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Mineralogy and Chemical Composition of Lower Cretaceous Ceramic Clays from Estercuel Basin (Teruel, Spain)

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Abstract

A group of clays with industrial application have been studied. The clays come from a mining area in Teruel, and in particular from the area located between Ariño and Crivillén, where clay industries are situated. In relation to their mineralogical composition, three main groups of lutites have been found. The first group has a predominance of kaolinite (more than 85%). The second group of lutites has a low quartz content and a predominance of kaolinite-illite, while, the third group shows a predominance of kaolinite-illite, but unlike those in the second group, quartz contents may be up to 40%. The study of the chemical and mineralogical composition allows the evaluation of the applicability of the clays studied: refractory, fine clay (meaning white paste of pavement and coating), red paste of pavement and coating, and heavy clay.

Key words: Estercuel basin, Ceramic clays, Clay mineralogy, Chemical composition.

1. Introduction

There is a significant stock of literature on ceramic clay mineralogy. The studied clays, located in the provinces of Castellón, Valencia, Barcelona and Teruel, undoubtedly comprise the raw material base of the Spanish ceramic industry. This paper specifically discusses the mineralogical and geochemical characteristics of the Lower Cretaceous Clays from Estercuel Basin, around Teruel and Castellón.

It is well known that industrial clays have a complex mineralogical composition. During the firing process of phyllosilicates and accompanying minerals like quartz, feldspar, calcite, dolomite and hematite, a series of transformations occur, which govern the final properties of the ceramic products[1-4].Through the ceramic process, these crystalline structures partially decompose and others are formed simultaneously. There is no instantaneous destruction of the pre-existing structure[4]. Knowledge of the origin, diagenesis and physicochemical composition of the clays is essential when designing compositions that are suitable for ceramic production.

The clay deposits which were studied are located in the Terminal Lower Cretaceous. As it frequently occurs, the clays deposits are located within coal deposits, so that constitute coal spoils. The outcrops of formations of the Terminal Lower Cretaceous in the mining area of Teruel are represented in figure 1. Here, the most important coal producing areas are situated in the Utrillas-Escucha-Estercuel and Ariño-Andorra regions (Figure 2). The La Cañada de Verich-La Cerrollera area constitutes a zone of refractory clay formations. This report mainly refers to the detrital Lignitos de Escucha and Arenas de Utrillas formations.

Some materials exploited in the area shown in Figure 2 (La Cañada de Verich, Cerrollera-Rafales, Fuentespalda-Beceite Foz- Calanda and Castellote areas), are marketed as refractory clays or as "ball clays". The ball clays are used nowadays in clay pavement-coating, with a spectacular increase of their consumption in the home market since 1990. The refractory clays are exported to Portugal, Italy and Morocco, and their consumption has decreased in the home market.

The main objective of this study has been to establish a classification on industrial clays that are exploited nowadays in the mining area described. Such a classification is based on petrographic characterization, mineralogical analysis

Table 1. Mineralogical composition (%) of the studied samples.
Legend: 0: non-present mineral phase; +: Minor mineral phase present). Q: quartz; K: kaolinite; I: illite; Cl: chlorite.; S: Smectite; F: feldspars; Ca: calcite; D: dolomite; H; hematite; Si: siderite; Py: pyrite. Mineralogical composition of clay fraction (K & I) and cristallinity values (FWHM).

