Synthesis process of forsterite refractory by Natural Serpentine

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Abstract

Mg-olivine (forsterite) is used in the manufacturing industry vastly and plays a significant role especially in refractory and foundry industry. Most principal usage of this mineral is providing of Brazen, Fe, Al, and Ti- sandy molding alloys and also Fire-brick, roof clay and Mn bearing steel. In many countries Magnesite with enstatite are blended one another and heated till 1650˚C for processing artificial forsterite. Experimental studies indicate that serpentine decomposition to forsterite in high temperature. Serpentine has been expanded in Iranian ophiolitic rocks. Testing Neyriz ophiolitic rocks shows that forsterite has been produced from heating of serpentine in 600˚C. Therefore it facilitates the usage of serpentinic rocks as primary material in refractory industry. The test results show that, Dehydration reactions on serpentine started at approximately between 100 to 150°C and dehydroxilation reactions started at approximately 550-700°C. As a result of thermal reaction the decomposition of serpentine will take place and then changing in to olivine (forsterite). Crystallization of olivine (forsterite) will start at 600°C.

Keywords: *olivine, forsterite, serpentine, refractory, XRD, DTA-TG*

1- Introduction

Refractories are defined as materials having the ability to retain their physical shapes and chemical identities when subjected to high temperatures. They are resistant to corrosive solids, liquids and gases at temperatures of greater than 1500°C. They are used to manufactures furnaces, driers, parts of jet engines, missiles and spacecraft (De Waele and Simasiku ,2002). Forsterite (Mg_2SiO_4) is a kind of main mineral phase in refractory, which has the properties of nice creep stability and high refractoriness temperature under load (Song,1978). It is a kind of thermal insulation and heat preservation refractory because its heat conductivity is low (about 1/3-1/4 of the pure MgO) (Xu and Wei, 2005). Therefore, it can be used in steel-making as drainage sand, and in casting models as metallurgy accessories (Pan.1982 Harvey et al, 1938; Birch et al, 1935). As a kind of high-temperature refractory, the products of forsterite can be used in torpedos, ladles, continuous casting tundish, non-ferrous metal smelting, glassmaking, rotrary cement kiln and so on (Mitchell et al., 1998; Pack et al.,2005). In many countries Magnesite with Enstatite are blended one another and heated till 1650˚C for processing artificial forsterite (Newman, 2006). Experimental studies indicate that serpentine decomposition to forsterite in high temperature (Frank et al, 2005). Serpentine has been expanded in Iranian ophiolitic rocks. Testing Iranian ophiolitic rocks shows that forsterite has been produced from heating of serpentine. Therefore it facilitates the usage of serpentinic rocks as primary material in refractory industry.

2- Material and Method

This work was conducted as three stages: petrographyical studies, X-ray analyses and DTA-TG analyses. In petrographical studies, mineral paragenesis and textural properties of rocks were described and classifications of Wicks and Whittaker (1977) which were later developed by O'Hanley (1991, 1996) were used. X-ray analyses of 7 samples from the Neyriz Ophiolite Complex (SW Iran) were made with Philips Xpert brand X-ray diffractometer at Iranian Mineral Processing Research Center (IMPRC) (fig.1). Before the X-ray analyses, dried samples were left in furnace for about one hour at temperatures of 200°C, 400°C, 550°C, 600°C, 650°C, 700°C, 750°C, 850°C and 1100°C. DTA-TG analyses, which give information on phase transformations in parallel to temperature increase and the amount of mass loss, were performed with NETZSCH STA 409 PC Luxx brand device. During the analyses which were conducted at temperatures between 20°C and 1100°C, temperature increasement were selected as 20°C/minute and 100 mg sample was used for the analyses.

3- Petrography

In petrographical studies, source rock of serpentines was found as harzburgite. In completely serpentinized rocks with pseudomorphic texture, serpentine ± talc ± magnetite. According to classification of Wicks and Whittaker (1977) and O'Hanley (1991, 1996) on the basis of textural features under microscope, lizardite ± antigorite and vein-type chrysotile were found in samples of pseudomorphic texture (fig .2).

4- X-Ray Analyses (XRD)

In order to determine mineralogical changes as a result of thermal reactions, samples that were heated at certain temperature were subjected to X-ray analyses (fig.3). Results of routine analyses are conformable with those of petrographic studies and lizardite was the main mineral observed. There was no mineralogical change in analyses of all samples conducted at 200°C, 400°C and 500°C while only a little decrease was observed in the lizardite abundance with temperature increase. It was observed that the lizardite abundance was continued to decrease at 550°C and olivine (forsterite) started to crystallize. At 600°C, lizardite abundance was significantly decreased and forsterite continued to crystallize and its abundance was increased. At 650°C, lizardite was mostly disappeared and forsterite continued to crystallize. In analyses performed at temperatures higher than 700°C, forsterite continued to crystallize and their abundances were increased. Considering the analyses conducted at 550°C, 600°C and 650°C, a significant amorphousization was detected.

