Estimation and addition of MgO dose for upgrading the refractory characteristics of magnesite ore mining wastes/by-products

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Introduction

The total amount of mining wastes/by-products, due to magnesite ore enrichment processes, is estimated to more than 35x10^6 tons, being stock-pilled in the mining area, without current utilization options. The natural serpentinization process leads to the deterioration of technologically desired physicochemical properties to be used as refractory materials.

The development of an appropriate thermal treatment process with/or without the presence of additives could convert these mining wastes into refractory products with added value (e.g. firebricks, magnesium-olivine refractory metallurgical masses), leading to new economic opportunities and an effective solution for potential environmental problems (e.g. disposal).

Figure 1: "Grecian Magnesite SA" mine (Chalkidiki, N. Greece)

- The scope of this research is the estimation of necessary MgO dose for improving the refractory properties of these mining wastes, and the effects of MgO (caustic calcined magnesia) addition in ratio 5, 10, 15 wt.%, in representative samples after a thermal treatment process at 1300° C.

Results & Discussion

Based on the initial concentrations of MgO, FeO and SiO_2 and the calculated ideal molar ratio of:

([MgO]+[FeO])/[SiO_2] = 2

- Calculation of MgO dose (wt.%) for the optimization of olivine formation at 1300° C
- MgO content (wt.%) for the samples W12 and W13 are 9.3 wt,% and 15.6 wt.%, respectively.

XRD patterns with the proper addition of MgO reveal (Table 1):

- ✓ Initial samples consist mainly of olivine (forsterite) and pyroxenes (enstatite).
- ✓ The MgO addition induced the formation of magnesioferrite (~7-9%) and periclase.
- ✓ The percentage of pyroxenes (enstatite) decreased, with the increasing percentage MgO, while the percentage of olivine (forsterite) increased.
- The increase of MgO maximizes the formation of olivine (≥1300° C).
- Highest percentage of olivine and lowest percentage of pyroxenes have shown better refractory properties after thermal treatment at ≥1300° C.