Sample	Q	K	FWHM (7Å)	I	FWHM (10Å)	Cl	S	F	Ca	D	H	Si	Py
OE1	47	35	0,54	13	0,28	+	+	3	0	0	0	1	+
OE2	19	56	0,71	22	0,25	+	+	1	1	0	0	0	0
OE3	28	44	0,63	25	0,21	+	+	1	1	1	0	0	0
OE4	18	23	0,59	56	0,42	+	+	1	1	0	0	0	0
OE5	20	43	0,61	32	0,27	+	+	2	1	0	0	0	0
OE6	9	52	0,62	35	0,28	+	+	1	1	1	0	0	0
OE7	27	46	0,82	21	0,44	+	+	1	2	1	0	0	+
OE8	8	45	0,76	42	0,47	+	+	3	1	0	0	0	0
OE9	30	41	0,37	24	0,35	0	+	1	2	0	0	0	0
OE10	44	31	0,40	21	0,22	0	+	1	1	1	0	0	0
OE11	33	24	0,44	36	0,17	0	+	1	1	2	+	1	0
OE12	21	75	0,60	0	0,36	+	+	0	1	0	+	0	0
OE13	30	44	0,35	20	0,18	+	+	1	2	2	0	0	0
OE14	7	84	0,57	8	0,17	0	+	0	0	0	0	0	0
OE15	21	65	0,60	5	0,29	0	+	0	5	0	+	0	0
OE16	4	67	0,09	24	0	+	+	1	2	1	+	0	+
OE17	3	92	0,13	0	0	0	+	0	2	0	+	0	0
OE18	13	80	0,59	3	0,13	0	+	1	0	0	+	0	0
OE19	8	78	0,79	8	0,23	0	+	1	1	0	+	1	0
OE20	17	69	0,75	13	0,27	0	+	0	0	0	0	0	0
OE21	33	62	0,62	0	0,27	0	+	1	0	0	+	0	0
OE22	29	47	0,45	15	0,22	0	+	1	6	0	0	1	0
OE23	3	71	0,52	22	0,20	0	+	0	0	0	+	0	0
OE24	14	47	0,54	33	0,20	0	+	1	2	1	0	0	0
UK1	13	59	0,29	25	0,30	0	+	0	1	1	0	0	0
UK2	24	43	0,39	32	0,34	0	+	1	1	0	0	0	0
UK3	35	36	0,39	28	0,40	0	+	1	0	0	0	0	0
FR1	15	74	0,43	11	0,20	0	+	0	0	0	0	0	0
OE25	36	36	0,47	24	0,28	0	+	1	2	1	0	0	0
OE26	14	78	0,68	7	0,33	0	+	0	0	0	0	0	0
AA1	56	27	0,51	13	0,29	+	0	3	0	0	+	1	0
AA2	59	26	0,42	12	0,28	0	+	2	0	0		0	0
AA3	58	33	0,60	8	0,60	0	0	0	0	0	+	0	0
AA4	38	40	0,47	22	0,22	0	0	0	0	0	0	0	0
AA5	37	42	0,47	21	0,33	0	0	0	0	0	0	0	0
AA6	33	42	0,38	24	0,36	0	+	0	0	0	+	0	0
AA7	42	28	0,4	31	0,28	0	+	0	0	0	+	0	0
AA8	36	39	0,60	23	0,29	+	0	0	0	0	+	2	0
AA9	48	43	0,53	9	0,32	+	0	1	0	0	+	0	0
AA10	61	17	0,46	15	0,30	0	0	6	0	0	0	1	+
AA11	32	30	0,47	34	0,28	0	0	0	0	0	0	4	0
AA12	33	33	0,54	3	0,46	+	0	1	0	0	+	1	0
AA13	56	30	0,72	8	0,48	0	0	1	0	0	0	4	0
AA14	33	44	0,60	22	0,51	0	0	0	0	0	0	0	+
AA15	47	36	0,50	13	0,12	0	0	0	0	0	+	4	0
AA16	26	50	0,45	22	0,13	0	0	0	0	0	+	0	+
AA17	36	49	0,52	13	0,30	+	+	1	0	0	+	0	0
AA18	41	31	0,50	26	0,29	0	0	1	0	0	+	0	0
AA19	57	29	0,52	13	0,30	0	0	0	0	0	0	0	+
AA20	17	31	0,55	50	0,40	+	0	1	0	0	0	0	+

in the matrix. For the group association of the samples the distances between themselves within a cluster (the smallest one possible), and the distance between different clusters (the largest one possible) were kept in mind. The distance between the individuals was measured by the square of the "Euclidean distance". In the case of the chemical composi-

Table 2.- Major elements (weight percentage).

