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Research paper

Partitioning of minor, trace elements and rare earth elements in bentonite affecting by thermal alteration

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ABSTRACT

Minor and trace elements, included the rare earth elements (REE), of bentonite that has undergone the natural action of a thermal alteration have been determined. This study has been conducted in the Cala del Tomate outcrop, Cabo de Gata region (Almeria Spain), where an important volcanic dome has intruded in a bentonite mass producing a temperature gradient from the contact area to the exterior. Data are compared with those obtained in bentonites that not were subjected to the thermal effect.

No major differences in the REE distribution of bentonite subjected to a thermal contact area in front of a stratigraphic contact zone have been found. On the whole, the contact metamorphism causes element mobilisation, depending on whether there is a temperature gradient. Elements whose behaviour depends directly on temperature, behave as qualitative indicators of element mobility. Rb mobilises significantly near a thermal contact, a pattern that contrasts with its behaviour in a mechanical contact. Other elements that are sensitive to the effect of temperature are lithophile elements. These elements demonstrate a fractionation of Light Elements Lithofile Elements (LILE) compared with High Field Strong Elements (HFSE) near the thermal contact.

The main chemical differences with the stratigraphic contact area not subject to the effect of temperature are the incorporation of trace elements with a small radius (HSFE) in the structure of the smectites subject to the effect of temperature, to the detriment of those with a larger radius (LILE).

1. Introduction

Several studies show that crystal chemistry exerts a major control on trace element partitioning (Wood and Blundy, 1997, 2001). Marks et al. (2004) compared the trace element contents of mafic minerals in order to investigate the partitioning behaviour of trace elements in natural alkaline silicate melts. Trace elements determination in basaltic systems have been developed by Coogan et al. (2000); Thompson and Malpas (2000); Tiepolo et al. (2002), in hydrothermally altered rocks by Shikazono et al. (2008), in process of alteration of rhyolitic rocks to bentonite by Muchangos (2006) and element mobility during the bentonite formation have been studied by Özdamar et al. (2014).

In most minerals, trace elements fill lattice sites by replacing the main element of the lattice. They can be precipitated within cracks of the crystal in special composition. Although the level of trace elements is as low as parts per thousand (ppt), and part per million (ppm) in soil or rocks, they can provide useful metal deposits which can have economical importance.

Rare earth elements (REE) in sedimentary rocks concentrate in the silt and clay fractions and their contents appear uncorrelated with clay mineralogy (Cullers et al., 1979). The differences in the REE content may be inherited from the REE composition of the source rock or determined by chemical weathering processes in the source area (Banfield and Eggleton, 1989). Generally, the incompatible element composition of bentonites is similar to that of the surrounding volcanic rocks, suggesting that the incompatible elements were generally immobile during alteration processes (Arslan et al., 2010).

REE distribution in the clay fraction of sediments from central Portugal was studied by Prudencio et al. (1989) who suggested that kaolinite, among the clay minerals, tends to be the principal REE carrier. They pointed out also that there is a general tendency for clay minerals to accommodate Eu^{2+} more easily than trivalent REE. Caggianelli et al. (1992) in studies about REE distribution in the clay fraction of pelites from the southern Apennines, Italy, show that only illite is correlated with REE, while a smectite-rich sample is characterized by the lowest content in REE. Strong correlations exist between REE and TiO_2, Nb, Zr and a less significant one with Sr; no correlations exist between these elements and Y.

Trace element studies in bentonites from Cabo de Gata region, Spain, were conducted by Linares et al. (1987) who calculated the

