties that are largely dependent on their mineral structure and composition. Other than the clay structure and composition, there are several additional factors which are important in determining the properties and applications of a clay.

This work is an attempt to outline the geological and geochemical properties of clay at the study area to help understanding some of its industrial applications, mainly based on its chemical composition .The geological position on brief description and geological logging of pits drilled for this study is outlined too. This is a proposed picture on the variability of clay at the study area in the lateral, spatial and vertical changing form. The investigations are adopted with the governing depth of which the pits arrived to.

The demand of clay as a raw material for some of the new industries constructed at the area near the site of this study was the main urge to do this work.

Location and accessibility

The Study area located in Abyan governorate in Yemen, it is near Jaar town, at Al-Harur area, about 12 km to west north west. It can be reached to by 4WD cars on earthy road crossing agricultural loamy- sandy lands. In using UTM , WGS 84 international geographical position system .It is located between the coordinates 521000 to 522500 E and 1462800 to 1463370 N. In geographical latitude- longitude system, it is from 45° 11' 38.5" to 45° 12' 30" E longitude and from 13° 13' 54.9" to 13° 14' 13.8" N. latitude. The study covered an area of about(1284400) m², as shown in Fig. 1.

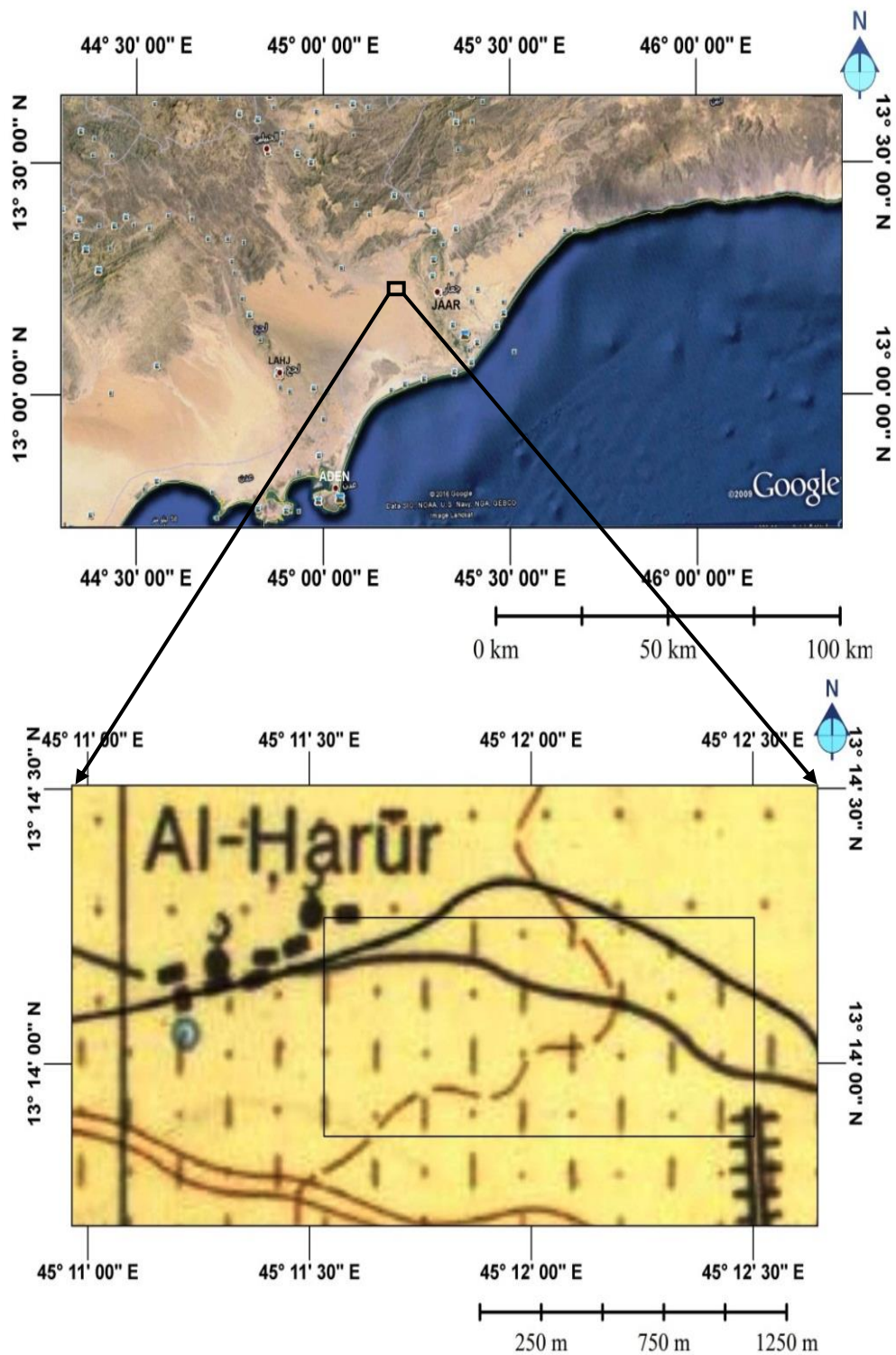


Fig.1 : Location map showing study area at Al-Harur, Abyan governorate(1, 6).

Previous studies

Previous studies of Regional Geological Mapping works by the Department of Geology and Minerals Exploration-Aden had been done between 1980 – 1990.

