Applied Clay Science 161 (2018) 151–162

Contents lists available at ScienceDirect

Applied Clay Science

journal homepage: www.elsevier.com/locate/clay

Research paper

Potential use of the lower cretaceous clay (Kef area, Northwestern Tunisia) as raw material to supply ceramic industry

Imed Ben Salah[a,1], Ali Sdiri[b,*,1], Moufida Ben M'barek Jemai[a,1], Mabrouk Boughdiri[a,1]

[a] Department of Earth Science, Faculty of Sciences, University of Carthage, Zarzouna 7120, Bizerte, Tunisia
[b] Department of Georesources and Environment, National Engineering School, University of Sfax, P. Box 1173-3038, Sfax, Tunisia

ARTICLE INFO

Keywords:
Clays
Albian deposits
Characterization
Technological tests
Ceramic industry

ABSTRACT

The aim of this study is to evaluate the potential use of clay deposits from northern Tunisia (Albian system) for the manufacture of bricks and ceramic tiles. Clay samples were collected from the Slata study site to the north of the Kef district, Tunisia. Chemical composition by atomic absorption spectrometry (AAS) showed that these clays were mainly composed of silica (33%), alumina (15%), iron oxide (6%) and minor amount of potassium oxide (3%). Mineralogical analysis by X-ray diffraction (XRD) confirmed the results of AAS; it showed reflections of quartz, calcite, kaolinite (65–70%) and illite (15%) associated with low percentage of interstratified illite-smectite (5%). After firing near 900 °C, new mineralogical species such as mullite, anortite and spinel appeared due to several temperature-dependent transformations. Further analysis indicated that plasticity index (PI) ranged between 16 and 20%.

Geotechnical and thermal tests have shown acceptable values of drying shrinkage (3%), firing shrinkage (10%), water absorption (8.9–15.9%) and a very high mechanical bending strength (17–20 MPa) indicating non-refractory clays. Those results further confirmed the potential application of the Albian clays from Slata site in ceramics.

1. Introduction

The use of natural clay goes back for millennia (Pampuch, 2014). Among the pioneer indices of Neolithic revolution, clayey materials has been, since then, playing an important role in the development of new technologies and processes for both industrial and environmental applications (Chakraborty, 2014). After that, the development of civilizations and dwelling techniques was tightly related to the advent of firing clay and other natural materials for pottery and other potential applications (Mukherjee and Ghosh, 2013). Numerous studies paid special attention to the valorization of natural clay in ceramic industry (Jordán et al., 2014, 2008; Konta, 1995; Meseguer et al., 2011, 2010; Oikonomopoulos et al., 2015; Pardo et al., 2011; Wagner et al., 1998). Dondi (2016) prepared a short overview of the most important deposits of natural clay that have the required technical specifications for use in ceramic industry. In Tunisia, ceramic manufacturing plants are effectively contributing the economic balance of the country with > 3 million tons of clay consumed annually (Medhioub et al., 2012). The effective contribution was ascertained to 10% of the whole exportation for the manufacturing industry, as of 2016 (INS Tunisie, 2016); it reached an annual growth of 3%, further confirming the important contribution to the raw material sector development. Those statistical data emanated from continuous prospection efforts and studies to seek for new resources for ceramic manufacturing (i.e., natural clay deposits). In this context, numerous works were carried out by Mahmoudi et al. (2008a, 2014, 2016a, 2016b) to characterize several sites from northern Tunisia. They used natural Valanginian to Hauterivian clays of Djebel Oust for traditional ceramic products. Recently, Bennour et al. (2015a) studied the ceramic potentialities of the kaolinitic clay samples (Oligo-Miocene system, northwestern Tunisia). The resulting ceramic bodies showed interesting properties that would allow a cost-effective exploitation. Other researchers, including Hammami-Ben Zaied et al. (2015), Ben M'barek Jemaï et al. (2015) and Boussen et al. (2016) have paid special attention to the outcropping clays in various sites throughout the country. However, the northwestern area of El Kef district (i.e., Dejebel Slata) has not been studied in detail. Therefore, much work is still to be done on that suitable candidate as raw material supply in ceramic industry. Geological in-situ reserves showed a thick series of marls and shale with subordinate limestone layers (Chihaoui et al., 2010). Those deposits of the Fahdene formation (Albian system) showed > 500 m of marls with interbedded limestones layers (Ben Fadhel et al., 2011). In addition, preliminary assays on clay deposits of

