CHARACTERIZATION OF NORTHERN MORROCAN CLAY FOR THEIR INDUSTRIAL APPLICATION

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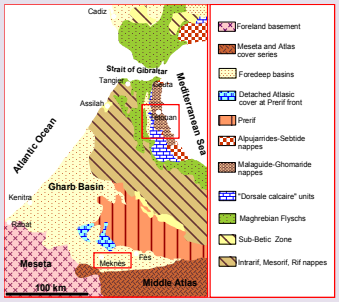
Introduction

Morocco is one of the world's producers and consumers of clayey building materials. The industry of ceramic tiles and bricks is frequent in the northern of Morocco. It is justified by the abundance of natural clay materials in this region , but also by the economic role of this region, it operates regional clays and produces over 45% nationwide building materials (bricks, ceramic tiles and refractories). This region has large development projects and construction of housing to meet the population growth in this region. However, the exploitation of these natural materials in the clay industry, ceramics and bricks, is not supported by prior studies to select the material.

The aim of this study is to characterize those raw materials and explore the possible manufacturing of ceramic floor tiles or bricks. Seven Miocene yellow clay samples selected in Saiss basin deposits, which are located at about 15 km of Meknes (center northern of Morocco) and twenty Cretaceous clay samples are taken from Tetouan area (northern west of Morocco).

In the present investigation, the clay samples were characterized by a wide range of techniques with respect to their mineralogical, chemical, thermal and fired properties. These clays were used in manufacture of the floor tile and bricks, in which the Meknes clays used for ceramic tile production and traditionally for pottery manufacture. On the other side, Tetouan clays are used for ceramic tiles and bricks. However, manufacturers have claimed some problems such as breakage and deformation of their products.

Geoligical setting



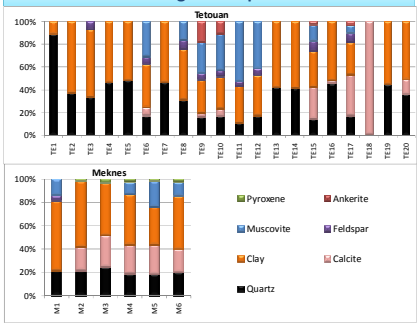
Problematic

Materials and methods

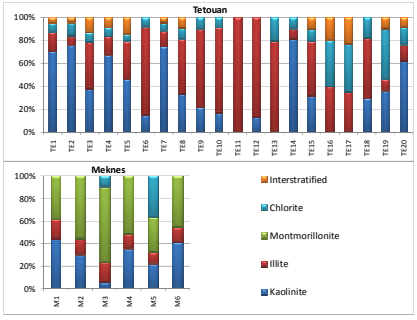
The characterization of Tetouan and Meknes clays was determined by mineralogy determination and measuring their properties related such as grain size distribution, Atterberg limits, cation exchange capacity, calorimetry and specific surface area in order to evaluate viability of the clay deposit for ceramic uses. At the end of this study, one can affirm those clays have qualities necessary for the manufacture of ceramic floor tiles and/or Bricks. It is expected that the present investigation will help to improve the knowledge on the Tetouan clay and Meknes clay as well as to contribute to a correct exploration of the Moroccan northern deposit.

Results and discussion

Mineralogical composition



Clay mineralogy



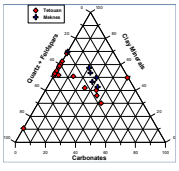


Fig. Ternary diagram of the mineralogical composition of clays from Tetouan and Meknes area. Fields represent an estimated uncertainty of ±5%.

✓In Meknes area, the mineralogy is diversified, it is composed clay mineral (35% to 60%), quartz (>20%), calcite (>20%), muscovite and traces of pyroxene. Whereas clay composition consists of smectite (>30%), kaolinite (5% to 45%), illite (<20%);

✓In Tetouan area, bulk composition is mainly clay mineral (15% to 65%), quartz, calcite, muscovite and feldspar. Morever, clay fraction shows a mixture of kaolinite, illite, chlorite and interstratified clay.

Evaluation of Plasticity

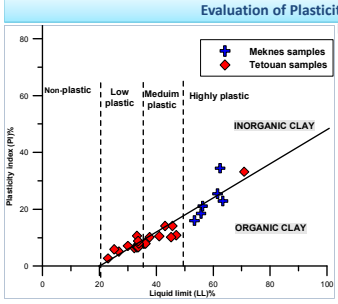


Fig. Location of Tetouan and Meknes samples on the Casagrande chart

	Liquid limit (LL %)	Plastic limit (PL %)	Plasticity index (PI %)
Meknes			
M1	55,70	40,50	18,50
M2	63,40	40,50	22,90
M3	63,40	37,40	16,00
M4	61,50	36,04	25,46
M5	62,40	34,46	34,46
M6	58,30	35,20	21,10
Tetouan			
TE1	36,90	28,00	7,90
TE2	36,20	28,30	7,90
TE3	32,30	26,00	6,30
TE4	23,00	20,30	2,70
TE5	33,20	26,60	6,60
TE6	37,60	27,42	10,18
TE7	47,00	36,13	10,87
TE8	33,20	22,60	10,60
TE9	43,10	29,00	14,10
TE10	26,80	21,70	5,10
TE11	41,00	30,50	10,50
TE12	70,90	37,70	33,20
TE13	45,70	31,60	14,10
TE14	33,60	26,90	6,70
TE15	25,20	19,30	5,90
TE16	33,60	26,90	6,70
TE17	33,80	25,90	7,90
TE18	30,00	22,90	7,10
TE19	45,20	35,00	10,20
TE20	33,60	24,80	8,80

Table. Atterberg parameters of Tetouan and Meknes clay

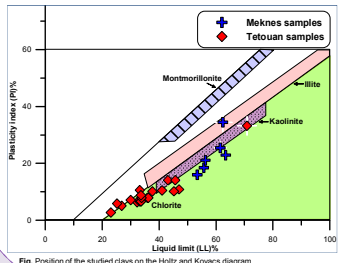


Fig. Position of the studied clays on the Holtz and Kovacs diagram

✓Meknes clay presents similar values of plasticity. In fact, the elevated values of PI for Meknes clay characterize them as highly plastic;

✓ Tetouan clay shows mostly low plasticity (PI<10%), expect TE12 is highly plastic and samples (TE6, TE7, TE8, TE11, TE13 and TE19) they have meduim plasticity (PI>10 %).

