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UNIVERSIDAD DE GRANADA, Departamento de Mineralogía y Petrología, Progama Doctorado - Ciencias de la Tierra

BRICKTECH: ASSESSMENT FOR THE USE OF WASTE IN BRICK PRODUCTION. PETROPHYSICAL CHARACTERIZATION OF NEW MIX DESIGNS AND OPTIMIZATION OF THE FIRING CONDITIONS

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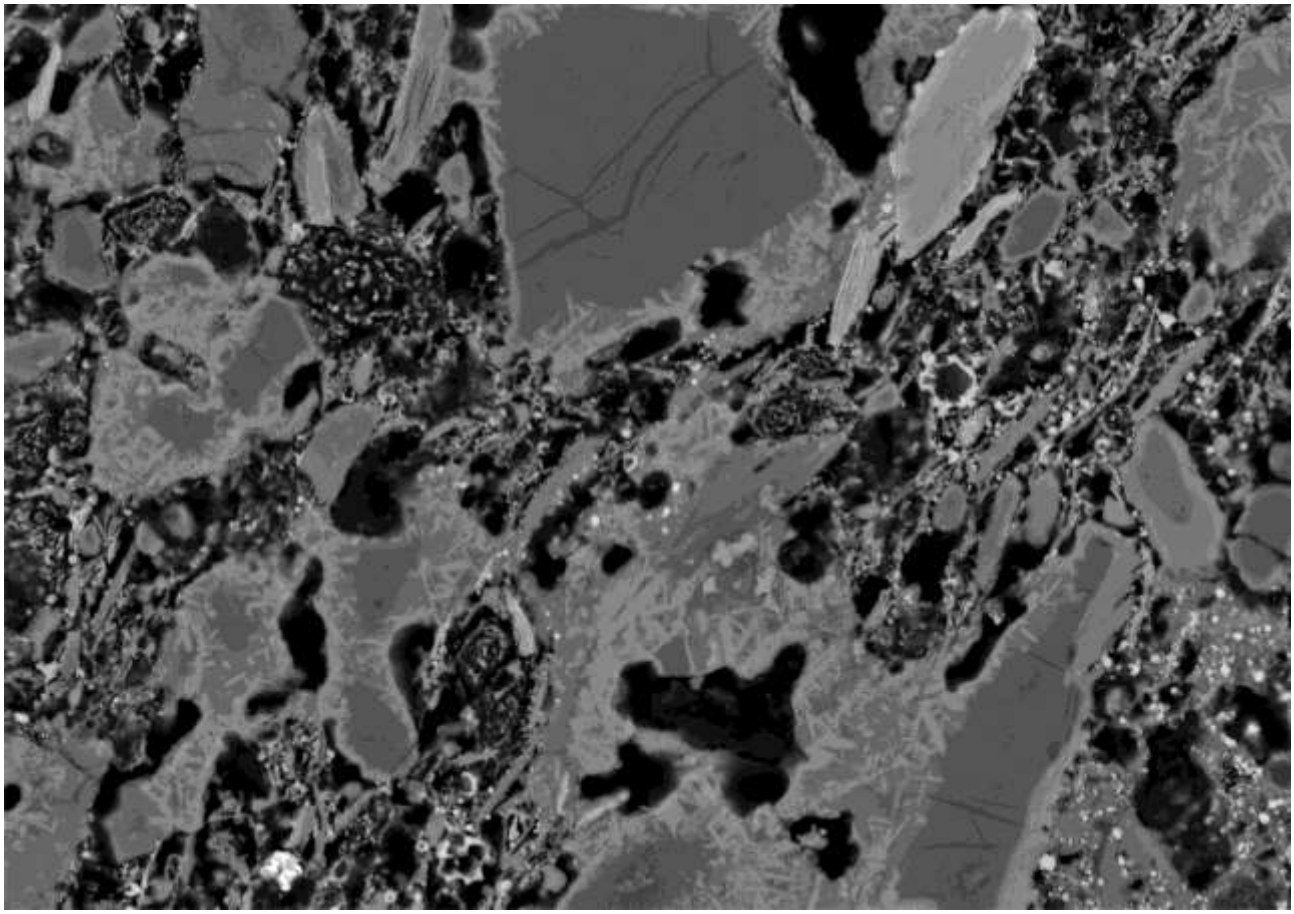

Abstract

Brick is a traditional building material with ancient origins, but that can respond to the important challenges to which industrial research is currently facing, i.e. the energy savings, the lowering of costs production and the quality improvement of the finished product. The growing demand for a sustainable production addressed research to obtain new materials in respect of the environment preservation and the community welfare.

A possible way for achieving these goals and for satisfying of these different aspects is the optimization of new mix design, re-using waste, produced from industrial, urban and excavation activities.
The consolidation of a sustainable production is twofold because it determines the reduction of new geo-resources exploitation, as well as solves the problem of waste accumulation and management, reassessing this residual material as a secondary source of interest, which allow to produce new environmental-friendly materials.
Although since the last decades many studies have been carried out addressed to the production of bricks reusing waste as alternative resource, demonstrating also a wide applicability, their implementation in the industrial sector is still very limited, due i) to the low partnership between academic research and the real needs of industry; ii) the lack of specific standards for the evaluation of processes and finished products; and iii) the limited public education on the possible sustainable frontiers. Another important aspect which should be considered in the production of new materials is the maintenance of the aesthetic qualities of the traditional material. Bricks, in fact, being building materials, have to respect parameters of "cultural compatibility", understood as recognition of the territorial identity of a community.

