Influence of granite cutting waste on the formation of dibasic calcium silicate hydrates

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INTRODUCTION

High energy costs, CO_2 emissions, and limited resources are forcing the concrete industry to look for new ways to develop sustainable and environmentally friendly production. There are several ways to reduce the negative impact on nature, while the production of environmentally friendly cement by using industrial wastes is the most effective way. For example, environmentally friendly cement such as “Solidia” and “Celitement” allows to reduce the emission of carbon dioxide up to 70% in comparison to Portland cement. “Solidia” and “Celitement” can be produced by two-step synthesis:

1) hydrothermal synthesis of calcium silicates hydrates (CSH);
2) mechanochemical activation and/or thermal treatment at low temperatures (<1000 °C) of CSH.

The properties of these cement depend on the mineralogical composition and properties of precursors. However, the scientific literature containing the data about the influence of industrial waste on the formation of CSH is scarce. Thus, this work aimed to determine the influence of granite cutting waste additive on the formation of calcium silicate hydrates during hydrothermal synthesis at 200 °C temperature.

MATERIALS AND METHODS

In this work the following materials were used:

- Calcium carbonate $CaCO_3$ (AB “Eksparas”), additionally ground for 5 min at 900 rpm in vibrating disc “Pulverisitte 9” mill and calcined at a temperature of 900 °C for one hour. Activity of theobtained calcium oxide is 99.7%
- Quartz sand (Anykščiai), activity >98.4%. Quartz sand grinded for 25 minutes at 900 rpm.
- Granite cutting waste. Determined composition of waste: 55.8% of SiO_2, 14.7% of Al_2O_3, 6.84% of $CaCO_3$, etc.

Composition of 1 mixture	
SiO_2	0,8383 g
CaO	1,1617 g
Composition of 2 mixture	
SiO_2	0,7834 g
CaO	1,1429 g
Granite c. w.	0,0736 g

Hydrothermal synthesis

- Unstirred suspension autoclave
- Solution/solid ratio – 10.
- 200 °C.
- Duration – 16 h; 72 h.
- Products rinsed with acetone and filtered.
- Vacuum-drying at 50 °C for 24 h.

RESULTS

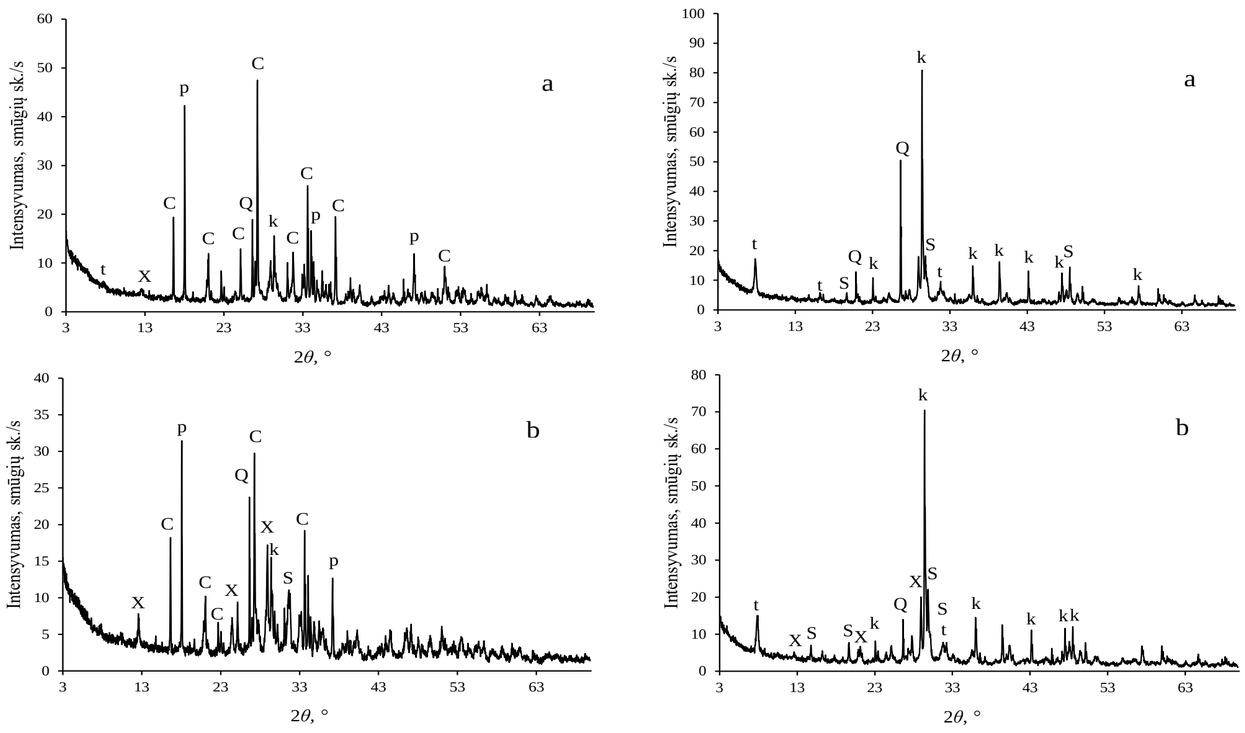

Fig. 1 XRD patterns of synthesis products formed in first mixture after hydrothermal treatment for 16 h (a) and 72 h (b). Indexes: C – α-C_2SH; Q - SiO_2; p – $Ca(OH)_2$; k - $CaCO_3$; t – tobermorite; X – xonotlite; S – scawtite.