Methodology and Objectives

A systematic sampling from pits prepared for the purpose is the method, according to the observational changes in the soil occurrence and accompanied by the geological logging and description. Pits locations are planned in adopt with the local in habitation regards. Sample sizes are ranged from (4 to 5 kg) in weight.(Fig. 3 shows location of pits).

In the laboratory , full chemical silicate analysis for the collected samples was done, the results are then analyzed initially and processed to determine its suitability for the required cement industry raw material for the required industry in the best form of order.

Brief Geology of study area and surrounding

The geological framework of the study area (Fig. 2) represents the position of different soil types in relation to the environmental conditions of sedimentation. We can distinguish five soil types varied from fluvial quaternary of Upper Pleistocene to alluvial and eolian Quaternary Holocene. It includes the following: fluvial, alluvial, alluvial-eolian, alluvial deposits and eolian sands of which denoted in the geological map (Fig. 2) by fQ3, alQ3-4, al-eQ3-4, al, alQ4 and eQ4 respectively (5).

The description of the individual genetic types of these deposits briefly explains the sediments terminology, presents the lithologic characteristics, conditions of sedimentation and stratigraphic position .One of the standard classification of the individual sediments , proposed by J. Konta (1969), was mentioned in the reference No (5) . A description of the individual genetic types of deposits in the area is given below :

Fluvial deposits

These deposits are almost loose or slightly consolidated sandy gravels, hetroclastic, fine grained to boulder size with prevailing fraction in excess of 16 mm. They encountered both gravels with supporting boulder structure. The boulders are of different shapes (ball, disc, blade, mainly subrounded, rounded, less subangular) . It is mostly grey to brown-grey (5).

The stratigraphic position is in distinct or horizontal, dipping, stratification is developed in lesser extent, with intercalations of fine grained gravels and sands. The thickness of fluvial gravels is variable and ranges from several decimeters to several tens of meters, particularly in gravels deposited on accumulation plains. The denotation of fluvial deposits fQ3 in the geological map is given in Fig. 2 (5).

Alluvial deposits

In the term alluvial deposits, the coarse included is grained to fine grained deposits of recent wadis. During the alluvial sedimentation, in wadis, a distinct grading of the transported material occurred. The respective fractions were the following:

Coarse-grained\gravels, sand with gravel\ which was dragged over the bottom or transported by saltation and the fine – grained sandy – silty fraction are transported in suspension. The characteristics of the alluvial sedimentation in individual sections of water courses depend upon the gradient curve and additional geological, morphological, tectonic and climatic factors (5).

Alluvial fine – grained deposits are represented by silty and sandy deposits which sedimented in depressions and wadi valleys. During periods of rainfall, intensive transportation of the fine – grained material in suspension occurs. The sedimentation of the fine grained fraction occurred at the chance of sedimentation conditions either immediately in the wadis or in the form of flood deposits outside of the wadi beds(5).

Macroscopically, involved loess -like sediments, light brown to ochre brown, distinctly calcareous, and silty – sandy. Alluvial fine grained deposits feature sub horizontally sedimented accumulations with vertical walls and with approximately rectangular jointing. These deposits can

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be most frequently followed along the lower parts of wadi flows, where they form outcrops with the thickness ranging from 5 to 15 m and several kilometers long\ W (Umm Sahaybyah in Fig. 2).

In fine grained alluvial deposits, there are locally found beds of alluvial coarse grained sands and gravels with thicknesses ranging from 0.1 to 2.0 m. The alluvial fine grained deposits are very important from the viewpoints of soil formation and agricultural exploitation. The coarse grained and fine grained alluvial deposits correspond to the latest Upper Quaternary to Recent deposits with the denotation\ alQ3-4 and alQ4\ (5).

Alluvial – eolian deposits

Alluvial eolian deposits represent a transition between alluvial and eolian deposits. We denote in this manner the deposits of mixed facies during the formation of which both the eolian sedimentation as well the transportation and sedimentation of particles in water flows participated(5).

Alluvial fine grained deposits which were found in the past or are encountered at present along the wadis are either frequently covered by eolian sands or affected by the eolian effects of wind. Contrary to that, some eolian sedimentation can be transported during sudden floods along water courses (5).

Macroscopically, these deposits have a silty – sandy characteristics with sandy fraction prevailing over the silty fraction, light brown, yellow brown to grey brown, calcareous, locally finely sandy laminated. The bedding is not distinct to sub horizontal, the stratification is not distinct(5).

Microscopically, the prevailing mineral is quartz, also biotite, feldspars, carbonates, amphibole, pyroxene, halite and further minerals are represented. The content of caly fraction is very low\ on average 2%\ (5).

