Use of Angren granite in production of facing and flooring ceramic tiles

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The ceramic industry takes one of the main places in the infrastructure of the national economy of Uzbekistan and development of ceramic products with enhanced properties on the basis of new raw materials is important. The aim of the present research work is to investigate the possibility of using Angren granite as fluxing agent in production of facing and flooring tiles and glaze.

The deposit of the granite is located in the district of Angren, Tashkent region (Uzbekistan). The Angren granite is light pink, hard, and tough igneous rock formed from magma. The granite samples were collected from four different places and subjected to chemical analysis. The chemical composition of the Angren granite is averaged as follows (wt.%): SiO_2 – 74.72-75.88; Al_2O_3 – 12.62-13.27; Fe_2O_3 – 1.60-2.62; MgO – 0.40-0.49; CaO – 0.22-0.40; Na_2O – 3.26-3.40; K_2O – 4.21-4.26; L.o.I. – 0.80-1.21. The XRD analysis showed that it mainly consists of microcline, albite, quartz and negligible amount of pyroxene, biotite, and augite.

The different compositions for facing and flooring ceramic tiles were prepared by wet milling the raw materials (kaolin, grog, bentonite, clay and granite) using ball mill for 10 h. To obtain powders suitable for shaping, the slips were sieved to pass through 200 mesh and dried overnight in an oven at 110°C. The test specimens were prepared by adding water to the dried powders, followed by semi-dry pressing at 30 MPa. After drying at 100°C for 24 h, the specimens were sintered at temperature ranging from 800 to 1100°C for 1 h in an electric furnace at heating rate of 5°C/min and cooled naturally. The linear shrinkage, bulk density, apparent porosity, water absorption, bending and compressive strength of the sintered specimens were determined according to ASTM standard methods. The experimental results showed that the sample for facing tile with the composition of 70 wt.% kaolin, 5 wt.% grog, 5 wt.% bentonite and 20 wt.% Angren granite and the sample for flooring tile with the composition of 60 wt.% kaolin, 5 wt.% grog, 5 wt.% clay, 5 wt.% bentonite and 25 wt.% Angren granite sintered at 1000°C showed the highest mechanical properties as follows (facing/flooring): linear shrinkage – 3.85/2.0%, bulk density – 2.16/2.13 g/cm^3, apparent porosity – 11.2/10%, water absorption – 12.83/3.66%, bending strength – 25.80/29.63 MPa

and compressive strength – 45.89/54.24 MPa. The phase evolution during sintering process of the specimens was characterized by X-ray diffraction (XRD) and scanning electron microscopy (SEM). The sintered specimens for facing tile contain mullite, cristobalite and quartz and for flooring tile contain mullite, anorthite and wollastonite crystals embedded in the glassy matrix.

Glaze is a functionally important layer for ceramic tiles and its quality mainly depends on the formation of fine crystallized phases. We have also investigated the influence of the Angren granite on the properties of the glaze for ceramic tiles by varying its amount ranging from 30 to 50 wt% in the composition with quartz sand, dolomite, disodium tetraborate and ZnO. The frits were melted in an electric furnace at 1350°C and quenched in distilled water. The frits were ground in a ball mill with addition of water to obtain glaze slurry. The glaze slurry was applied in layers of 0.5 mm thickness over previously engobed tiles, dried and sintered at 900°C for 30 min. The results showed that the Angren granite had a considerable effect on mechanical properties of glaze and the sample with the composition of 50% granite, 20% sand, 15%disodium tetraborate, and 5% ZnO and 10% dolomite have the highest values for the following mechanical properties: softening temperature – 550°C, temperature expansion coefficient – 58.2 × $10^{-7}C^{-1}$, reflection index – 58, lustre – 23.0, density - 2.794 g/cm^3, elasticity – 7.8 kg/m^3, chemical resistance – 99,92% in 20% HCl and 99,91% in 2 N NaOH. Increase in density, elasticity and strength and decrease in softening temperature, apparent porosity, thermal expansion coefficient, reflection index, luster, thermal and chemical resistance were observed with increasing amount of the Angren granite. The major formed phases in the glaze are diopside ($MgCaSi_2O_6$) and wollastonite ($CaSiO_3$).

As a final remark, Angren granite has a positive effect on mechanical properties of specimens for facing and flooring tiles as well as glaze. Traditional fluxing agents can be replaced by the Angren granite to obtain ceramic tiles for different assignments as well as glaze for low temperature sintering.