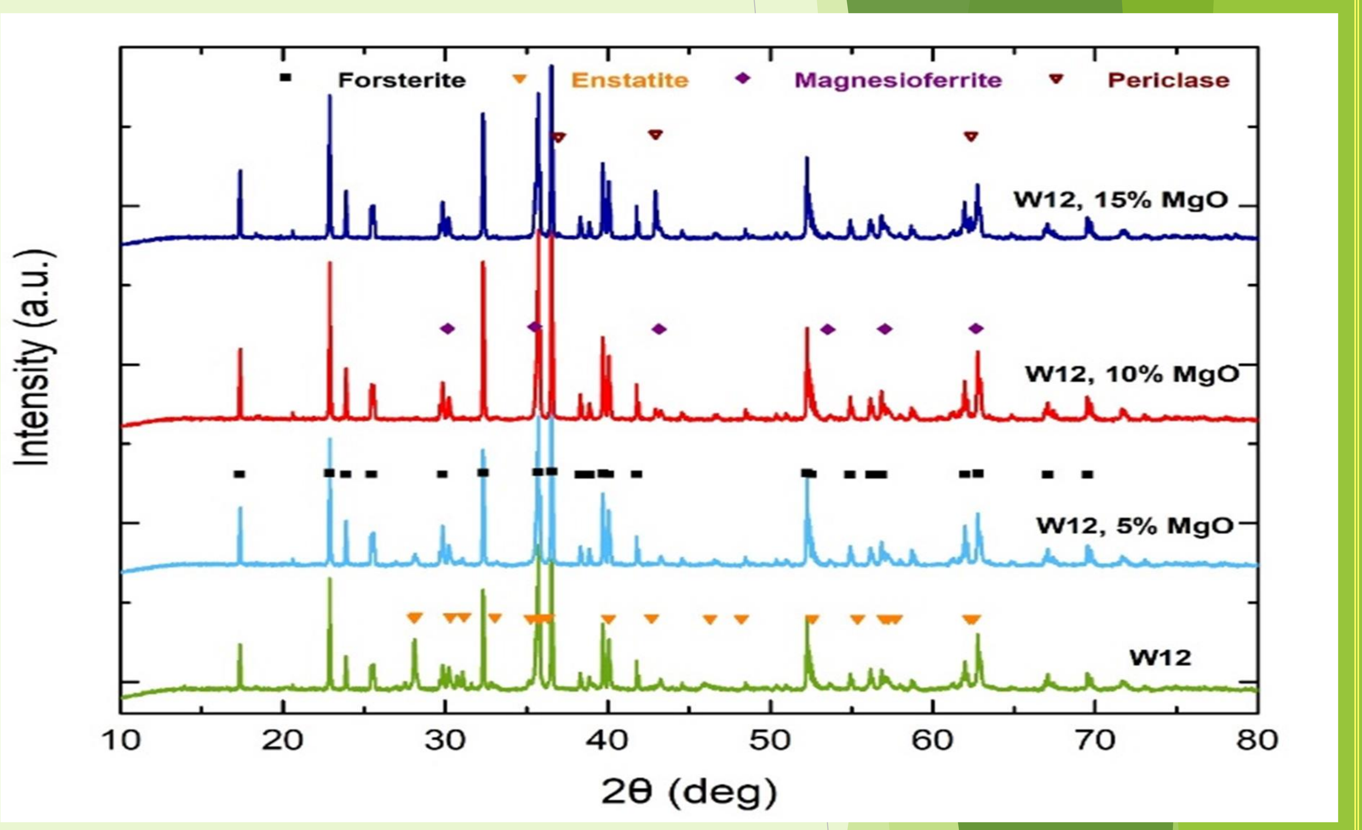

Figure 2: XRD patterns of sample W12 with the addition of 5, 10 and 15 wt.% MgO at 1300° C.

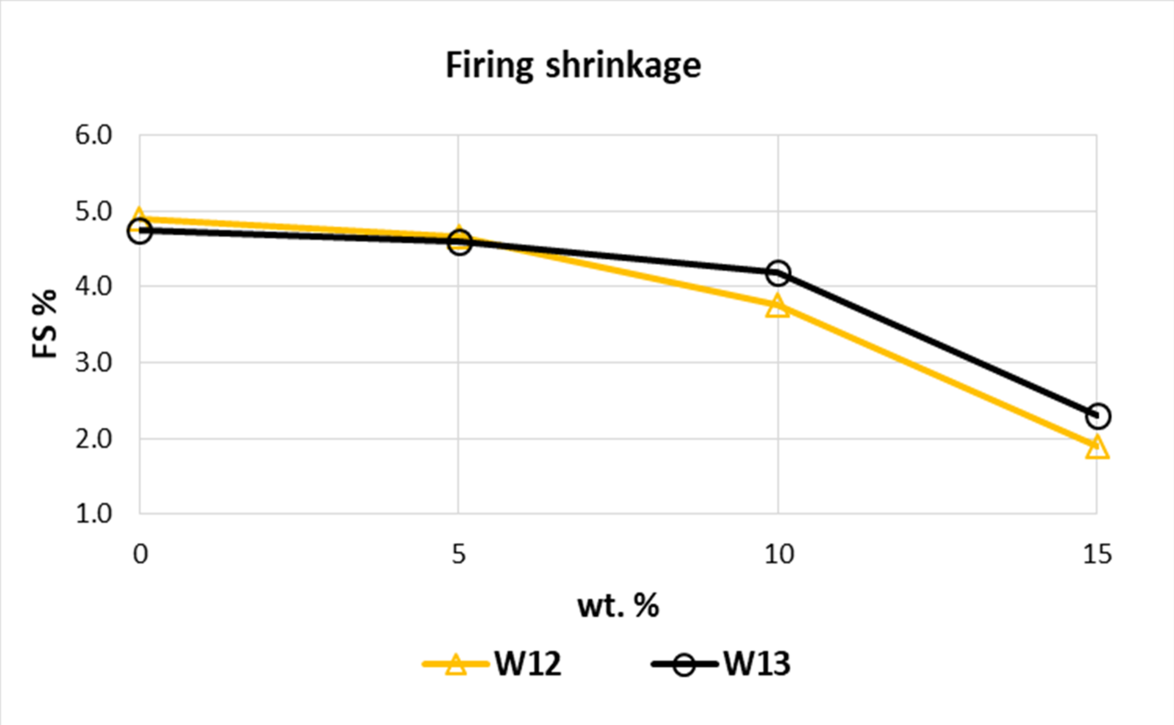

Figure 3: Firing shrinkage of samples W12 and W13 vs. the wt.% of MgO.