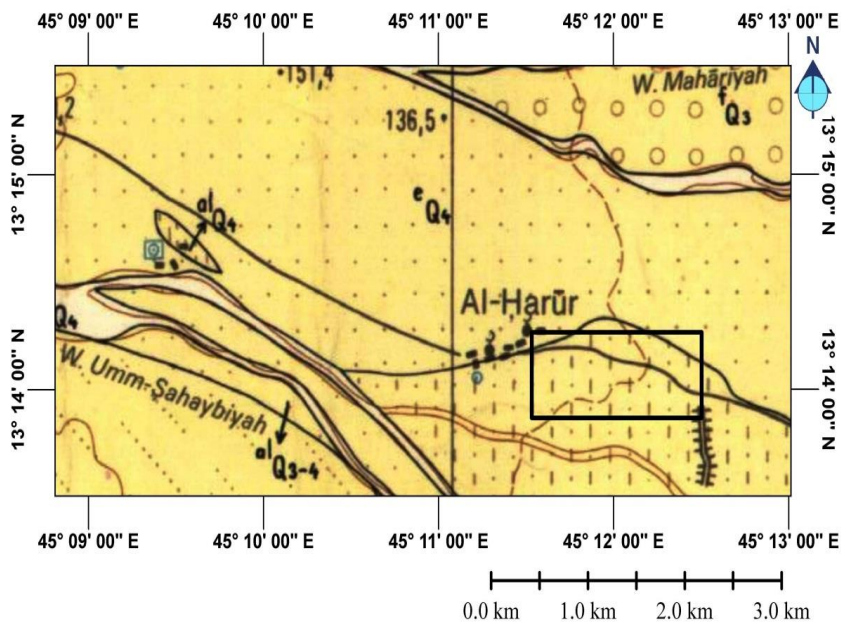
Alluvial – eolian deposits are found particularly in areas near the mouth of big wadis openings to accumulation plateau like wadi umm sahaybiah (5). Alluvial overlay locally are the underlying proluvial and fluvial deposits and are frequently partially overlain by recent eolian sands of expanding deserts. Because of the importance of these deposits for the agricultural exploitation, it will be necessary to consider an appropriate protection of these deposits against the effects of water and wind erosions (5). Stratigraphically, these deposits correspond to the Upper Quaternary to Recent Era\al-eQ3-4\ (3).

Eolian sands

Eolian sand covers extensive region. The fine grained material of different origin was transported by the wind and the particles sedimented in the form of eolian (windblown) sands (3). Macroscopically, the eolian sands are yellow – grey, grey to yellow brown, fine grained to medium grained, and very well graded (5). Mineralogically, the prevailing mineral is quartz \ in excess of 60%, the content of feldspars and biotites is variable (1-60%),while lesser participation have halite and carbonates (1-20%). Further amphiboles, pyroxenes, Fe-oxides, garnets, titanite, tourmaline and other minerals (0-5%) were found (5).

Eolian sand feature different accumulation formations and principal morphological forms of desert sand are distinguished in the geological map as well as sandy sheet, low dunes, and seif dunes. Sandy sheets are found in areas with low thickness of eolian sands, frequently in basins and depressions (5).

Eolian sands could be formed of different primary materials, i. e. fluvial and alluvial deposits. From the surface, beds of eolian sands belonging to the latest Recent deposits (eQ4) are viewed (5).



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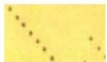
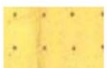
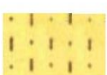

-  Study area.
-  Geological probable boundary.
-  Alluvial coarse grained deposits of recent wadis (gravel, sandy gravel).
-  Ridges (Seif dunes)
-  Eolian deposit, e_{Q4} : fine to medium grained deposits, very well graded, morphological forms of desert sands.
-  Alluvial & alluvial - eolian deposit, al_{Q3-4} , al_{Q4} & $al-e_{Q3-4}$: coarse - grained\gravels, sand with gravel, fines represented by silty and sandy & clays.
-  Fluvial deposit, f_{Q3} : loose or slightly consolidated sandy gravels, hetroclastic, fine grained to boulder size.

Fig.2: Geological map of the study area(2)

Geology of clay of study area

Alluvial fine-grained deposits and alluvial-eolian fine grained deposits are represented by clay and other interlayers of silty to slity-sandy clay, which accumulated during the different periods of wadi flows. It can be distinguished in sub-horizontal sedimentation or indistinct layering. Clay is stiff in common and are grey instead of light grey as well as brownish grey color, stiff light grey and brownish clay mostly cracked vertically, openings of crakes in stiff clay are up to few millimeters in general; this may be due to the prevailence of arid climate. Friable silty to silty sandy clay types are brown and soft in common of which crakes are absent within.

Detailed descriptions of clay of pits excavated during this study are given in the below geological map. It shows the intervals of sampling represented in these logs too. Fig. 3 represents the study area and pits locations.

General view of the studied area is shown in Fig . 4.

