Particularities of the structure of ceramic tiles and building bricks obtained using high amount of incinerator bottom ash

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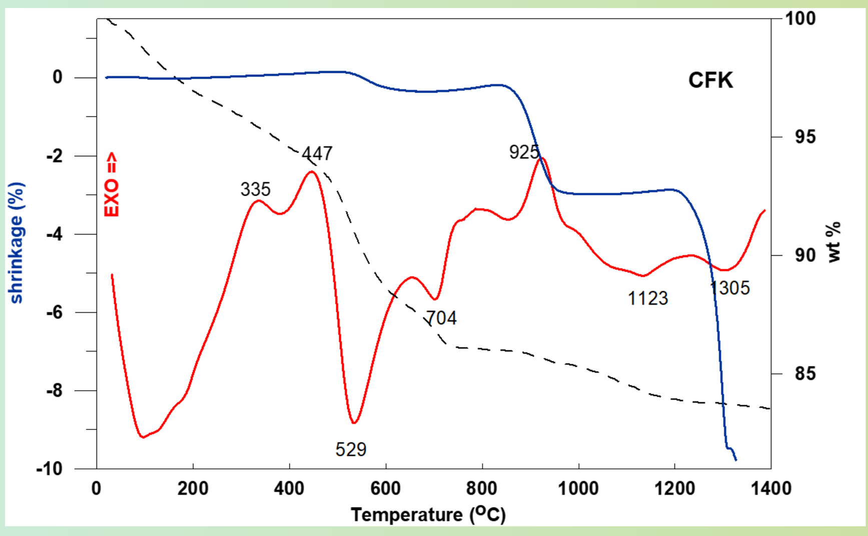
Introduction

Last decades several industrial and urban wastes become appropriate raw materials for bricks and tiles production. This gives possibility for recycling and inertization of different residues, which disposal otherwise can create several problems. One of widely studded wastes are the bottom ashes from Municipal Solid Waste Incinerators (MSWA).

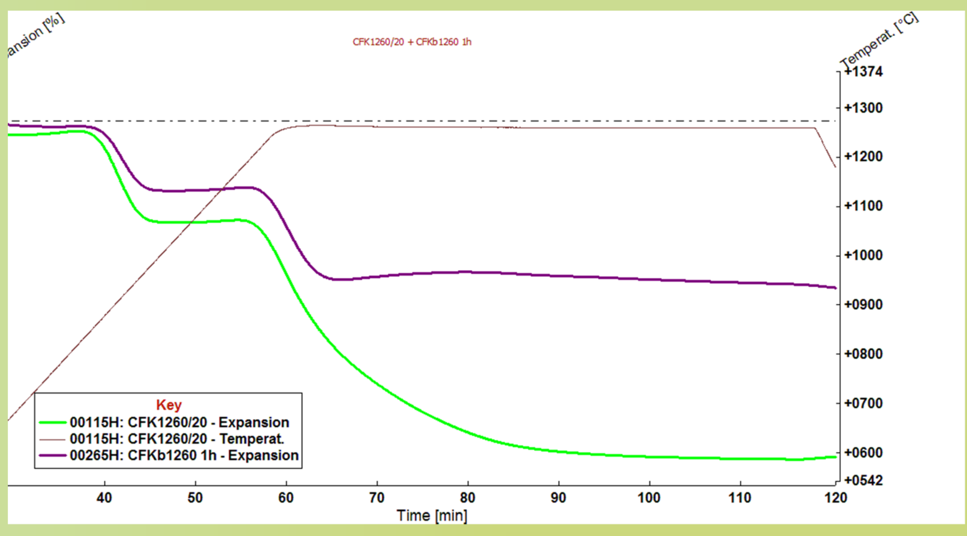
The present research also is related to this topic. The aims are some features of the structure of ceramic tiles and building bricks, which are consequence of the specific phase formation processes, going on during the heat-treatment. These structures explained the improved mechanical characteristics of obtained specimens.