Fig. 2 XRD patterns of synthesis products formed in second mixture after hydrothermal treatment for 16h (a) and 72h (b). Indexes: Q - SiO_2; k - $CaCO_3$; t – tobermorite; X – xonotlite; S – scawtite.

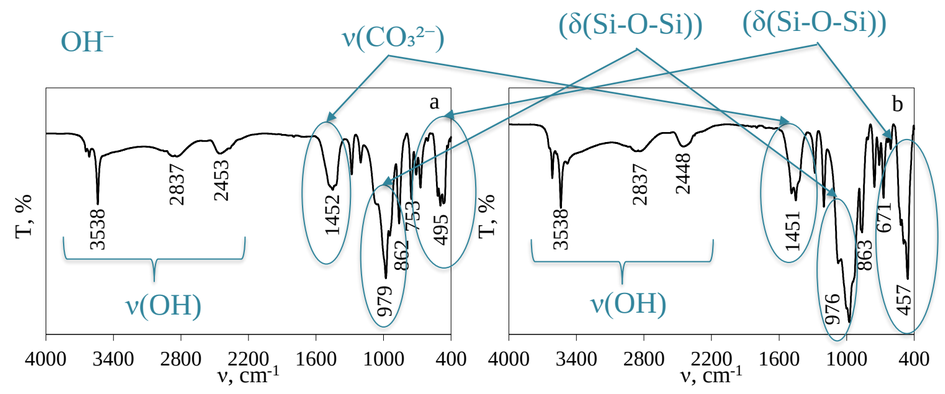

Fig. 3 FT-IR spectrum of synthesis products formed in first mixture, when duration of hydrothermal treatment was 16 h (a) or 72 h (b).

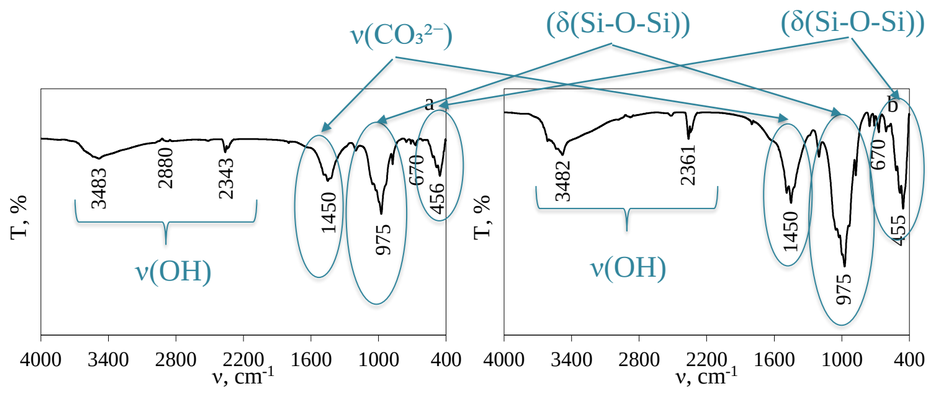

Fig. 4 FT-IR spectrum of synthesis products formed in second mixture, when duration of hydrothermal treatment was 16 h (a) or 72 h (b).

- First of endothermic effect shows recession of absorption water.
- Fission of portlandite and dehydration of α - C_2SH is displayed by second endothermic effect.
- Third endothermic effect is characteristic of carbonization of calcium carbonate.
- α - C_2SH recrystallization into wollastonite is defined by fourth, exothermic, effect.

Fig. 6 TGA (1 c.) and DSK (2 c.) curves of synthesis products formed in first (a, b) and second (c, d) mixtures, when hydrothermal treatment duration was 16 h (a and c) and 72 h (b and d).

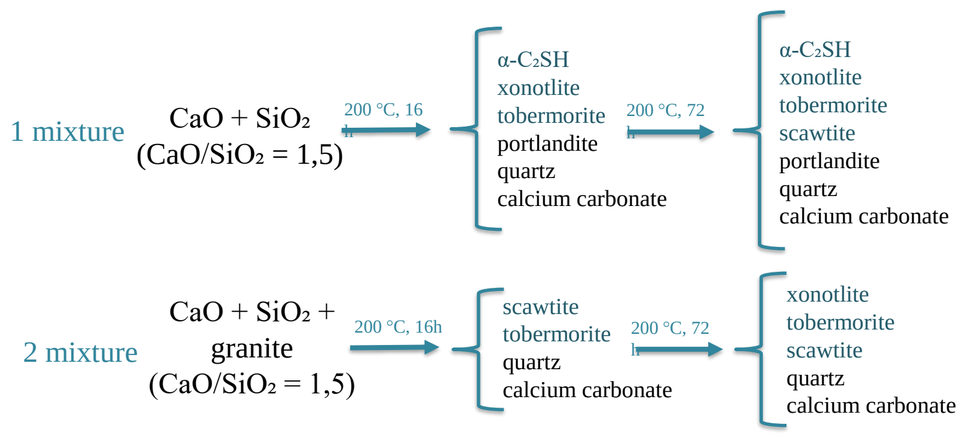

Fig. 5 Sequence of compound formation after hydrothermal treatment.

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