* Corresponding author.
E-mail address: ali.sdiri@enis.rnu.tn (A. Sdiri).
[1] All authors have contributed equally

https://doi.org/10.1016/j.clay.2018.04.015
Received 20 January 2018; Received in revised form 7 April 2018; Accepted 12 April 2018

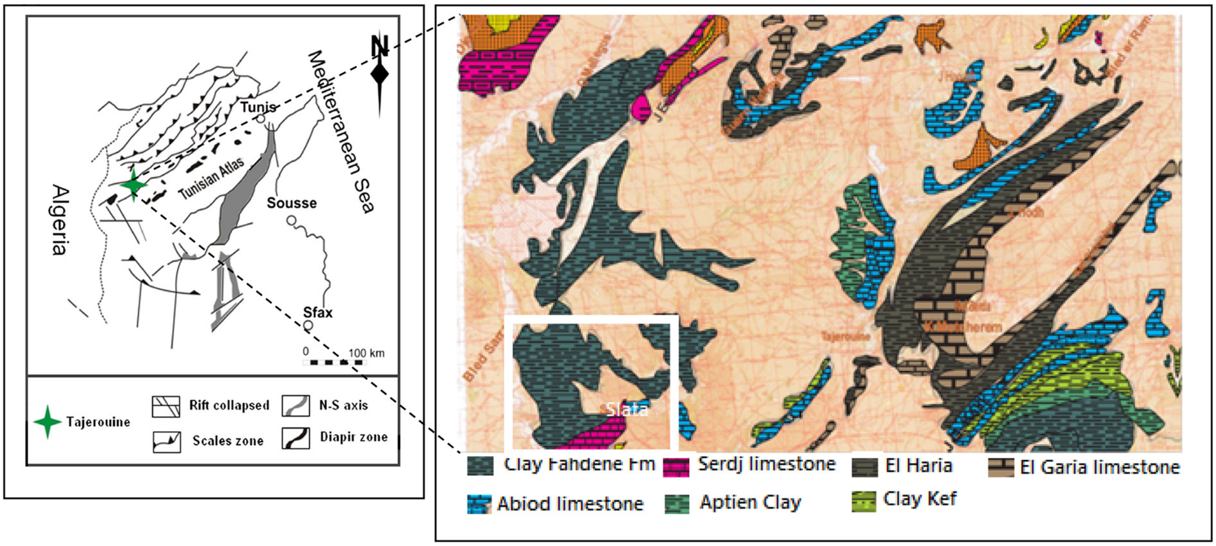

Fig. 1. Geological map of the Tajerouine showing the study area.

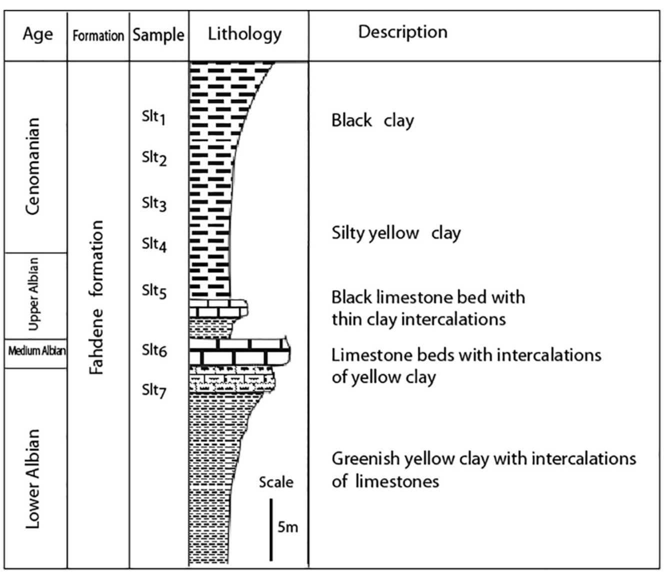

Fig. 2. Cross section of the Fahdene formation showing the collected Slata clays.

