Applied Clay Science 47 (2010) 372–377

Contents lists available at ScienceDirect

Applied Clay Science

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

Ceramic behaviour of five Chilean clays which can be used in the manufacture of ceramic tile bodies

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ARTICLE INFO

Article history:
Received 30 July 2009
Received in revised form 23 November 2009
Accepted 25 November 2009
Available online 13 December 2009

Keywords:
Chile
Industrial clays
Ceramic tiles
Technological behaviour

ABSTRACT

This study is focussed on the behaviour of ceramic clays from Chile which has an important local ceramic industry. Five deposits of clays with industrial application have been studied. The clays come from San Vicente de Tagua-Tagua (SVTT), Litueche (L), Las Compañías – Río Elqui (LC), La Herradura – Coquimbo (LH) and Monte Patria – Coquimbo (MP). The chemical and mineralogical compositions of clays were determined by X-ray fluorescence (XRD) and X-ray diffraction (XRD), respectively. Also, the plasticity index (PI) was measured for each sample. The chemical and mineralogical compositions of samples differ considerably. Test samples have been prepared by pressing and firing in the range of 800–1150 °C. Linear contraction (LC), water absorption capacity (WAC) and thermodilatometric analysis (TDA) were done in order to characterize clays after firing. A considerable decrease in the WAC coinciding with the beginning of vitrification, is observed between 1050 and 1100 °C. At 1150 °C the porosity of the tile bodies decreases significantly and the tile bodies became earthenware. All studied clays seem to be easily adaptable to a correct dry pressing ceramic process. In particular, illite–kaolinite-rich samples show the best behaviour. Samples SVTT are suitable for the production of fast firing vitreous pieces. L samples present the highest refractory behaviour.
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1. Introduction

It is well known that industrial clays have a complex mineralogical composition, which makes rather difficult the study of mineral phases present in the raw material. Paste contraction occurs while grains are approaching each other. Each particle in the body is separated by water film at the initial stages of drying (Jeridi et al., 2008). The water film becomes thinner until the “critical point”, at which the rate of drying and shrinkage sharply change (Dondi et al., 2002), and the particles come into contact occupying the open space left by the released water. Shrinkage tends to increase as vacuum volume rises, and this seems to explain partially why shrinkage is lower when pressing load increases (Jeridi et al., 2008). During the firing process a series of transformations occur, which will be decisive to achieve the final properties of the ceramic products (González-García et al., 1990; Jordan et al., 1999). Through the ceramic process, once the crystalline structures of minerals exceed their stability limits, they are partially decomposed while simultaneously others are being formed. The destruction of the pre-existing structure does not occur instantaneously (Jordan et al., 1999). The knowledge of the origin, diagenesis and physicochemical composition of the clays is essential when sketching out suitable compositions required for ceramic production (Sanfeliu and Jordan 2009).

The relationship between the mineralogy of the raw materials and the phase changes taking place during their sintering under different conditions have been examined (Daskshama et al., 1992; Jordan et al., 1999 and Jordan et al., 1999). Between 900 and 1000 °C a sintering process takes place, which consists in the aggregate compaction of particles. This process is not complete, so the ceramic tile bodies are still quite porous. Towards 1000 °C the larger pores are seen to increase (between 1 and 10 μm). This phenomenon coincides with the destruction of illites, chlorites and their re-crystallisation into quartz and spinel principally (Jordan et al., 2008).

Ceramics industry in Chile starts between 1950 and 1960 as a result of the optimistic and positive attitude of a country, which has made great effort to implement a small industry located around Santiago de Chile. The continuous improvement of the initial modest facilities using primitive methods of manufacture has been the result of joint efforts of various companies and factories that together implemented new and improved manufacturing techniques. These enabled producing from the clay gres stoneware to the most advanced ceramic products for varied uses.

There is no previous study about these non exploited clay deposits in the region and it is the first time that the applicability of these clays as raw materials for ceramic industry has been tested. The main objective of this paper is the study of the chemical–mineralogical

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0169-1317/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.clay.2009.11.056

compositions and technological behaviour that allows the evaluation of the applicability of the clay deposits studied.

2. Materials and methods

Five deposits of Chilean clays which can be used in the formulation of ceramic pastes were selected (Fig. 1). The clays come from San Vicente de Tagua-Tagua (SVTT), Litueche (L) in the VI Region of Chile, and Las Compañías – Río Elqui (LC), La Herradura – Coquimbo (LH) and Monte Patria – Coquimbo (MP) from the IV Region of Chile.

The Tagua-Tagua basin in Chile (VI Region) was studied by Varela (1976) and Nuñez et al. (1994). The Formation "Laguna de Taguatagua" had a lagoon origin and it was form during the Würm glaciation. Meseguer et al. (2009c) studied the geology and mineralogy of the Upper Tertiary white clays from Litueche (VI Region). The geology of Elqui basin (IV Region) presents a wide variety of Units from Palaeozoic to Tertiary. Studied clays (LC) belong to alteration hydrothermal zones of the Infiernillo Unit (Lower Miocene).

