DEVELOPMENT OF NOVEL AND COST-EFFECTIVE COATINGS FOR HIGH-ENERGY PROCESSING APPLICATIONS.

H2020 FORGE PROJECT

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INTRODUCTION

Energy-intensive industries deal with materials deterioration caused by the extreme conditions generated by the industrial processes. The FORGE project (*), entitled "Development of novel and cost-effective coatings for high-energy processing applications", is a research and innovative project, funded by the European Commission under the Horizon 2020 programme, which is addressing this topic by developing new compositionally complex materials.

The project focuses on developing and testing advanced coatings for the materials used in energy-intensive industries, which have to withstand harsh conditions, such as high temperature, corrosion, and erosion, when they are implemented at industrial facilities. The improvement in the performance of the materials will yield a longer lifespan of the equipment and higher production efficiency.

The FORGE consortium comprises 13 partners from 8 countries. It includes industrial user members from steel, cement, aluminium and ceramic industries and specialist materials, to ensure the project's focus on real-world issues, coupled with world-leading experience in the development of materials, protective coatings and their application in harsh environments.

The ceramic industry is participating in the project with a view to testing new coatings, developed in the framework of the FORGE project, to be applied in the insulating refractory bricks used in continuous roller kilns used for firing ceramic tiles, with the aim of reducing the corrosion that reduces their lifespan and causes defects in the final ceramic tiles.

METHODOLOGY

Some samples were from different sections in a real industrial kiln to analyse the corrosion observed, caused by the combustion gases.

Surface and transverse microstructural characterisation was performed by scanning electron microscopy (SEM). Test piece cross-sections were prepared to determine the penetration depth of the attack. The composition profiles were determined by taking three energy-dispersive X-ray (EDS) spectra of 2600x230μm at each depth and averaging the results.

To determine the surface composition, five EDS analyses of each sample surface were performed on areas of 250x250μm, selected at random, averaging the results.

RESULTS

The results obtained in the characterisation of the industrial attacked refractories by SEM-EDS can be seen in Figure 1 and Figure 2. The example shown corresponds to a sample that was located in the high temperature zone of the kiln.

The attack of industrial refractories by metallic elements was determined by SEM-EDS. Four zones of different appearance were observed:

Zone 1 consisted of a thin brown layer. It was composed mainly of crystals containing aluminium, zinc, magnesium, chromium, and iron (probably spinel) embedded in a glass matrix of similar composition.

Zone 2, glassy in appearance and with large pores, was characterised by a high content of transition metals (Cr, Fe, Zn) and alkali metals (Na and K). Small spinel crystals were also observed. This layer was about 1mm thick.

Zone 3 also had a glassy appearance but was less porous. Alkali metals and transition metals were detected, the latter in a very low proportion. As the distance to the surface increased, the alkali metal content decreased, and the composition and microstructure of the refractory became closer to that of the original. The thickness of this layer was about 3 mm.

Zone 4 had a microstructure similar to that of the original refractory. The most substantial difference was a higher potassium and sodium content.