Pits and their measurements are presented in Figs. 5, 6a –b and 7a- b

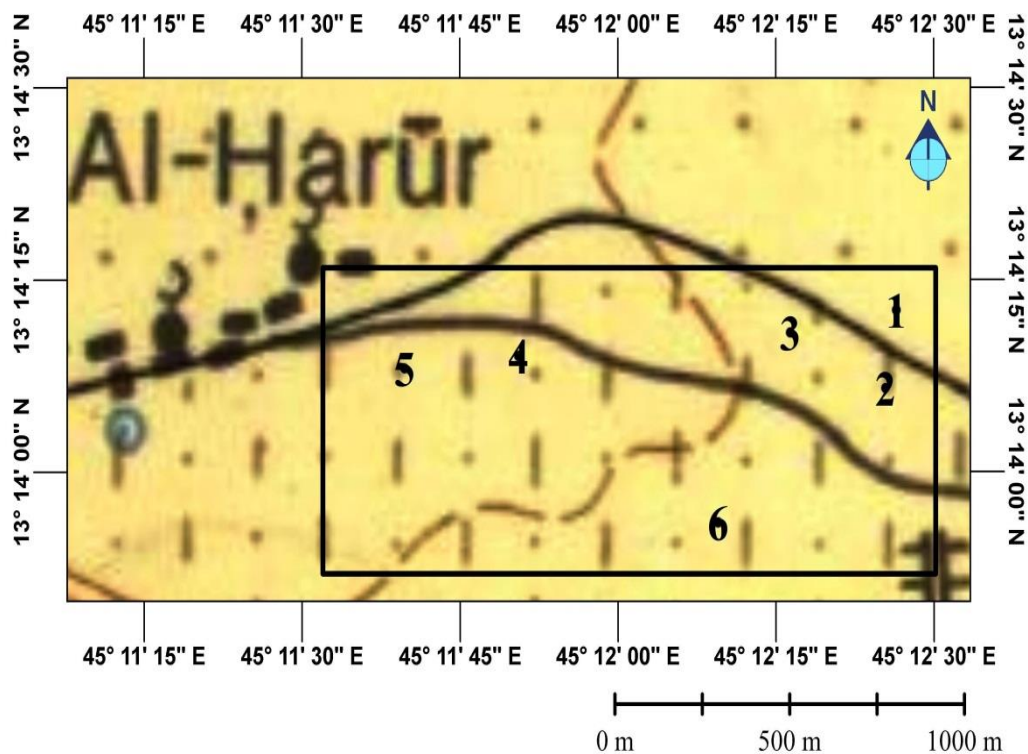


Fig. 3: Geological map of study area, showing locations of pits excavated for this study, for legend see fig. 2(2)



Fig.4: General view of clay deposit at the study area

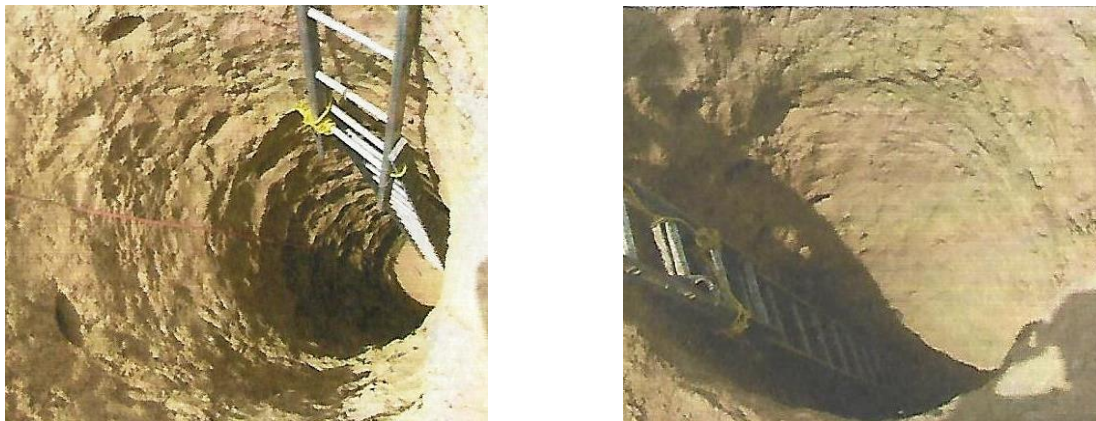
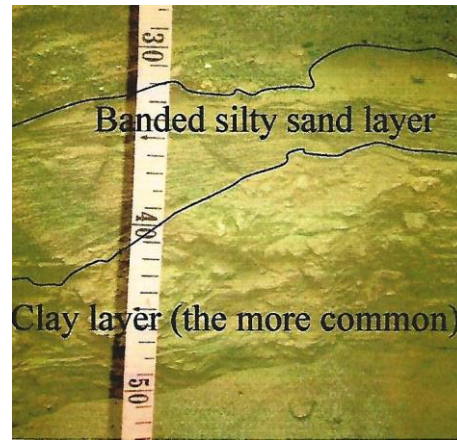


Fig .5 : Hand – dug pits excavated for soil sampling



a)

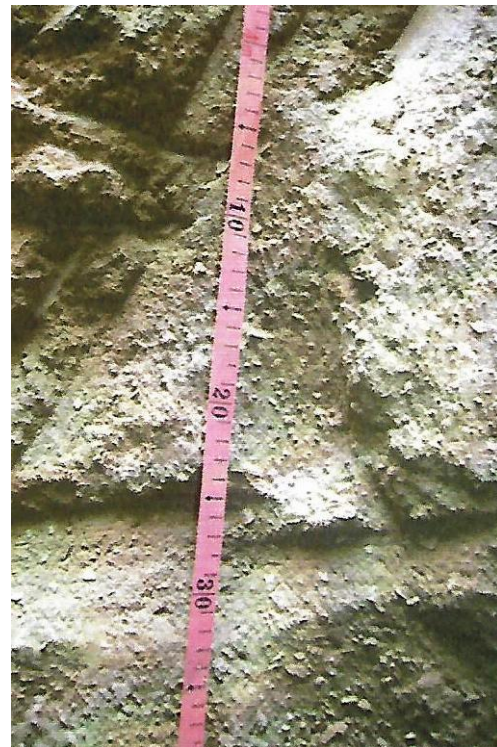


b)