Results & Discussion

Thermal behaviour



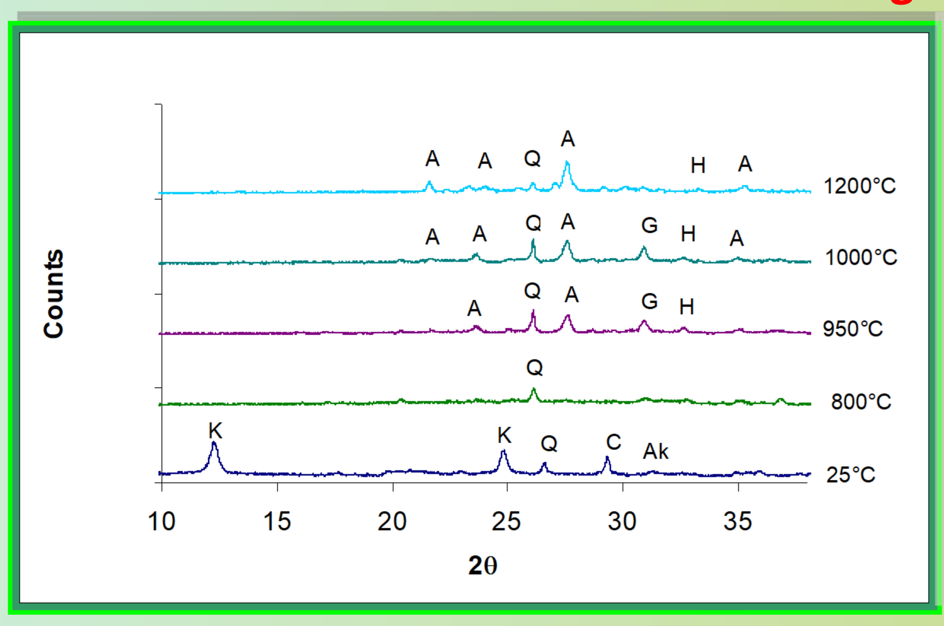
Isothermal DTA-TG and DIL plots of parent batch



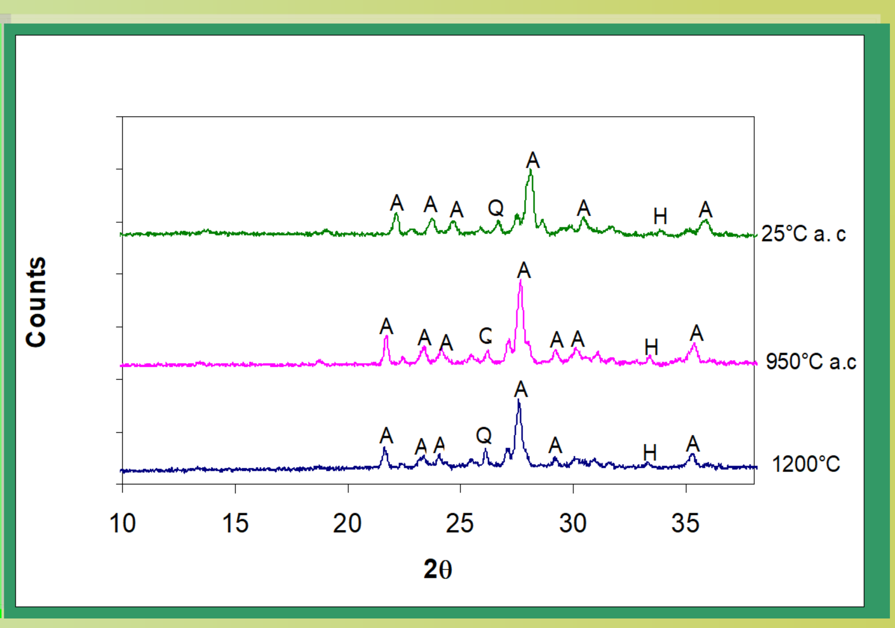
Non-isotherma DIL plots with and without burn-out

