CHEMICAL AND MINERALOGICAL CHARACTERIZATION OF VOLCANIC GLASS (PERLITE) FROM REPUBLIC OF MACEDONIA

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Abstract: Characterization of the volcanic glass (perlite) from Bitola region (Republic of Macedonia) was performed by the chemical, XRPD, IR and SEM analyses. The chemical analysis shows that the volcanic glass (perlite) represents an acidic volcanic rock with high percentage of SiO_2 (72.45%), high percentage of alkali metal oxides (4.21% K_2O, 3.56 % Na_2O), and loss on ignition 3.54%. Results of the XRPD analyses indicate the presence of the amorphous phase with small presence of crystalline phases (feldspars, quartz, cristobalite and magnetite). SEM examinations point to the glassy structure with presence of pores with 50-100 µm in size.

Key words: perlite, volcanic rocks, X-ray, SEM

INTRODUCTION

The name perlite, originates from the term perlstein (pearl stone) that was given by German petrologists in the nineteenth century, to certain rhyolitic, glassy rocks with numerous concentric cracks which on fragmentation yielded pieces vaguely resembling pearls (Evans, 1993) perlite was originally identified by its vitreous, pearly luster and characteristic curved (onionskin texture) perlitic fractures (Breese, 1984; Kogel, 2006; Koukouzas, 1998). Perlite is one of the natural volcanic aluminosilicate glasses (rhyolitic rock) which has formed by rapid cooling of viscous lava or magma (Breese, 1984; Kongkachuichay, 2006) -. Upon heating (760-1100 ˚C), perlite is known to expand up to 20 times its initial volume, while increasing the porosity and decreasing the density. The main components of perlite are the following oxides, SiO_2 (70-75%), Al_2O_3 (12-18%) as well as K_2O and Na_2O, other oxides such as Fe_2O_3, CaO, MgO, TiO_2, however in smaller quantities (Burriesci et al., 1985; Gifkins et al., 2015; Gürtürk et al., 2015; Jing et al., 2011; Oktay & Odabaş, 2017; Kabra et al., 2013; Kaufhold et al, 2014; Kolvari et al, 2015; Roulia et al., 2005; Varga et al., 2015; Varuzhanyan et al., 2006). The aim of this study is to perform the chemical and mineralogical characterization of volcanic glass (perlite) from the Republic of Macedonia.

METHODS

The raw material subject of this research is taken from Bitola region (Republic of Macedonia). The samples are characterized with a white to greyish colour, with fine grains, with clearly visible phenocrysts. The chemical composition of perlite is determined by the classical silicate analysis. The characterization from the mineralogical point of view was performed by X-ray powder diffraction (XRPD), thermal analysis (TGA/DTA), scanning electron microscopy (SEM) and infrared spectroscopy (IR).

RESULTS

Perlite represents a white to light grey material, with clearly visible black particles of glass, with a specific gravity ranging from 2.23 – 2.40, and hardness of the samples from 4.20-5.30. Based on the results of the chemical composition, the raw material represents an acidic volcanic rock with high percentage of SiO_2 (72.48%), and high percentage of alkali metal oxides (K_2O and Na_2O) which are present with 4.21% and 3.56% respectively. Results of the XRPD analysis of perlite depicts amorphous behaviour of the sample manifested by the appearance of one complex “bump” widely distributed between 15 and 30° (2θ) with the maxima peaking in the 22–26.7° (2θ) range, which is a result of the high percentage of aluminosilicate glass phase in which are small amounts of crystalline phases. The crystalline phases are mainly represented by the presence of feldspars (plagioclase and orthoclase). In smaller quantities compared to feldspars evident is the presence of SiO_2 polymorph modifications: quartz (2θ - 26.674°) and cristobalite (2θ - 21.946°), as well as the presence of magnetite. The IR spectrum of perlite exhibits absorption bands at 786 cm^{-1} as result of the stretching vibrations of Si-O-Si band, whereas the band at 1078 cm^{-1} is a result of the stretching vibrations of Si-O-Al. The band at 1644 cm^{-1} is due to stretching and bending vibrations from the absorbed water, while the band at 3650 cm^{-1} is due to the combination of OH stretching. On the SEM microphotograph is clearly visible the fluidal character in the glassy mass (Fig. 1a) and the compactness glass mass of perlite, with presence of some pores, as well as tiny crystals (Fig.1b).