Fig. 6 : Appearance of soil types and some vertical varieties and changing of soil occurrence with depth in some pits, a) common appearance, b) closed view of some soil varieties



a)



b)

Fig. 7: Variability of soil occurrence on consistency fact, a) stiff clays, b) friable silty and sandy silty clays

The geological logging of pits of this study are as follows:

PIT NO. 1

Ser. No.	Sample No.	Sample Interval (m)		Description
		From	TO	
1	Cl-1	0.00	2.10	Stiff clay, brown
2	Cl-2	2.10	4.00	Clay with silt, grey, friable, medium grained, angular fragments sandy silty clay are within (from few mm up to 2 cm) fragments of clay are brown and stiff to hard.
3	Cl-3	4.00	4.80	First 40 cm, hard fragments of stiff clay with sandy clay material , grading to sand to silty sand, friable, grey, siliceous. Last 10 cm hard fragments of stiff clay appeared again.
4	Cl-4	4.80	6.30	Grey sand, banded, siliceous, fine to medium grained, last 1 m of stiff brown clay.
5	Cl-5	0.00	6.30	Composite sample represent the whole depth of the pit.

PIT NO.2

Ser. No.	Sample No.	Sample Interval (m)		Description
		From	TO	
1	Cl-6	0.00	2.00	Stiff clay, brown to brownish clay, contains vertical crakes had appeared again.
2	Cl-7	2.00	4.00	As above
3	Cl-8	4.00	5.20	As above
4	Cl-9	5.20	6.20	Sand to silty sand, grey, fine to medium grained ,few of clays are within.
5	Cl-10	0.00	6.20	Composite samples represent the whole depth of the pit.

PIT NO. 3

Ser. No.	Sample No.	Sample Interval (m)		Description
		From	TO	
1	Cl-11	0.00	2.30	Concretional form of soil, enclosing brown clay fragments .
2	Cl-12	2.30	3.20	Silt to clayey silt, grey, inter-granular with clay fragments.
3	Cl-13	3.20	4.00	Clay, brown to brownish grey, silt mix occur.
4	Cl-14	4.00	5.00	Silty clay, friable, fragments of clay of platy and semi platy shapes (mm in diameter).
5	Cl-15	5.00	5.70	Sand, medium to coarse grained, grey, laminated and banded; 10 cm thick layer of clay at the base of which alternated with siliceous sand.
5	Cl-16	0.00	5.70	Composite sample represent the whole depth of the pit.

PIT NO.4

Ser. No.	Sample No.	Sample Interval (m)		Description
		From	TO	
1	Cl-17	0.00	2.50	Clay to silty clay, grey colored, intensively cracked; 20-25cm thick interlayer of stiff brown clay, banded silt also within.
2	Cl-18	2.50	4.60	Alternation of stiff red clay with grey clay .
3	Cl-19	4.60	7.00	Brown clay, interlayer of sand (from 5.20 - 5.50m interval of depth).
4	Cl-20	0.00	7.00	Composite samples represent the whole depth of the pit.

PIT NO. 5

Ser. No.	Sample No.	Sample Interval (m)		Description
		From	TO	
1	Cl-21	0.00	2.10	Alternation of stiff red clay is which vertically cracked, with friable grey clay to silty clay.
2	Cl-22	2.10	3.20	Grey colored clay to silty clay; friable, sand band at interval depth from 2.60 - 2.70m.
3	Cl-23	3.20	4.20	Red clay, fragmented, vertically cracked.
4	Cl-24	0.00	4.20	Composite samples represent the whole depth of the pit.

PIT NO. 6

Ser. No.	Sample No.	Sample Interval (m)		Description
		From	TO	
1	Cl-25	0.00	1.75	Alternation of clay with silty clay, the base 10cm is sand.
2	Cl-26	1.75	2.80	Brown to reddish brown clay, vertically cracked.
3	Cl-27	2.80	4.00	Banded sand, grey colored, medium to fine grained; thin bands of laminated clay are within.
4	Cl-28	0.00	4.00	Composite samples represent the whole depth of the pit.

Sampling and Results of chemical analysis for clay at the study area

A typical chemical analysis of clay will include the following major radicals; SiO₂, Al₂O₃, TiO₂, Na₂O Fe₂O₃, MnO, CaO, MgO, SO₃, K₂O, Cl, P₂O₅. Full silicate analysis of samples collected from clay deposits at the study area presented in Table No.1 , including CaO, MgO, SiO₂, Al₂O₃, Fe₂O₃, Na₂O, K₂O, SO₃, MnO and Loss of Ignition.

Knowledge of the chemical composition of certain clay deposit provides a useful guide to the way in which it will behave in a product made from its constituents. Clay is normally analyzed for the oxides of aluminum, silicon, titanium, calcium, magnesium, potassium, sodium and the loss on ignition (LOI) (4).

These analyses provide valuable guides as follows:

- (i) Al₂O₃ and SiO₂: These may help in distinguishing between china clay and ball clay.

China clay is also known as kaolinite and white clay. Primary clay is formed by natural kaolinization process. It is formed by decomposition of some parts of feldspar mineral, white in color, used in ceramic slip casting process, pressing processes, and forming processes as a body former and filler. The chemical formula is $Al_2Si_2O_5(OH)_4$ chemically characterized by casting rate. High casting rate in slip casting is similar to ball clay, particle size is large when compared to ball clay, modulus of capture is low compared to ball clay, and plasticity is low compared to ball clay.