The geology of the Coquimbo area (IV Region) comprises units ranging in age from Palaeozoic to Tertiary. The Paleozoic rocks crop out along a narrow belt in the coast and mostly consist of monotonous mica schists series. These rocks were partially covered by Pliocene to Quaternary marine sedimentary rocks. Eastward from the coast the geology is dominated by volcaniclastic, volcanic and sedimentary units of lower Cretaceous age. The studied clays (LH and MP) belong to these sedimentary units.

Samples of each clay deposit were collected. They were oven-dried at 110 °C until constant mass and then grounded with a hammer mill to null residue in the 630 μm control sieve, following the normal practice in ceramic laboratories (Meseguer et al., 2009a). Eight

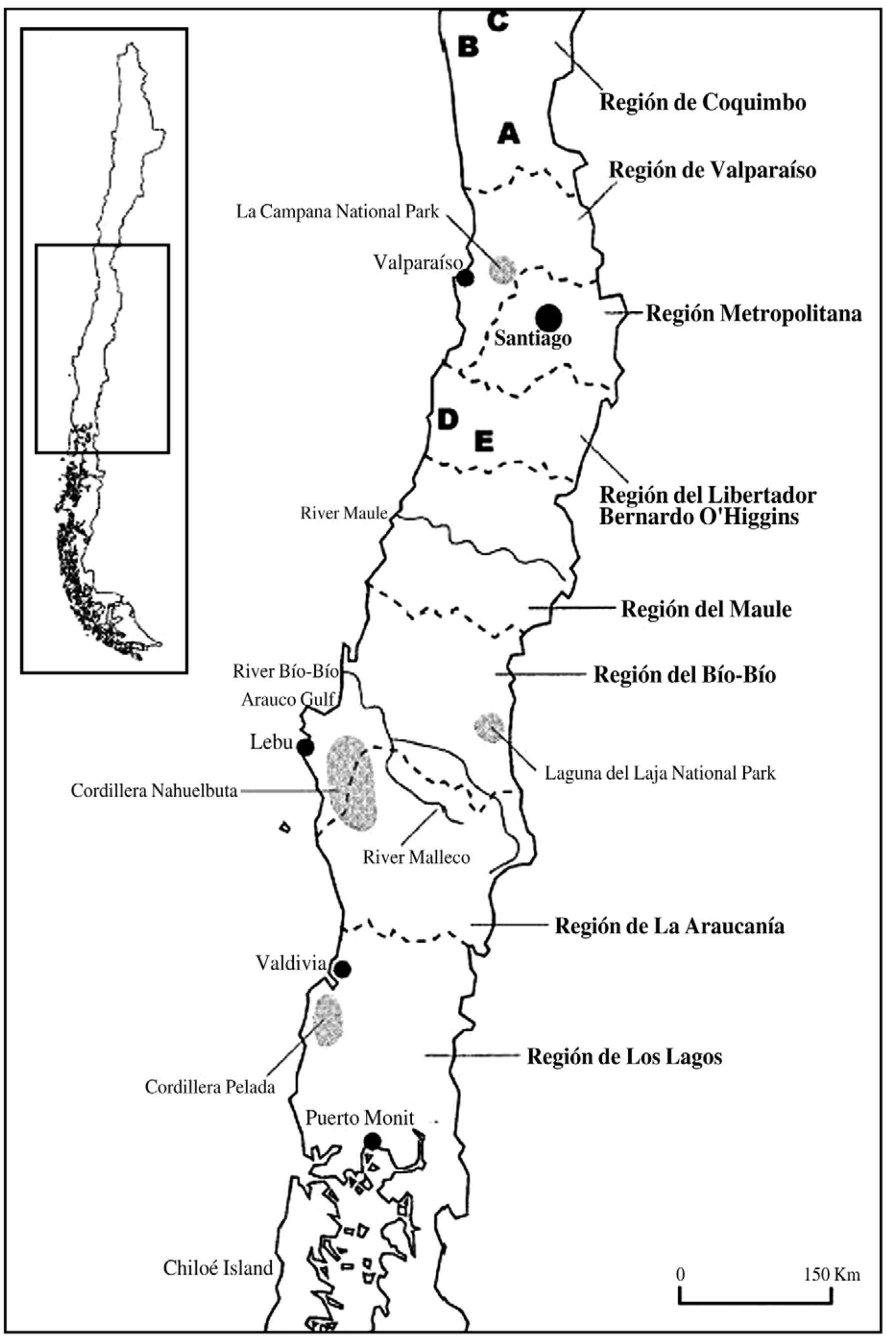

Fig. 1. Location of the studied clay deposits. Legend: A: Monte Patria (MP); B: La Herradura (LH); C: Las Compañias (LC); D: Litueche (L); E: San Vicente de Tagua Tagua (SVTT).

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