Cation Exchange Capacity CEC and Specific Surface Area S_{BET}

Samples	CEC (mEq/100 g)	SBET (m2/g) ±5	Vp (cm3/g) ±0,05	VDUB (cm3/g) ±0,01
Meknes				
M1	12,94	37,89	0,055	0,015
M2	9,08	36,33	0,055	0,015
M3	9,72	33,33	0,053	0,015
M4	10,14	36,33	0,053	0,015
M5	20,58	34,65	0,049	0,015
M6	12,49	35,16	0,094	0,015
Tetouan				
TE1	18,48	32,35	0,069	0,015
TE2	17,13	32,90	0,072	0,015
TE3	13,83	35,47	0,077	0,015
TE4	14,57	34,49	0,075	0,015
TE5	10,32	36,35	0,078	0,015
TE6	10,68	30,99	0,068	0,014
TE7	7,64	26,00	0,069	0,011
TE8	11,98	17,71	0,047	0,008
TE10	7,08	18,11	0,048	0,010
TE11	13,69	21,27	0,056	0,010
TE12	18,06	18,15	0,048	0,008
TE13	17,19	30,96	0,072	0,015
TE14	17,58	27,04	0,062	0,015
TE15	8,54	34,60	0,080	0,020
TE16	10,02	26,22	0,061	0,014
TE17	18,34	27,90	0,064	0,015
TE18	13,13	26,16	0,086	0,012
TE19	9,32	30,21	0,091	0,012
TE20	17,93	36,43	0,101	0,015

Table. Pore texture characteristics, specific surface area SBET, cation exchange capacity CEC, specific pore Volume Vp and micropores volume VDUB.

✓Meknes clay reveals a medium cation exchange capacity and specific surface area values; due to they smectite content;

✓Tetouan clay has meduim to low CEC and medium SSA values, indicating the expandable minerals and higher kaolinite content for samples with medium CEC values.

Particle Size Analysis

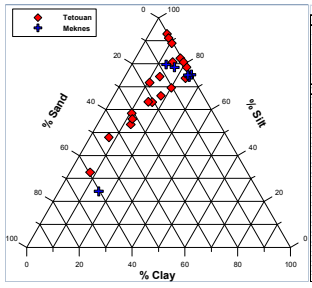


Fig. Ternary diagram clay:silt:sand

	< 2 µm	> 20 µm	2-20 µm
Meknes			
M1	24	15	61
M2	49	0	51
M3	13	33	54
M4	17	26	57
M5	25	4	71
M6	24	15	61
Tetouan			
TE 1	16	25	59
TE 2	14	41	45
TE 3	20	18	62
TE 4	11	52	37
TE 5	13	43	44
TE 7	10	40	50
TE 6	7	73	20
TE 8	10	51	38
TE 10	17	15	68
TE 11	7	23	70
TE 12	8	16	76
TE 13	12	32	56
TE 14	7	65	28
TE 15	20	15	65
TE 16	15	28	58
TE 17	15	28	58
TE 18	10	55	36
TE 19	13	24	63
TE 20	16	22	63

Table. Fractional particle size distribution

✓For Meknes samples, the fraction below 2 µm is mostly high (49% for M2, around 25% for M6, M5 and M1). The silt fractions (particles with sizes between 2 and 20µm) are about 33% for M3, 26% for M4 and 15% round for M1 and M6;

✓For Tetouan samples, the percentage of clay minerals (particles with sizes <2µm) is mainly moderate, except is smaller for TE7, TE11, TE12 and TE14 (about 7%). Whereas silt and sand fractions are principally high.

Conclusion

In conclusion, the clay characterization of north center of Morocco (Tetouan and Meknes area) is suitable for ceramic manufacture. In this prospect, caracterisazion tests have been designed, hoping they could contribute to the actual exploitation of these mining by-products by the ceramic industry. As concluding remarks, the following aspects related to the characterization and industrial application of these clays can be summarized:

✓The outstanding phase present in Meknes clays were illite, kaolinite, smectite and chlorite and containing a substantial amount of quartz and carbonate and others impurities such as feldspar, muscovite and pyroxene, solely M1 sample don't has calcite and pyroxene. The clay materials from Tetouan region can be defined as mexture of kaolinic, illite and chlorite with mixed layers clay, quartz and feldspar, only eight samples clay content calcite;

✓The samples are basically consisted of a finely grained material. Higher proportions of finer particles especially for Meknes clay. The both clay regions containing quartz favoured vitrification due to good compaction of samples during firing. Olso the most samples content calcite favouring the development of lighter colours and promoting a higher degree of vitrification and higher compressive strength at lower temperatures;

✓Meknes clay reveals a medium cation exchange capacity and specific surface area values. Though, Tetouan clay has meduim to low CEC and medium SSA values, indicating the expandable minerals and higher kaolinite content for samples with medium CEC values. This agrees with mineralogical analysis and is favorable for uses in ceramic;

✓The studied raw materials are classified as silty clays and be used as ceramic bodies. Meknes and Tetouan clay show optimal plasticity.