China clay is used in all kinds of ceramic product, sanitary works including tile production, refractory production, in paper industry as filler, in rubber industry as raw material in pottery work.

Ball clay is kaolinitic sedimentary clay that commonly consists of 20-80 % kaolinite, with mica and quartz and is characterized by more fine particles, high plasticity, dry shrinkage and dry strength, compared to china clay. The chemical formula of ball clay is $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, casting rate is relatively low compared with china clay in slip casting with some fluidity, viscosity and density drying time is low compared to china clay, while water absorption after firing is around 10%.

A large number of samples [28] are analyzed. Then, it is found that these constituents are fairly consistent in china clay, but widely variable in ball clay.

- (ii) Fe_2O_3 and TiO_2 : These are the coloring oxides (pure TiO_2 is very white when fresh, but over time it turns to yellow); their analyses, in general, can be used as guide to fired color.
- (iii) CaO and MgO : Analysis of these are of importance in case the types of clay are bentonite and fuller's earth. Bentonite is an absorbent aluminium phyllosilicate clay consisting mainly of montmorillonite. The main uses of bentonite are for drilling mud, purifier absorbent and as a ground water barrier. It has the property of dispersion in water to form a viscous shear thinning material. Bentonite is used in drilling fluids to lubricate and cool the cutting tools, to remove cutting, and to help prevent blowouts. Fuller's earth is a clay material that has the capability to dechlorize oil or other liquid without chemical treatment fuller earths, typically consists of palygorskite or bentonites, absorbents for oil, grease and animal waste and as a carrier for pesticides and fertilizers, and is also used as a filler in paint, plaster, adhesives and pharmaceuticals.
- (iv) K_2O and Na_2O : The alkali oxides are derived from feldspars and micas affecting vitrification behavior since they act as fluxes.
- (v) LOI: Clays are hydrates containing varying number of water molecules. So, LOI generally comes from the loss of water on burning and it varies from clay to clay.

Table No 1: Results of chemical analysis of clay samples from the study area

Sample No.	NTENT %														Sum
	SiO2	Al2O3	TiO2	Na2O	Fe2O3	MnO	CaO	MgO	SO3	K2O	Cl	P2O5	L.O.I.		
C-1	48.70	15.33	0.812	0.89	7.93	0.17	9.55	3.36	0.200	2.35	0.349	0.010	11.19	99.95	
Cl-2	46.30	13.50	0.806	0.99	6.87	0.112	12.67	4.10	0.227	2.10	0.360	0.018	12.38	99.44	
Cl-3	50.91	14.92	0.810	0.86	7.13	0.132	8.79	3.44	0.210	2.24	0.336	0.041	9.36	98.32	
Cl-4	48.37	15.14	0.818	0.85	7.49	0.149	9.19	3.77	0.200	2.28	0.350	0.066	12.15	99.97	
Cl-5	47.80	14.62	0.823	0.80	7.28	0.134	11.0	3.66	0.220	2.23	0.355	0.032	11.79	99.94	
Cl-6	47.73	13.95	0.810	0.91	6.77	0.161	11.02	3.66	0.202	1.15	0.359	0.010	12.68	99.69	
Cl-7	45.50	12.66	0.744	0.91	6.15	0.134	14.29	3.45	0.210	1.15	0.370	0.000	15.23	99.89	
Cl-8	46.07	13.22	0.75	0.75	7.34	0.147	12.21	3.49	0.210	2.22	0.366	0.000	13.42	99.44	
Cl-9	51.47	14.39	0.875	1.00	6.46	0.105	8.61	3.49	0.193	1.95	0.330	0.000	10.60	98.47	
Cl-10	46.19	13.32	0.753	0.88	7.30	0.143	12.46	3.41	0.210	2.20	0.370	0.010	13.53	99.90	
Cl-11	50.46	13.22	0.897	0.86	6.82	0.103	9.95	3.38	0.200	2.04	0.350	0.000	12.02	99.89	
Cl-12	47.72	15.13	0.811	0.80	7.59	0.16	10.52	3.55	0.200	2.26	0.360	0.000	11.40	99.70	
Cl-13	46.49	13.58	0.79	0.86	6.99	0.12	11.61	3.84	0.190	2.13	0.370	0.000	13.34	99.45	
Cl-14	50.40	13.01	0.90	0.73	6.77	0.101	9.93	3.77	0.200	2.02	0.340	0.000	11.94	99.38	

