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Research paper

New insights on mineralogy and genesis of kaolin deposits: The Burela kaolin deposit (Northwestern Spain)

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ABSTRACT

The Burela deposit is the largest kaolin deposit in Spain, mined for more than 50 years, the product being mainly used for porcelain. Kaolin is dominantly associated with Lower Cambrian felsites, interbedded with quartzites, micaschists and metapelites (Cándana Series), and was strongly folded during the Variscan orogeny. Kaolin layers were ductile and incompetent materials among more competent ones, producing many slides with a diastrophic appearance. Consequently, kaolin outcrops are morphologically very variable– i.e. pockets – and interlayered between metapelites and/or quartzites, resulting in complication for prospection and mining.
The kaolin consists mainly of kaolinite, tubular halloysite, and spherical allophane along with quartz and minor illite. The content of kaolin minerals reaches up to 90% in the finer fractions (<2 μm and <1 μm).
Geochemical analyses of trace and REE show a close relationship between kaolin and associated rocks. Two kaolin types can be differentiated: (i) massive, associated to felsite; and (ii) related to metapelite. A temperature range from 15 to 35 °C, with an average of approximately 28 °C was calculated on the basis of the isotopic signatures ($\delta^{18}O$, δD) for the kaolin materials. This scatter suggests that if continental weathering was involved in the kaolin formation on the lower side of the temperatures, it was not the only process, especially for kaolin associate with felsites and metapelites. The higher temperatures are indicative of a hydrothermal auto-metamorphic alteration, followed by a folding of the series that induced an apparently chaotic kaolin distribution with a combined continental weathering superimposed on the previous low-temperature hydrothermal felsite transformation.

1. Introduction

The origin of primary kaolin deposits is usually a matter of controversy because kaolinite can be formed in situ by weathering reactions (supergene kaolins), hydrothermal alteration during the late stages of magma cooling (hydrothermal kaolins), or by a combination of both processes (Murray, 1988). Kaolinite can be formed also within sedimentary continental basins by diagenetic processes (Galán and Ferrell, 2013). Various criteria and indicators have been proposed to distinguish supergene from hypogene kaolins (e.g. Dill et al., 1997; Gilg et al., 1999), although some of them are considered as ambiguous. Unravelling the genesis of kaolinite in deeply weathered magmatic rocks is one of the most important challenges faced by clay geologists.

In the Variscan belt of Galicia (NW Spain) kaolinization of crystalline rocks is widespread. Large high-grade deposits of kaolin (e.g. Vimianzo, Nuevo Montecastelo) and other minor occurrences are found in association with weathered granites. The combined oxygen and hydrogen isotope composition of kaolinite from such deposits is consistent with data of supergene formation (Clauer et al., 2010, 2015; Fernández-Caliani et al., 2010). However, some deposits associated with felsite dykes or sills and quartz vein networks could have been formed in situ by complex fluid/rock hydrothermal and supergene interactions.

The Burela kaolin deposit (Northern Galicia) is a volcanic-hosted deposit, which is of particular interest in addressing the origin and timing of kaolinization. Volcanic-hosted kaolin occurrences of no current economic interest are also found in other areas of Spain, such as the Canary Islands and within the volcano-sedimentary complex of the Iberian Pyrite Belt. However it is in the Burela area where kaolinization is best represented. The deposit is geologically located (Fig. 1) in the West Asturian-Leonese Zone (WALZ), one of the major tectono-stratigraphic terranes into which the Iberian Massif is classically subdivided (Julivert et al., 1972). The WALZ exposes Precambrian to Devonian metasediments that experienced the effects of the Variscan orogeny between Late Devonian and Late Carboniferous times (Martínez-Catalán et al., 1997; Pérez-Estaún and Bea, 2004).

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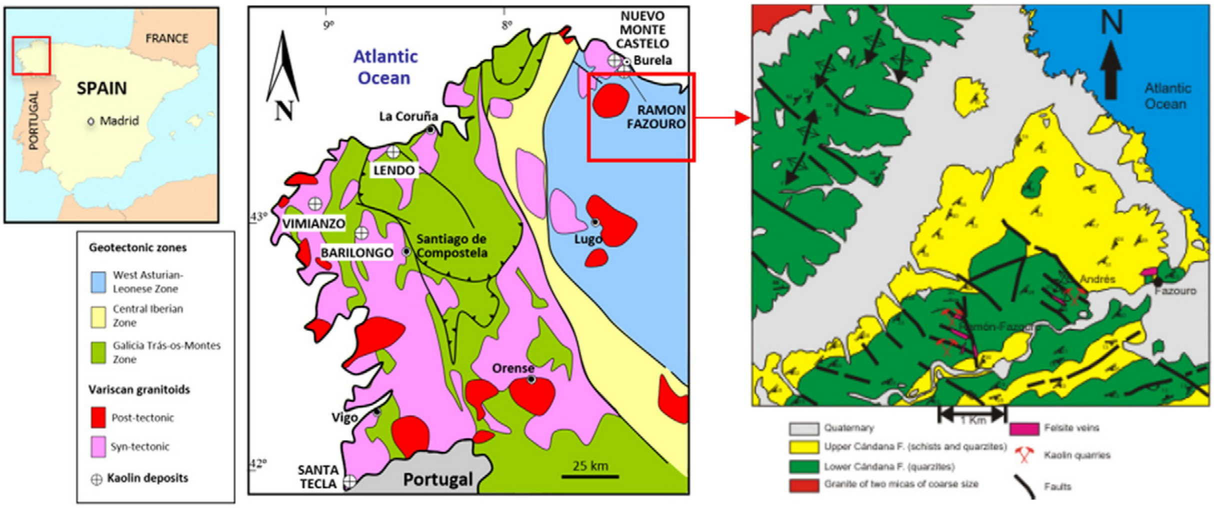

Fig. 1. Regional geological map of Galicia (NW Spain) after Martínez-Catalán et al. (1997) showing the location of the studied kaolin deposit.