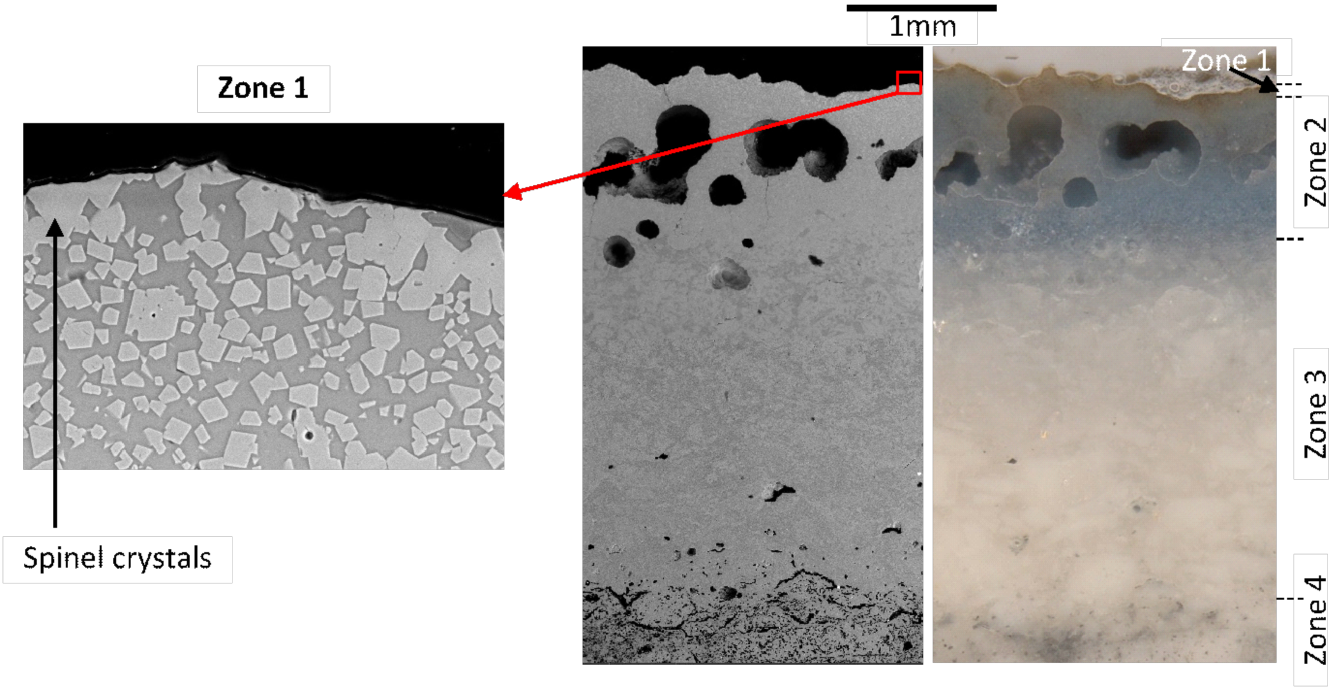

Figure 1. *SEM and stereoscopic micrographs of the cross-section of the attacked refractory.*

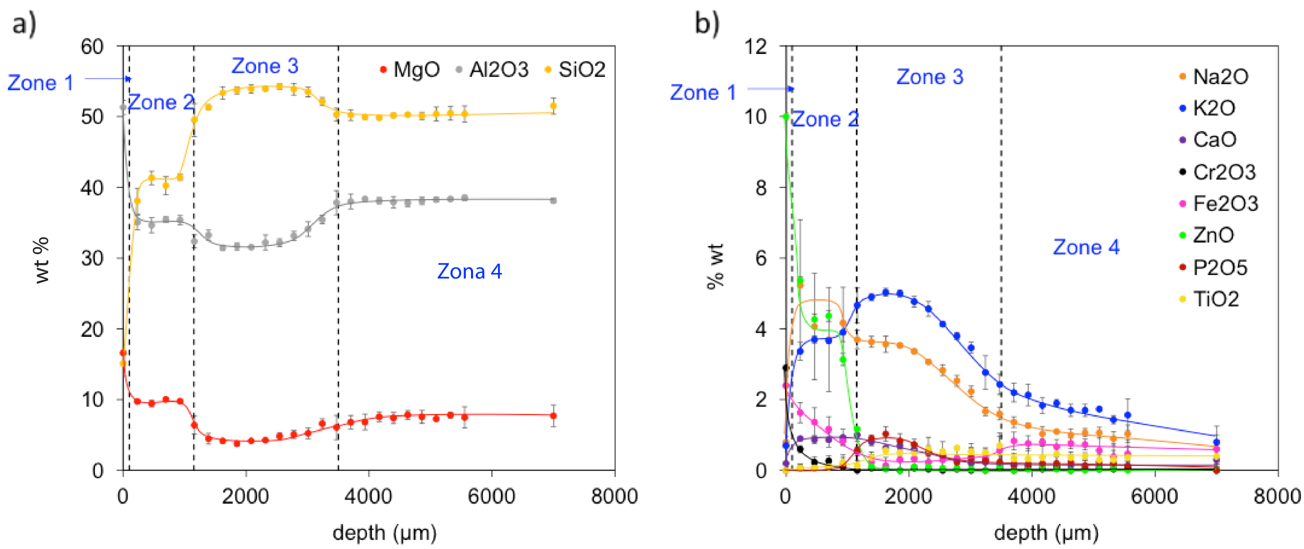

Figure 2. *EDS depth profile of the cross-section of the attacked refractory: a) major oxides and b) minor oxides.*

CONCLUSIONS

In the attacked refractories, four zones of different appearance were detected. These regions contained different amounts of transition and alkali metals. The former were mostly located in the most superficial attacked zones. The latter, on the other hand, were preferentially located in the inner attacked zones.

The attack of the refractories by the kiln gases involves their diffusion through the pores of the firebrick and their chemical reaction with the components of the refractory. This causes an increase in the content of the glassy phase of the material and a decrease in its viscosity, which results in a deterioration of the material as a consequence of undesired sintering, forming a glassy layer in its surface, and a decrease in the mechanical resistance to compression of the refractory. As a result, stresses are generated between the inner region and the surface of the firebrick, leading to crack formation. In addition, the sintering of the glassy layer results in loss of its insulating capacity.

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