Table No 1: Results of chemical analysis of clay samples from the study area

Sample No.	NTENT %														Sum
	SiO ₂	Al ₂ O ₃	TiO ₂	Na ₂ O	Fe ₂ O ₃	MnO	CaO	MgO	SO ₃	K ₂ O	Cl	P ₂ O ₅	L.O.I.		
C-1	48.70	15.33	0.812	0.89	7.93	0.17	9.55	3.36	0.200	2.35	0.349	0.010	11.19	99.95	
Cl-2	46.30	13.50	0.806	0.99	6.87	0.112	12.67	4.10	0.227	2.10	0.360	0.018	12.38	99.44	
Cl-3	50.91	14.92	0.810	0.86	7.13	0.132	8.79	3.44	0.210	2.24	0.336	0.041	9.36	98.32	
Cl-4	48.37	15.14	0.818	0.85	7.49	0.149	9.19	3.77	0.200	2.28	0.350	0.066	12.15	99.97	
Cl-5	47.80	14.62	0.823	0.80	7.28	0.134	11.0	3.66	0.220	2.23	0.355	0.032	11.79	99.94	
Cl-6	47.73	13.95	0.810	0.91	6.77	0.161	11.02	3.66	0.202	1.15	0.359	0.010	12.68	99.69	
Cl-7	45.50	12.66	0.744	0.91	6.15	0.134	14.29	3.45	0.210	1.15	0.370	0.000	15.23	99.89	
Cl-8	46.07	13.22	0.75	0.75	7.34	0.147	12.21	3.49	0.210	2.22	0.366	0.000	13.42	99.44	
Cl-9	51.47	14.39	0.875	1.00	6.46	0.105	8.61	3.49	0.193	1.95	0.330	0.000	10.60	98.47	
Cl-10	46.19	13.32	0.753	0.88	7.30	0.143	12.46	3.41	0.210	2.20	0.370	0.010	13.53	99.90	
Cl-11	50.46	13.22	0.897	0.86	6.82	0.103	9.95	3.38	0.200	2.04	0.350	0.000	12.02	99.89	
Cl-12	47.72	15.13	0.811	0.80	7.59	0.16	10.52	3.55	0.200	2.26	0.360	0.000	11.40	99.70	
Cl-13	46.49	13.58	0.79	0.86	6.99	0.12	11.61	3.84	0.190	2.13	0.370	0.000	13.34	99.45	
Cl-14	50.40	13.01	0.90	0.73	6.77	0.101	9.93	3.77	0.200	2.02	0.340	0.000	11.94	99.38	

Continued Table No 1:

Ser. No.	Sample No.	CONTENT %														Ser. No.
		SiO ₂	Al ₂ O ₃	TiO ₂	Na ₂ O	Fe ₂ O ₃	MnO	CaO	MgO	SO ₃	K ₂ O	Cl	P ₂ O ₅	L.O.I.	Sum	
15	C-15	55.61	13.11	0.79	0.65	6.96	0.103	7.41	2.65	0.190	2.78	0.320	0.000	8.73	98.65	1
16	CI-16	47.55	14.34	0.81	0.80	6.64	0.15	11.14	3.70	0.200	2.22	0.360	0.000	12.81	99.92	2
17	CI-17	48.27	14.06	0.82	0.64	7.25	0.13	11.11	3.33	0.200	2.20	0.350	0.003	12.04	99.76	3
18	CI-18	48.85	15.87	0.81	0.64	7.17	0.186	9.18	3.31	0.198	2.40	0.340	0.000	10.85	99.16	4
19	CI-19	48.16	13.44	0.83	--	6.71	0.11	11.31	3.68	0.200	2.46	0.350	0.000	10.81	98.06	5
20	CI-20	47.49	14.94	0.84	0.71	7.42	0.135	10.14	3.57	0.200	2.16	0.360	0.003	11.89	99.15	6
21	CI-21	47.18	13.93	0.82	0.79	7.18	0.125	11.73	3.32	0.200	2.12	0.350	0.000	12.86	99.82	7
22	CI-22	50.41	13.51	0.87	0.67	8.71	0.109	9.11	3.60	0.200	2.06	0.340	0.000	9.95	99.87	8
23	CI-23	49.84	15.47	0.82	0.71	6.74	0.17	9.23	3.35	0.200	2.36	0.340	0.000	10.93	99.45	9
24	CI-24	48.25	13.43	0.85	0.69	6.80	0.11	10.30	3.80	0.200	2.09	0.340	0.000	12.27	98.44	10
25	CI-25	48.33	14.46	0.83	0.77	7.18	0.129	10.44	3.65	0.200	2.19	0.350	0.000	11.58	99.34	11
26	CI-26	48.18	14.86	0.84	0.76	7.33	0.16	10.03	3.64	0.211	2.25	0.350	0.000	11.88	99.73	12
27	CI-27	50.85	13.61	0.87	0.68	7.79	0.108	9.030	3.74	0.190	2.06	0.336	0.000	9.640	98.22	13
28	CI-28	50.03	14.11	0.86	0.67	7.06	0.119	9.77	3.59	0.190	2.09	0.346	0.000	10.60	98.77	14

Assessment of chemical-grade of clay at the study area

Clay at the study area is included in the study evaluation. Briefly, its depositional geological environments are according to previous related studies. In addition to this, chemical analysis of samples are collected and also generated for the purpose of this study. Primary, the geochemical of this study shows the characteristics of this soil. It is possible focusing on the general features.

Firstly, it can be outlined, in general, the clay minerals in content and chemical main character. Clay minerals occur as fine minute flaky crystals have the $\text{Si}_4 \text{O}_{10}$ – sheet structure. Those dealt with here are as follows(4):

Kaolinite, Nacrite, Dickite, $\text{Al}_4\text{Si}_4\text{SiO}_{10}(\text{OH})_8$.

Halloysite, $\text{Al}_4\text{Si}_4\text{SiO}_{10}(\text{OH})_8 \cdot 4\text{H}_2\text{O}$.