Sample	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	Fe_2O_3	MnO	TiO_2	P_2O_5	LOI	S
Units	%	%	%	%	%	%	%	%	%	%	%	%
Det. Lim.	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.001	0.01	0.01	0.01
OE1	59.4	23.2	0.35	0.73	0.22	2.28	3.28	0.04	1	0.07	9.25	99.82
OE2	59.1	23.4	0.58	0.68	0.11	2.54	2.07	0.03	1.04	0.05	9.15	98.75
OE3	61.1	22.2	0.2	0.68	0.17	2.54	2.66	0.04	0.971	0.07	8.55	99.18
OE4	48.8	27.4	0.47	1.36	0.23	3.46	4.16	0.04	0.92	0.1	12.8	99.75
OE5	63.2	21.9	0.18	0.69	0.18	2.85	1.91	0.04	1.04	0.07	7.5	99.56
OE6	57.1	25.2	0.29	0.73	0.24	2.78	2.13	0.03	0.975	0.09	9.45	99.02
OE7	59.2	23.4	0.21	0.7	0.21	2.82	1.9	0.03	1.02	0.08	8.7	98.27
OE8	54.7	25.2	0.24	0.9	0.26	2.62	4.16	0.04	1.02	0.08	10.3	99.52
OE9	62	23.6	0.05	0.55	0.12	2.31	1.53	0.03	1.14	0.06	8.55	99.94
OE10	61.9	23.7	0.02	0.5	0.15	2.27	1.33	0.03	1.2	0.06	7.85	99.01
OE11	63.1	19	0.24	0.86	0.17	3	4.39	0.04	0.978	0.06	7.55	99.39
OE12	48.4	29.5	0.18	0.51	0.09	0.58	5.85	0.03	1.88	0.06	12.5	99.6
OE13	68.4	18.5	0.54	0.56	0.15	2.42	1.56	0.03	0.986	0.11	6.1	99.36
OE14	48.1	29.3	0.38	0.61	0.06	0.8	3.36	0.03	1.88	0.06	14.6	99.2
OE15	39.2	28.6	2.98	0.62	0.07	1.05	11.4	0.05	1.27	0.09	14.6	99.94
OE16	40.8	27.1	3.51	0.78	0.07	0.44	7.29	0.05	1.35	0.06	17	98.46
OE17	42.7	31.5	0.22	0.54	0.1	0.68	9.18	0.03	1.33	0.06	14	100.36
OE18	52.7	24.4	0.34	0.43	0.02	0.45	6.64	0.04	2.36	0.07	10.7	98.17
OE19	42.5	28.9	2.04	0.72	0.05	0.44	6.15	0.05	1.45	0.05	17.3	99.67
OE20	52.2	23.5	0.39	0.66	0.08	1.27	8.67	0.03	1.66	0.06	10.5	99.03
OE21	57.9	21.9	0.53	0.42	0.06	0.32	5.32	0.03	2.74	0.07	9.55	98.86
OE22	56.1	23.9	1	0.61	0.12	2.07	3.23	0.03	0.843	0.26	10.9	99.06
OE23	36.3	25.3	0.46	0.84	0.1	1.6	22.4	0.18	1.13	0.1	11.5	99.92
OE24	58.9	20.7	0.29	0.88	0.13	2.88	4.96	0.04	0.975	0.07	8.6	98.43
UK1	54.5	28.1	0.22	0.54	0.17	1.99	1.29	0.03	1.22	0.08	11.8	99.94
UK2	59.4	24.7	0.06	0.54	0.32	2.29	0.99	0.03	1.55	0.09	8.85	98.82
UK3	64.9	20.9	0.09	0.52	0.29	1.96	0.97	0.03	1.66	0.08	7.45	98.85
FR1	59.8	24.9	0.34	0.45	0.05	0.79	1.25	0.03	1.19	0.08	10.9	99.8
OE25	62.2	22.4	0.27	0.54	0.11	2.19	2.07	0.03	1.14	0.12	8.05	99.12
OE26	47.2	29.3	0.39	0.65	0.08	0.85	2.18	0.03	1.48	0.06	17.2	99.44
OE27	54.3	22.9	0.55	1.07	0.88	3.28	7.54	0.06	1.13	0.21	7.75	99.67
AA1	63.9	21.9	0.21	0.37	0.16	2.74	1.89	0	1.033	0.11	7.75	100.07
AA2	71.7	17.4	0.29	0.27	0.11	1.47	1.38	0	1.179	0.06	6.65	100.52
AA3	65.4	21.1	0.29	0.31	0.09	1.72	2.02	0	1.144	0.07	7.9	100.05
AA4	58.4	24.2	0.48	0.57	0.13	2.69	3.63	0.02	1	0.1	9.2	100.44
AA5	65.9	20.8	0.17	0.28	0.1	1.53	1.87	0	1.056	0.1	8.5	100.32
AA6	64.9	21.5	0.29	0.34	0.11	2.03	1.72	0	1.088	0.12	8.45	100.56
AA7	67.4	18.9	0.29	0.42	0.15	2.64	1.86	0	0.932	0.19	7.25	100.04
AA8	69	17.6	0.21	0.3	0.07	1.55	3.07	0.01	1.072	0.05	7.15	100.09
AA9	71.9	16.3	0.18	0.18	0.05	1.2	2.91	0	1.413	0.04	5.85	100.03
AA10	76.3	14.2	0.18	0.27	0.09	2.2	1.32	0	1.053	0.04	4.85	100.5
AA11	60.9	21.5	0.51	0.54	0.15	2.96	4.47	0.08	0.969	0.15	8.05	100.3
AA12	6..1	22.2	0.52	0.59	0.11	2.76	4.01	0.04	1.118	0.1	8.9	100.47
AA13	67.3	15.5	0.34	0.36	0.05	1.22	6.29	0.06	1.222	0.07	7.75	100.17
AA14	61.2	23.9	0.41	0.42	0.08	2.01	1.8	0.01	1.1	0.11	9.1	100.16
AA15	66	17.2	0.19	0.32	0.09	1.64	5.5	0.03	0.98	0.1	8.05	100.11
AA16	59.7	22.3	0.41	0.34	0.09	1.83	2.17	0	1.057	0.06	12.2	100.17
AA17	62.6	21.9	0.36	0.46	0.13	2.85	3.5	0	0.977	0.15	7.35	100.29
AA18	63.9	20.5	0.36	0.48	0.12	2.78	3.39	0.04	1.056	0.12	7.05	99.81
AA19	73	14.3	0.19	0.19	0.04	0.96	4.32	0	1.383	0.04	5.65	100.07
AA20	60.8	21	0.44	0.77	0.12	3.59	3.74	0	0.954	0.11	8.6	100.13

acterized by the presence of kaolinite with an intermediate value of 39%, illite with a higher value of 28%, quartz with an intermediate value of 30%, feldspars (intermediate value), calcite (with a content similar to group 3), dolomite with the