Table 1
Mineralogical composition of the studied Slata clays (% by weight).

Samples	Bulk clay mineralogy				Clay fraction mineralogy		
	Phy	Ca	Q	Gyp	Kaol	I	I-Sm
Slt 1	80.0	10.0	10.0	0.0	65.0	13.0	17.0
Slt 2	81.0	13.5	4.0	1.5	68.0	12.0	12.0
Slt 3	93.0	5.0	1.0	1.0	62.0	14.0	14.0
Slt 4	90.0	5.0	5.0	0.0	68.0	14.0	18.0
Slt 5	84.3	5.5	9.0	1.3	62.0	23.0	15.0
Slt 6	82.0	8.0	9.0	1.0	65.0	16.0	19.0
Slt 7	79.0	10.0	8.0	3.0	64.0	14.0	12.0

Phy: Phyllosilicates; Ca: Calcite; Q: Quartz; Gyp: Gypsum; Kaol: Kaolinite; I: Illite; I-Sm: mixed layer Illite/Smectite.

the Djebel Slata site showed encouraging results with regard to fired products. That is why we gave a special attention to the potentialities of using those natural clays as raw material for ceramic tiles production. Original clay samples from the Djebel Slata study site underwent a

Table 2
Chemical analysis of Slata clays (% by weight).

Samples	L.O.I	CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	K_2O	Na_2O	SO_3
Slt 1	14.2	15.47	39.94	17.88	8.94	0.86	2.59	0.18	0.16
Slt 2	22.13	25.65	28.75	12.65	5.85	0.45	3.12	0.05	0.43
Slt 3	21.59	23.31	31	15.08	6.77	0.59	2.6	0.11	0.48
Slt 4	24.07	23.55	29.67	14.05	5.75	0.65	3.65	0.21	0.12
Slt 5	29.96	23.97	30.74	19.32	4.75	0.43	2.29	0.15	0.13
Slt 6	20.72	23.76	29.55	14.04	6.23	0.59	2.51	0.15	0.66
Slt 7	17.51	17.15	38.98	15.58	7.84	0.99	4.25	0.42	0.12

L.O.I: Loss on ignition

systematic assessment of the main physico-chemical properties. The characterization concerned chemical composition; mineralogical analysis and Fourier transform infrared spectroscopy. Plasticity and liquidity indexes, thermodilatometric and thermogravimetric analyses were also carried on the raw material to assess its behavior when subjected to a firing program. Finally, green clay specimens were prepared according to the procedure described by Mahmoudi et al. (2016a, 2016b); they followed most of technological tests (i.e., firing shrinkage, dilatometry and, ceramic and brick tests).

2. Geological overview

The studied clay deposit is located 5 km to the west of Tajerouine city (200 km from Tunis); it belongs to the Albian system, filled up with the Fahdene formation (Ben Fadhel et al., 2011). This area is limited by allochtonous units of the Tell Atlas to the Northwest and the rift valley area to the South (Naouali et al., 2011; Perthuisot, 1981). The Jebel Slata study site is one of most important features in the western edge of the diapirs area (Fig. 1). It is characterized by extrusive plastic core structures and Triassic relief, reflecting the surface transpiration of deep tectonic boundaries (Chihaoui et al., 2010). The lithological cross section, shown in Fig. 2, indicated that Fahdene clays exceeded 130 m, with intercalations of siliciclastic and carbonate layers (Chikhaoui et al., 1998).

3. Material and methods

3.1. Materials

Experimental work was carried out on seven representative samples from the Djebel Slata site (Fig. 2). Hereafter we used abbreviated names