Chromite mining waste valorization: ultrabasic rocks as neutralizing agent of acidic media

E. Kokkinos, V. Kotsali, E. Peleka, A. Zouboulis

Laboratory of Chemical and Environmental Technology, Department of Chemistry, Aristotle University of Thessaloniki, 54124 Thessaloniki
Keywords: chromite mining, ultrabasic rock, neutralization, acidic media
Presenting author email: zoubouli@chem.auth.gr

Chromite, a critical raw material, occurs within ultrabasic rocks, mainly dunitic, such as serpentine, olivine, pyroxene (Saveliev and Fedoseev, 2019). Enrichment processes, initially, aim in chromite separation from these rocks and, as a result, a vast amount of waste are produced. Storage in piles is the dominant management method in order to be used for landfilled restoration. On the other hand, environmental issues may arise since inertness in many cases is under question, so their constant monitoring considered to be mandatory (Nayak et al., 2020). The valorization of these ultrabasic rocks in other applications, in the framework of sustainability and circular economy, have already been attracted the attention of the scientific community. Acid mine drainage neutralization (Gerogianni et al., 2015), additive in ceramics (Emami et al., 2017) and carbon dioxide storage (Molahid et al., 2022) are some of the proposed alternatives. Aim of this study was the chemical and structural characterization of an ultrabasic rock sample obtained from a chromite mining area and, subsequently, its valorization as a neutralizing agent of an acidic media.

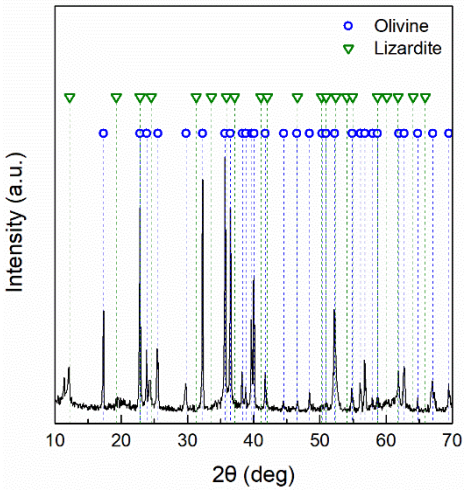

Figure 1. XRD diagram of the reference ultrabasic rock waste.

This study was carried out with samples collected from the Vourinos area in Kozani region (Western Macedonia, Greece), where chromite mines and the enrichment mineral plant are located. Initially, the samples were grinded by a ball mill, homogenized and sieved (<100 μm). The main structural phases were identified by X-Ray Diffractometry (XRD), using a water-cooled Rigaku Ultima+diffractometer with CuKa radiation, a step size of 0.05° and a step time of 3 s, operating at 40 kV and 30 mA. The diffraction patterns were compared to the respective Powder Diffraction Files (PDF) database. Chemical analysis was conducted by acid digestion of the sample and the concentration of metals was determined by Flame Atomic Absorption Spectrophotometry, using the Perkin-Elmer AAnalyst 800 instrument. For neutralization experiments, 1-6 g of the sample was placed in a conical flask and 50 mL of 0.01M H_2SO_4 was added. Then, the flask was placed on a rotary shaker for 30 min. Afterwords, the solution was filtrated, and the pH of the aquatic phase was measured.

Table 1. Chemical analysis of the reference ultrabasic rock waste.

Metal	**Fe**	**Mg**	**Si**	**Na**	**Mn**	**Ca**	**Cr**
%	5.1	24.9	20.2	0.8	0.08	0.06	Not detected

According to the XRD diagram of the reference ultrabasic rock, both olivine [$(Mg,Fe)_2SiO_4$] and serpentine [$(Mg,Fe)_3Si_2O_5(OH)_4$], as lizardite, were included in its structure (Acar, 2020). As it is concluded by

their formulas, serpentine is hydrous structures of olivine. The main metals that compose these structures, i.e., Fe, Mg and Si, were verified by the chemical analysis (Table 1). In addition, Cr was not detected. The resulting percentage content did not correspond to their ratio according to the formulas; therefore, the presence of oxides was not excluded.

The neutralizing of the acid media (pH ~1) was achieved rapidly, within 30 min, when 5 g of the ultrabasic rock waste was applied. Further increase of waste's weight was also increase the alkalinity of the solution. In addition, only 1 g of the sample was enough in order to obtain a high increase in pH value (4.56) and, then, the rate of increase was almost linear.

Based on the results of this work, it was concluded that ultrabasic rock waste from chromite mining was free of chromium which limits the risk of secondary contamination when using it in other applications. Moreover, its valorization as a neutralizing agent was achieved since the acid media reached an alkaline pH value after implementation. This considered to be the first step of the waste's evaluation in order to be used in real acidic waste, i.e., acid mine drainage.

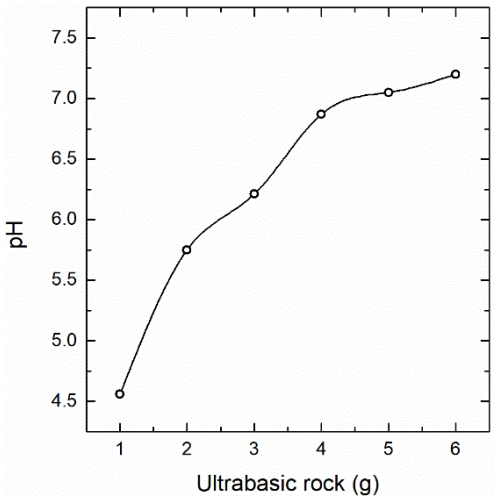

Figure 2. Neutralizing the acidic media by adding different weight of ultrabasic rock waste.

References

Saveliev, D.E.; Fedoseev, V.B. Solid-state redistribution of mineral particles in the upwelling mantle flow as a mechanism of chromite concentration in the ophiolite ultramafic rocks (By the example of kraka ophiolite, the Southern Urals). Georesursy 2019, 21, 31-46. doi:10.18599/grs.2019.1.31-46.

Nayak, S.; Rangabhashiyam, S.; Balasubramanian, P.; Kale, P. A review of chromite mining in Sukinda Valley of India: impact and potential remediation measures. Int. J. Phytoremediation 2020, 22, 804-818.

Gerogianni, N.; Magganas, A.; Stamatakis, M.; Pomonis, P. Effectiveness of Olivine-Rich Ultrabasic Rocks from Greece on Acid Mine Drainage and Dairy Wastewater Treatment. In Proceedings of International Conference IWWATV, Athens, Greece, 21-23 May 2015.

Emami, S.M.; Ramezani, A.; Nemat, S. Sintering behavior of waste serpentine from abdasht chromite mines Abdasht chromite mines and kaolin blends. Ceram. Int. 2017, 43, 15189-15193. doi:10.1016/j.ceramint.2017.08.051.

Molahid, V.L.M.; Kusin, F.M.; Hasan, S.N.M.S.; Ramli, N.A.A.; Abdullah, A.M. CO_2 Sequestration through Mineral Carbonation: Effect of Different Parameters on Carbonation of Fe-Rich Mine Waste Materials. Processes 2022, 10, 432. doi:10.3390/pr10020432.

Acar, İ. Sintering properties of olivine and its utilization potential as a refractory raw material: Mineralogical and microstructural investigations. Ceram. Int. 2020, 46, 28025-28034. doi:10.1016/j.ceramint.2020.07.297.

Acknowledgments

This research has been co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE (project code:T2EDK-02206).