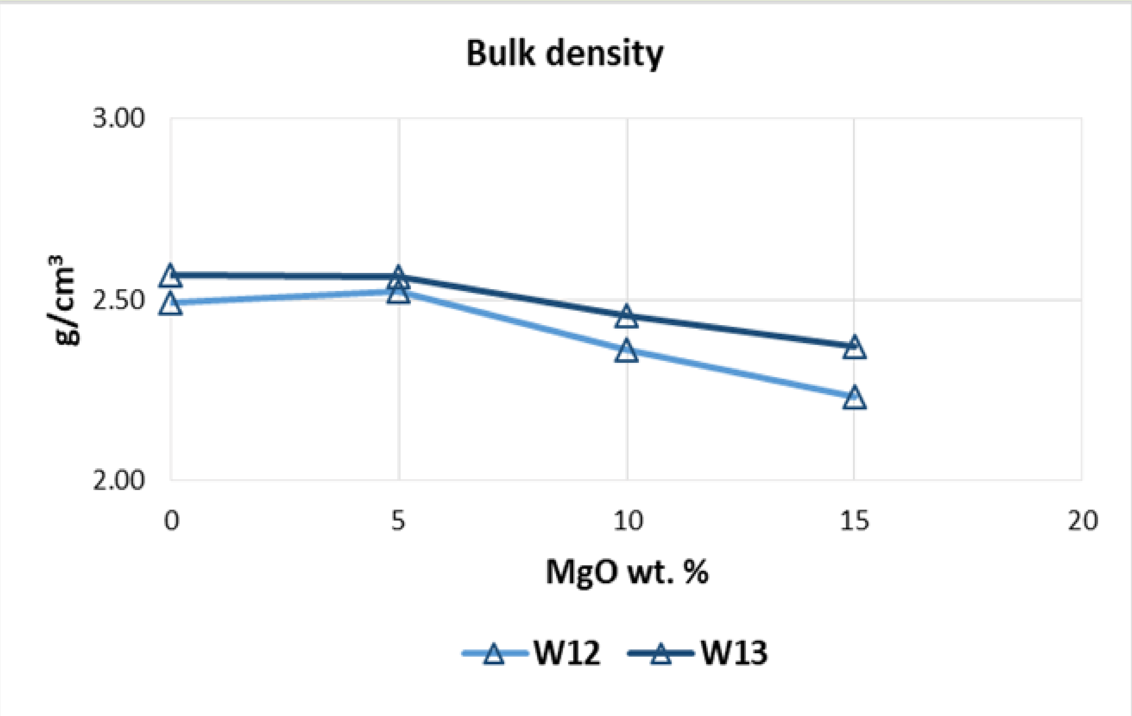

Figure 4: Bulk density of samples W12 and W13 vs. the wt.% of MgO.

Table 1. The mineralogical content (wt.%) of examined mineral waste samples with the addition of MgO after firing at 1300° C.

Sample (MgO wt.%)	Olivine (Forsterite)	Pyroxenes (Enstatite)	Magnesioferrite	Periclase
W12	66.5±4.6	33.5±2.4	--	--
W12 (5%)	84.2±5.6	7.7±0.9	8.1±0.6	--
W12 (10%)	90.3±6.4	--	8.6±0.6	1.1
W12 (15%)	85.2±5.7	--	8.2±0.6	6.6±0.6
W13	56.2±3.9	43.8±2.7	--	--
W13 (5%)	74.8±4.9	15.8±1.4	9.4±0.7	--
W13(10%)	86.2±5.8	--	7.1±0.6	--
W13(15%)	90.2±6.2	--	7.7±0.6	2.1±0.4

Firing shrinkage (FS%) levels (Figure 3) showed a decreasing trend.

- For sample W12, FS% from 4.9% (initially) decreased to 1.9% (15 wt.% MgO) and for sample W13 from 4.8% initially down to 2.3% (15 wt.% MgO).
- The formation of desired forsterite (≥1300° C) improves the refractoriness (i.e. low FS% levels), while keeping FS% in levels ≤2.5%.

Bulk density (BD) (Figure 4) showed a small decreasing trend, combined with a small increase of **apparent pororisty (AP%)** with the MgO addition, showing that fired pellets are not sintered and homogenized in that temperature and with this ratio of additives.

Conclusions

Thermal treatment in combination with MgO addition can modify the stocked mining wastes, favoring the production of useful refractory materials, improving the circular economy in the mining field, while FS% decreased in combination with increasing forsterite percentage (desired) and decreasing enstatite percentage (undesired).

Higher AP(%) values combined with lower BD values indicate that the fired products are not sintered enough by applying this temperature and using the specific percentages of examined additive (MgO).

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