5- DTA-TG Analyses

Thermal reactions in lizardite are developed in parallel to temperature increase and at 100°C temperature, free water in samples and absorbed water on the surface are lost due to dehydration. Examination of DTA and TG curves reveals that there is such a change in all samples at 100°C (fig.4). Lizardite peaks in all samples are observed as endothermic at 700°C and exothermic at 810°C. As shown in DTA curves, dehydroxilation was occurred at about 550°C to 700°C. As determined by the X-ray analyses, reactions associated with dehydroxilation resulted in formation of forsterite from lizardite ($Mg_3Si_2O_5(OH)_4$) at temperatures above 550°C, lizardite were lastly found at 650°C and considering the results of both DTA and XRD analyses reveal that lizardite can be stable at temperatures mostly 650°C-700°C. At temperatures higher than 700°C which defines the upper stability limit of lizardite, forsterite continued to crystallize and this new mineral formation was recorded on DTA diagrams as one exothermic peaks at around 810°C. As a result, all these mineralogical changes determined with the XRD studies are found to be conformable with DTA analyses. According to results of TG analyses, 13% mass decrease was found in samples.

6- Results and Discussion

This study indicates that serpentine decomposition to forsterite in high temperature. Serpentine has been expanded in Iranian ophiolitic rocks. Testing Neyriz ophiolitic rocks shows that forsterite has been produced from heating of serpentine in 600 ˚C. Therefore it facilitates the usage of serpentinic rocks as primary material in refractory industry. In this study, serpentine minerals were subjected to thermal treatment to investigate the upper stability limits of these minerals and resulting new mineral paragenesis. Considering the results of XRD analyses, lizardite can be stable until a temperature range of 650°C-700°C but its abundance decreases depending on reactions associated with temperature increase. In analyses at temperatures above 550°C, the amount of lizardite was further decreased and forsterite started to be formed. lizardite + forsterite association at temperatures above 550°C was continued until 650-700°C and lizardite was removed at higher temperatures. Results of DTA analyses which were conformable with X-ray determinations indicated that lizardite dehydroxilation reactions were started at 550°C and continued until 700°C. According to results of DTA analyses, endothermic peak shown at 810°C following the dehydroxilation at 700°C correspond to formation of forsterite. Examination of XRD analyses conducted at 550°C, 600°C and 650°C reveal the presence of amorphousization that is observed in all samples. The amorphousization is thought to be derived from silica that is released during the thermal reactions.

7-References

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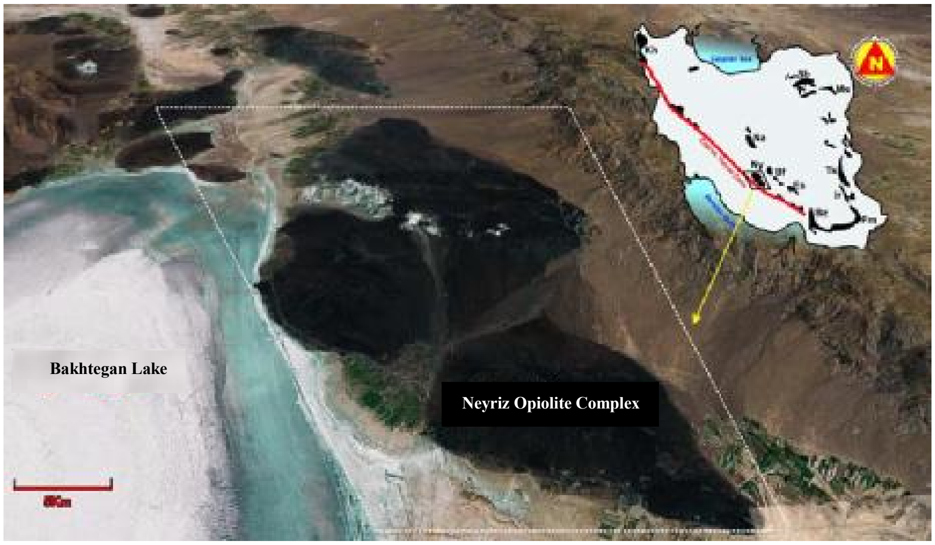

Figure 1: Landsat imagery for the Neyriz (SW Iran) and distribution of the ophiolite belts in Iran after Emami et al. (1993), Main Iranian ophiolite complexes: BZ:Band-e-Ziyarat KM:Kermanshah. NA:Nain. NY:Neyriz. SB:Sabzevar. SHB:Shar Babrak. THL: Torbat Hydariyah. TK:Tchehel Kureh.)