This work aims to fill the gap of between academic research and industrial development, through the close collaboration between university and industry (SanMarco-Terreal, Italy) and the achievement of common objectives.
New mix designs have been developed according to the objectives of Horizon 2020, (https://ec.europa.eu/programmes/horizon2020/), particularly in terms of sustainable use of natural resources, optimization of firing conditions, recycling and gas emission control, in order to satisfy the goals related to the scientific excellence, the societal challenges and the industry leadership.
Therefore, the study focused on:
1) the relationship between chemico-mineralogical characteristics and mechanical properties and durability in different stress conditions of bricks already on the market, obtained by different clays and fired at different temperatures;
2) the analysis of the porous system of commercial bricks with the main aim of obtaining a complete and reliable knowledge to define a protocol for the quantification and parameterization of morphological characteristics of pores through a combined use of traditional methods and techniques based on image processing;
3) the study of new mix design obtained by the addition of wastes from the extraction of stone materials and industry scrub for the production of new bricks based on the concepts of recycling and sustainable use of natural resources. The type of waste specifically adopted were: i) trachyte fragments from quarry activity (Euganean Hills, Italy); ii) a sludge resulting from the ceramic industry.
The study of the commercial bricks showed that the chemico-mineralogical and physico-mechanical properties, the porosity and the durability of the finished products are highly dependent on the raw material composition and the firing temperatures reached during the production process. The results obtained by the experimental mixes analysis demonstrate the real possibility to achieve new bricks reusing waste, maintaining the physical, mechanical and aesthetic features of the traditional materials and improving the quality of the finished product. It was observed as the presence of alkali feldspar in trachyte, which act as fluxing agents promoting the connection between the minerals, and the compactness, as well as the pores evolution. The use of trachyte, indeed, allowed

to obtain bricks at lower firing temperature, with a saving of energy and costs, and limiting the exploitation of new geo-resources.
Even the use of the ceramic sludge allowed us to reach satisfactory results, suggesting that this experimental brick type can be a valid substitute of commercial bricks for its physical-mechanical properties and for its aesthetic qualities, but resulted to be particularly vulnerable to freeze-thaw cycles. This suggests that caution should be taken when using in cold climates.

This PhD thesis is an important starting point to address the improvement of the traditional bricks in a sustainable way and the assessment for experimental mixes recycling waste in quality and durability, towards a brick industry renovation.
The comprehension of the intrinsic relationship between mineralogical composition, textural features, microstructure and physical properties resulted to be at the base of a conscious understanding of bricks, also in terms of developing of new mix-design.

Breve reseña curricular

Chiara Coletti es licenciada en Scienze e Tecnologie per i Beni Culturali por la Università degli studi di Padova (2008), con Master en Scienze e Tecnologie per i Beni Archeologici e Artistici por la Università degli Studi di Padova (2010). En el 2013 inició su tesis doctoral "BRICKTECH: Evaluación para la utilización de materiales de desecho en la produción de ladrillos. Caracterización petrofísica de nuevos productos y optimización de las condiciones de cocción" con un proyecto en cotutela entre la Università degli Studi di Padova (Dipartimento di Geoscienze) y la Universidad de Granada (Departamento de Mineralogía y Petrología). La investigación se ha basado en el conocimiento del ladrillo teniendo en cuenta varios aspectos: la relación entre las características químico-mineralógicas y texturales con las propiedades físico-mecánicas y el comportamiento de los materiales en diferentes condiciones de estrés, para obtener ladrillos cocidos adecuados para la construcción de edificios modernos y la restauración de los históricos; el estudio específico del sistema poroso como parámetro principal que regula la durabilidad del material, utilizando diferentes métodos analíticos, para tener un conocimiento fiable y completo de la porosidad de los ladrillos; y la evaluación de la reutilización de material de desecho, con función de degrasante, para la elaboración de nuevos ladrillos y incentivar una producción industrial que favorezca el reciclaje y la explotación sostenible de los recursos. Parte de los resultados obtenidos ha sido publicada en revistas de impacto internacional en el ámbito de la caracterización de materiales cerámicos y de construcción.

Publicaciones SCI:

Coletti C., Cultrone G., Maritan L., Mazzoli C. How to face the new industrial challenge of compatible, sustainable brick production: study of various types of commercially available bricks. Applied Clay Science 2016; (In Press).

Aportaciones a congresos:

- **COLETTI C.**, MARITAN L., MAZZOLI C., CULTRONE G., The assessment for the use of waste of trachyte in the brick production, SIMP –SGI- So.Ge.I. – AIV., Florence, Italy, 2-4 September 2015 (Oral Presentation).

- **COLETTI C.**, CULTRONE G., MARITAN L., MAZZOLI C., The assessment for the use of waste of trachyte in the brick production, EGU General Assembly 2015, Wien, Austria, 15 April 2015 (Poster).

- **COLETTI C.**, MARITAN L., MAZZOLI C., CULTRONE G.: Characterization of mineralogy and porosity of commercial bricks: 2D and 3D geometry analysis of the pore system. SGI-SIMP 2014,10-12 September 2014, Milano, Italy (Oral Presentation).

- **COLETTI C.**, CULTRONE G., MARITAN L., MAZZOLI C.: Combined multianalytical approach for the characterization of commercial bricks with a view to their technical use. XXXIV Reunión de la SEM (Sociedad Española de Mineralogía), 1-4 July 2014, Granada, Spain (Oral Presentation).

- **COLETTI C.,** MARITAN L., MAZZOLI C., DALCONI C.: BRICKTECH: combined multianalytical approach for the mix-design of bricks to use in restoration of historic brick masonry in Veneto. 12th European Meeting on Ancient Ceramics (EMAC 2013), 18-21 September 2013, Padova (Poster).

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