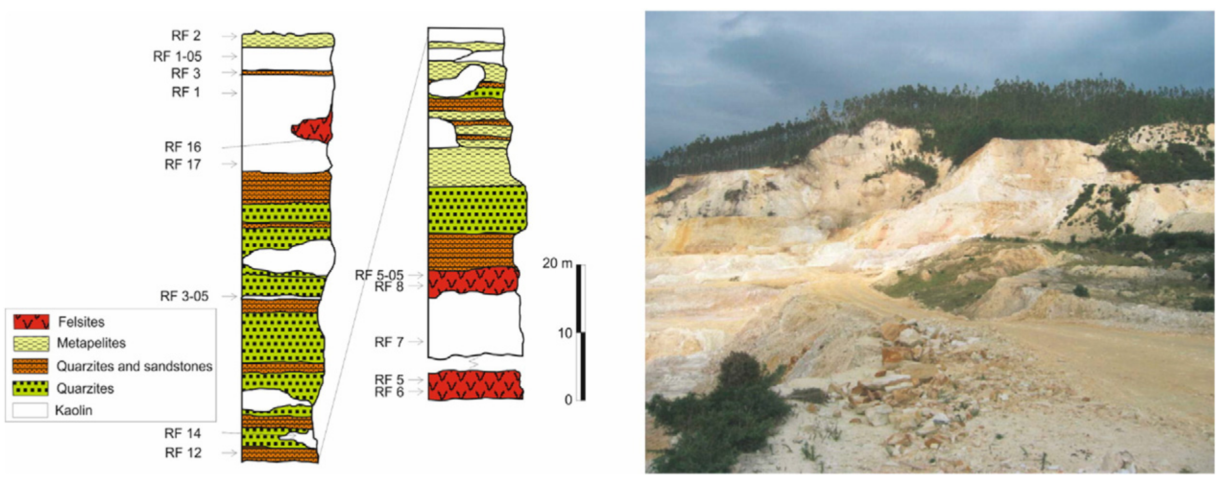

Fig. 2. Panoramic view of the kaolin quarries at Ramón-Fazouro and sketch of the sample location in the studied outcrops.

The main Burela quarries are San Andrés and Ramón Fazouro that are located near the western edge of Fazouro village (Fig. 1). The kaolin is spatially and genetically related to felsites and a swarm of quartz-porphyry dykes that intruded Lower Cambrian metasediments. Kaolin is dominantly associated with Lower Cambrian felsites, interbedded with quartzites and sandstones, and metapelites (Cándana Series), which were strongly folded during the Variscan orogeny. Kaolin-rich layers became a ductile and incompetent material interleaved among the more competent ones, producing many slides with a diastrophic appearance. Consequently, the kaolin outcrops are morphologically very variable (i.e. pockets) interlayered between other rocks, resulting in difficult prospection and mining.

This world-class kaolin deposit has been mined by ECESA for more than half a century (1957–2014), with the kaolin being mainly used as raw material in the manufacture of high quality ceramics, especially porcelain-ware. The kaolin material consists of a mixture of kaolinite and halloysite with minor allophane (Galán et al., 2013). The origin of this important economic deposit is still an ongoing matter of debate. It is unclear if extensive kaolinization resulted from hydrothermal (by meteoric fluids) alteration of felsitic rocks, or if weathering affected the materials that were already subjected to a first stage of low grade metamorphism, or if a combination of the two processes induced the deposit (Galán and Martín Vivaldi, 1972). The aim of this paper is to

Table 1
Mineralogical and chemical analysis (major elements in wt.%) for the representative rocks of the deposit.

Wt.%	Felsic volcanic rocks		Altered felsite	Altered metapelite	Quartzite
	RF-5	RF-6	RF-8	RF-2	RF-3
Quartz	24	33	30	27	97
Feldspars	60	67	35	4	
Mica	15		30	31	3
Clay minerals	Tr	Tr	<5	38	
MIA	29	33	46	87	100
SiO_2	73.06	62.33	70.73	65.00	98.86
Al_2O_3	14.64	20.38	16.21	23.10	0.29
Fe_2O_3(t)	1.46	1.05	1.06	0.44	0.03
MnO	0.01	<0.01	0.01	<0.01	0
MgO	1.20	0.31	0.56	0.38	0.01
CaO	0.03	0.17	0.09	0.04	0.02
Na_2O	2.80	4.93	0.57	0.32	0.02
K_2O	5.20	6.49	5.69	3.94	0.12
TiO_2	0.19	0.04	0.16	0.90	0.02
P_2O_5	0.03	0.02	0.03	0.05	0.02
LOI	2.32	3.58	4.92	5.82	0.40
TOTAL	100.94	99.30	100.03	99.99	99.79
CIA	64.58	63.75	71.85	84.31	64.44