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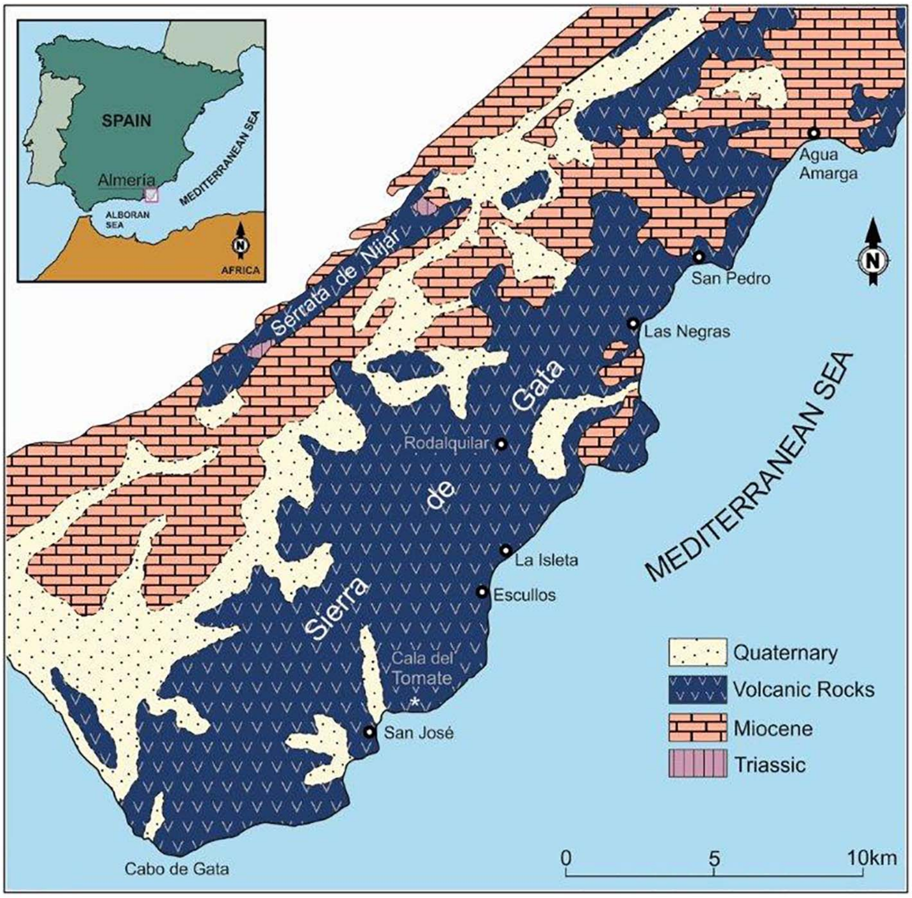

Fig. 1. Location map of the bentonite outcrop in the cabo de Gata región (SE, Spain).

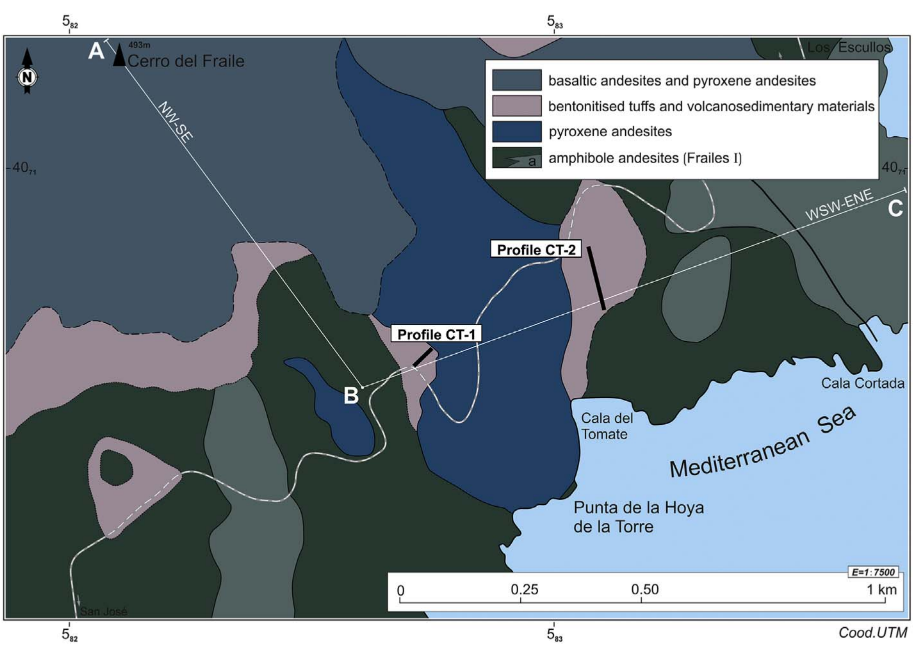

Fig. 2. Geological setting and two profiles sampled.

balance of major and trace elements during the process of alteration of volcanic rocks to bentonite and through statistical analysis to localize the trace elements in the bentonites. They showed that smectite retains a large proportion of the trace elements contained in the primary minerals of parent rocks in its crystal structure and hence can be very useful in order to establish the origin of bentonites. A comparative study of the mobility of major and trace elements during alteration of an andesite and a rhyolite to bentonite, have also been carried out by Christidis (1998).

In this study we present the content of minor and trace elements including the REE elements data for bentonite from an outcrop of Cabo de Gata region (Almeria, Spain), where volcanic dome intruded a bentonite mass producing a temperature gradient from the contact area to the exterior. The aim of this paper is to evaluate the minor, trace and