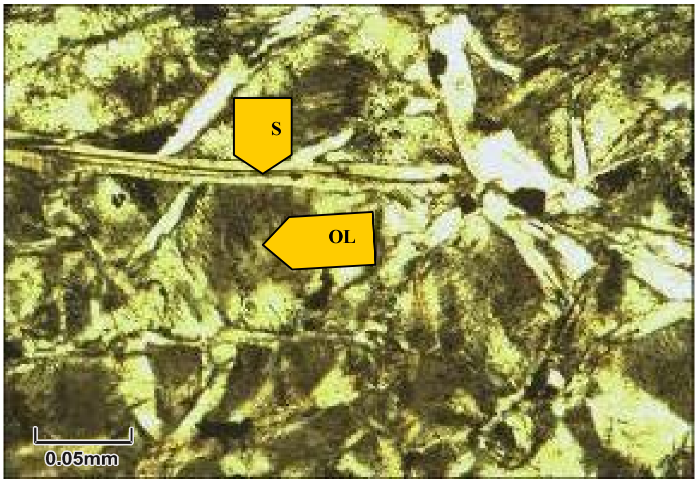

Figure.2: Microphotographs of representative magmatic rocks from the Neyriz ophiolite complex. Ol: olivine (forsteite) and S: Serpentine

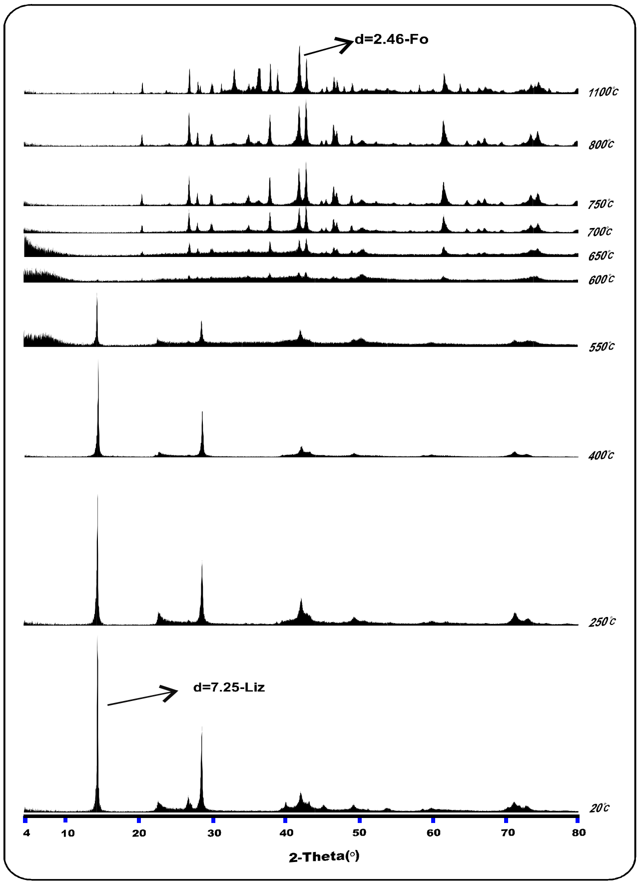

Figure 3- XRD block diagram of samples at different temperatures (Liz: lizardite, Fo: forsterite)

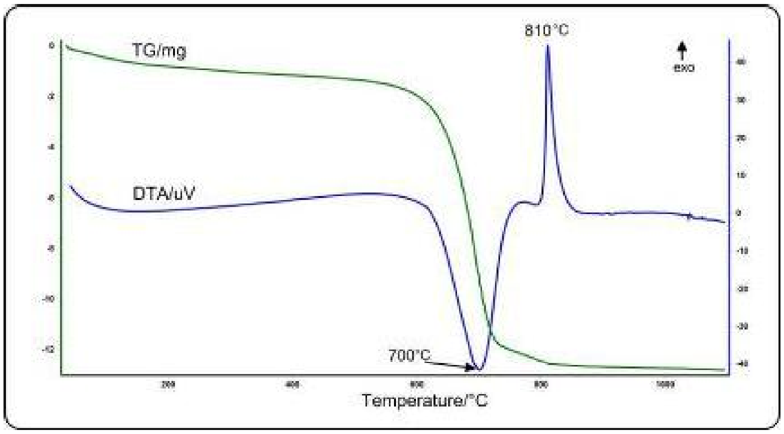

Figure 4- DTA-TG curves of samples.