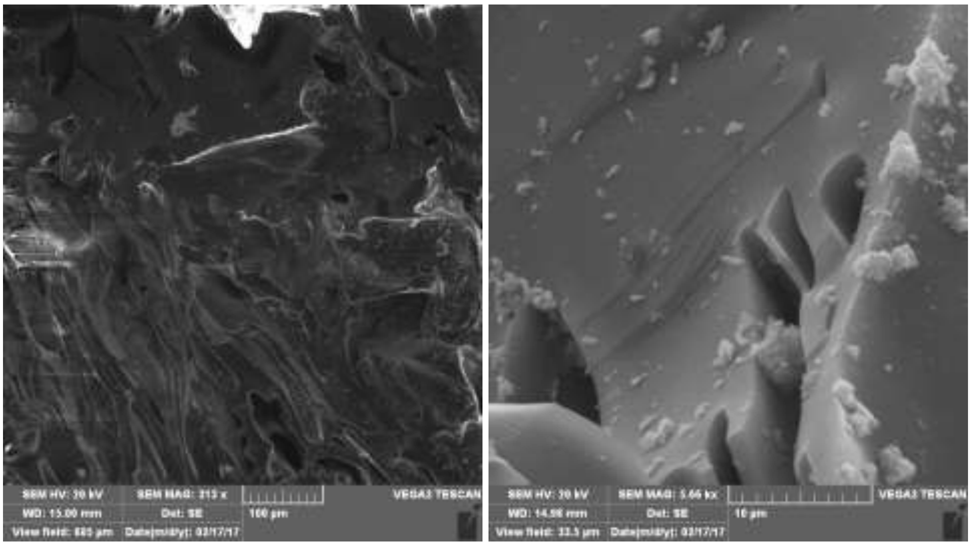

Figure 1. Scanning electron microscopy of natural perlite a) The fluidal character in the glassy mass b) The compactness of the glassy mass of perlite, and the presence of tiny crystals

DISCUSSION

- The chemical analysis of the volcanic rock shows that the raw material represents acidic volcanic rock, with the high percentage of SiO_2 (72.48%), while the presence of Al_2O_3 is 13.52%. The presence of K_2O and Na_2O is 4.21% and 3.56% respectively.
- Results from the XRPD examinations suggest high percentage of amorphous phase, where the presence of the crystalline phases is minimal. The crystalline phase is mainly composed of feldspars, SiO_2 polymorphs (quartz and cristobalite), and the minor amount of magnetite and biotite.
- The results from the light microscopy confirm the results obtained from the XRD analysis; the volcanic rock is composed of isotropic amorphous glassy mass, in which present fine-grained particles - microlites.
- The results from the scanning electron microscopy adhere to the results from the optical microscopy. SEM pictures show the fluidal character in the glassy mass and the compactness glass mass of the perlite, with presence of some pores, as well as tiny crystals.
- The thermal analysis of perlite (DTA/TGA) show that the loss of mass during the thermal treatment is 3.80%, and this loss in mass corresponds to the average % of water found in perlite.
- The IR spectra provide valuable information regarding the presence of water and OH groups in perlite. The band at 1644 cm^{-1} is due to stretching and bending vibrations from the absorbed water, whereas the band at 3650 cm^{-1} is due to the combination of OH stretching.

CONCLUSIONS

Based on the abovementioned results, it can be concluded that the volcanic rock (perlite) due to the low presence of crystalline phase, can be used to obtain high quality expanded perlite. As result of the high percentage of alkali metal oxides, the high percentage of SiO_2, the volcanic glass (perlite) can be used as raw material for the production of container glass. The high percentage of the glassy phase, the high percentage of SiO_2 and alkali metal oxides makes this raw material an attractive for production of acid resistant glazing materials. Based on its chemical and mineralogical content, the volcanic glass can be used as ceramic flux for lowering the sintering temperature.

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