Montmorillonite, $\text{Al}_4\text{Si}_8\text{SiO}_{20}(\text{OH})_4 \cdot n\text{H}_2\text{O}$, with Mg Al. →

Beidellite, similar to Montmorillonite, but with Al Si. →

Pyrophyllite, $\text{Al}_2\text{Si}_4\text{SiO}_{10}(\text{OH})_2$.

Allophane, amorphous silica – alumina gel.

These and other related minerals are associated in clays and minerals such as quartz, feldspar, micas, iron-oxides.

Contents of SiO_2 and Al_2O_3 are used to distinguish between china and ball clays of which fairly constituent in the first one and variable in the second. Using these chemical contents as a guide, clay at study area occurred more constituent in these two components of which averaging 48.68 % and 14.11% for SiO_2 and Al_2O_3 to be like china clay in consistency, but china clay generally has greater content of Al_2O_3 that reaches up to 30% and more in general. At these contents, clay of study area refer to be montmorillonitic .Table 2 shows good reliability occur for comparable in chemical composition of montmorillonite clay with the standard clay of this work. Montmorillonite mineral composition explained in the previous lines are also with Mg. On the alteration bases, the alteration of feldspar takes place in two stages, first to montmorillonite and, second to kaolinite (4), in this case, clay of study area may be in the stage of montmorillonite.

Coloring oxides are Fe_2O_3 and TiO_2 of which their contents in the studied clay arrived to 7.14 % and 0.82 % in average, respectively, whereas CaO and MgO values are of importance in case the types of clay are bentonite and fuller's earth; for these the averages respectively are 10.4% and 3.55%, using MgO content and comparing the chemical analysis of typical clay in Table 2, promote montmorillonite grouping of clay analyzed in this study. In accordance to grading, the clay analyzed to be used as raw material for different industrial requirements, it can be mentioned of low grade because the impurities in clay are SiO_2 , Fe_2O_3 , TiO_2 , CaO, MgO and Na_2O (5); these are of high percentages than the pure clay and confirm low contents that must be accomplished to be suitable for many industries. Some applications, such as one of the cement raw materials, can be used.

Alkali oxides (K_2O and Na_2O) affect verification behavior of clay since they act as fluxes. LOI generally comes from the loss of water on burning; it varies from clay to clay.

Table 2: Chemical analysis of typical clay minerals(5)

	Kaolinite	Montmorillonite	Illite	Chlorite	Glauconite
SiO ₂	45.44	51.14	42.96	26.28	52.64
Al ₂ O ₃	38.52	19.76	28.97	25.20	5.78
Fe ₂ O ₃	0.80	0.83	2.27	-	17.88
FeO	-	-	0.57	8.70	3.85
MgO	0.08	3.22	1.32	26.96	3.43
CaO	0.08	1.62	0.67	0.28	0.12
Na ₂ O	0.66	0.04	0.13	-	0.18
K ₂ O	0.14	0.11	7.47	-	7.42
H ₂ O-	0.60	14.81	3.22	-	2.83
H ₂ O+	13.60	7.99	6.03	11.70	5.86

Conclusions

1. Geological outlining and logging of clays in the study area is of alluvial fine – grained silty and sandy deposits which sedimented in depressions and wadi valleys, during periods of increased rainfall and intensive transportation. The chance of sedimentation conditions is either immediately in the wadis or in the form of flood deposits outside of the wadi beds.
2. Alluvial fine grained deposits are frequently either covered by eolian sands or affected by the eolian effects of wind. Contrary to that, some eolian sedimentation could have been transported during sudden floods along water courses.
3. Alluvial – eolian deposits are found, particularly, in areas near the mouth of big wadis opening to accumulation plateau, like wadi Umm Sahaybiah of where the study of clay was carried out ; its depositional environment and location are greatly related.
4. Mineralogical coordination of clay upon chemical composition shows Montmorillonite grouping of which Mg content is compatible.
5. In accordance to grading, clay is analyzed to be used as raw material for different industrial requirements, it can be referred to low grade, due to the impurities in clay are SiO₂, Fe₂O₃, TiO₂, CaO, MgO and Na₂O; these are of high percentages than the pure clays which confirm low contents that must be accomplished to be suitable for many industries. To sum up, some applications such as cement raw material can be used.

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دراسة جيولوجية وجيوكيميائية أولية للطين في منطقة الحرور بمحافظة أبين - اليمن

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المخلص

تقع منطقة الدراسة في محافظة أبين، وتحتل مساحة تقدر بحوالي 1284400م² في منطقة الحرور بين خطي عرض "13° 13' 54.9" - "13° 14' 8" شمالاً، وخطي طول "45° 11' 38.5" - "45° 12' 30" شرقاً. تتكون المنطقة من الناحية الجيولوجية من الرواسب الطينية والرملية التي تتراوح حجم حبيباتها بين 0.004-0.07 ملم للعصر الرباعي. اشتملت أعمال الدراسة على أعمال التخريط الجيولوجي، والدراسة السطحية والقاعية للتربة وجمع العينات للتحليل المعدني والكيميائي. وقد أثبتت الدراسة لخصائص التربة الكيميائية احتواءها على معدن المونتوموريلانيت وتؤكد صلاحيتها كمادة إضافية في صناعة الإسمنت.

الكلمات المفتاحية: جيولوجيا، جيوكيمياء، طين، الحرور، أبين.