Phase transformation

Hot-Stage XRD

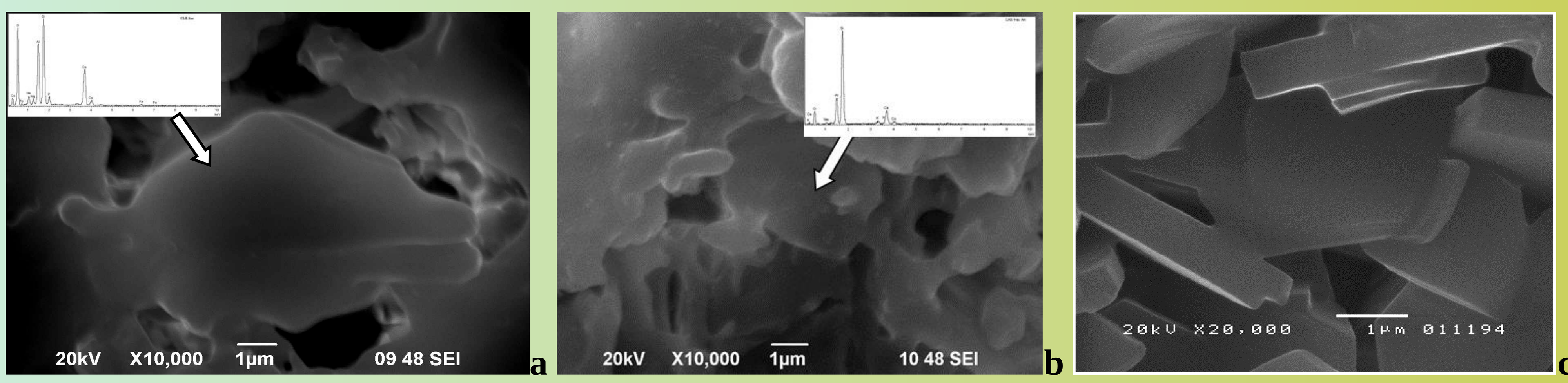


at heating

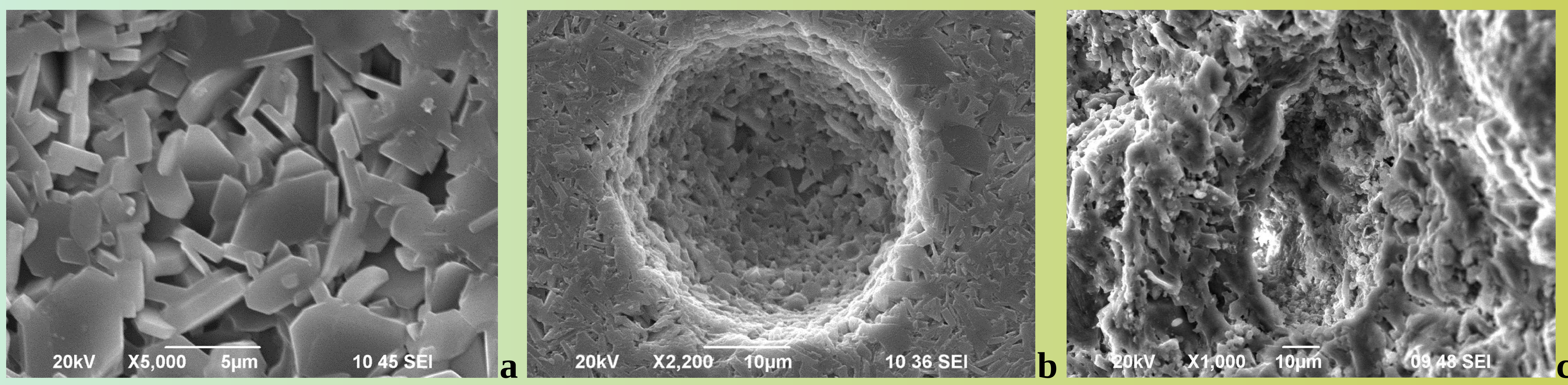


at cooling

Structure



SEM-EDS of anorthite formation at 1000 ºC (a), 1100 ºC (b) and 1240 ºC (c)



SEM of surface (a) and fracture (b) of final ceramic and fracture of "brick" sample, sintered at 1000 ºC (c)

- By mixing 60 wt% Municipal Solid Waste Incinerator bottom ash with 40 % industrial clay a ceramic with the following composition is obtained (in wt %): SiO_2 - 42.2, TiO_2 -0.8, Al_2O_3 - 25.8 2, Fe_2O_3 -7.9, CaO – 14.4, MgO - 2.1, K_2O - 1.1, Na_2O - 1.6, others – 2.7.
- In order to decrease the thermal losses during sintering and thus a part of the firing shrinkage the ash was preliminary heated for 2 h at 600 ºC to burn the organic residues.
- The "green" ceramic samples were prepared after homogenization with 6-7 % water and pressing at 40 MPa.
- The sintering behavior and the phase formations were studied by DTA-TG, optical dilatometry and hot-stage XRD. The structure of ceramics and crystal composition were observed by SEM-EDS.
- Thus optimal heat-treatment regimes for the sintering of tiling ceramics (**1 h at 1240 ºC**) or missionary bricks (**20 min at 1000 ºC**) were elucidated.
- Semi-industrial test in tunnel ceramic kiln were performed and the mechanical properties of obtained samples were compared with these of a traditional tiling ceramic.
- Notwithstanding of higher porosity the new ceramic show significantly belter mechanical properties.

Properties	CFK	terracotta
LS (%)	6.5	4.7
WA (%)	3.2	3.8
ρ_a (g/cm^3)	2.17	2.22
Total Porosity (%)	26	12
B.S (MPa)	51	29
E (GPa)	49	40
Mohs Hardness	7.5	6.5
α . 10^{-6} (° C^{-1})	6.1	6.9

LS – linear shrinkage; WA- water absorption; ρ - density; BS -bending strength; E – elasticity modulus; α – coefficient of thermal expansion

Conclusions

The phase compositions and structure of the new ceramic, sintered at 1240 ºC, are different from these of the traditional tiling ceramics. The main crystal phase, instead quartz and mullite, is anorthite. Due to the crystallization at cooling, amount of the residual vitreous phase is inferior which leads to regular fine polycrystalline structure and better mechanical characteristics.

If a short thermal cycle at ~1000 ºC is performed, samples with 2-3 % shrinkage, 1.9-2.0 g/cm^3 density, 12-13% water absorption can be also synthesized. These values correspond to the standards for traditional clay bricks, which however are produced at significantly longer thermal cycle.

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