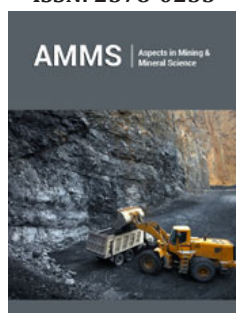


Serpentinite Rocks of Uzbekistan: A Promising Raw Material for Refractories

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Opinion

The modern development of ferrous and non-ferrous metallurgy, the chemical industry, as well as the production of ceramic, glass, and construction materials imposes increasingly stringent requirements on the quality and service life of refractory products. Under exposure to high temperatures, aggressive slags, and severe thermal shocks, refractories must exhibit high refractoriness, thermal shock resistance, corrosion resistance, and slag resistance. According to their chemical-mineralogical nature, refractory materials are classified as acidic (silica-based), basic (magnesia-based), neutral (alumina-, chromite-based, etc.), and special materials (carbon-, zirconia-containing) [1]. The selection of a specific refractory type is determined by slag composition and basicity, the temperature-time regime of the process, and the nature of thermo-mechanical loads. When operating with basic slags at high temperatures, MgO-containing refractories are of particular importance due to their enhanced slag resistance and property stability [2].

Raw materials for the production of forsterite refractories include olivine-bearing rocks, serpentinites, dunites, talc, and other magnesia-silicate rocks [3]. Among them, serpentinites are considered one of the most promising feedstocks; they are hydrated magnesium silicates with the general composition $(\text{Mg, Fe})_3\text{Si}_2\text{O}_5(\text{OH})_4$. In terms of crystal structure, serpentine-group minerals are complex layered formations built by alternating octahedral and tetrahedral sheets. The serpentine group comprises three main varieties-chrysotile, lizardite, and antigorite-which differ in crystal lattice type and particle morphology, and these differences largely determine their practical applications [4-6]. Until now, the needs of industrial enterprises of the Republic for refractory materials have been met through supplies from foreign countries.

This paper presents the results of determining the potential of serpentinite rocks from several deposits in the Republic of Uzbekistan for the production of refractory materials. Serpentinite is a green and greenish-gray metamorphic rock composed of serpentine ($\text{H}_2\text{Mg}_3\text{Si}_2\text{O}_9$), antigorite, and chrysotile. It may also contain small amounts of chromium spinelide, magnetite, brucite, magnesium carbonates, talc, chlorite, and other minerals. The rock's hardness ranges from 2.5 to 4.0 on the Mohs scale. The serpentinites of the Arvaten deposit are located in the Gallyaaraal district of the Jizzakh region, in the Northern Nurata mountains. Depending on the location, the serpentinite deposit ranges in color from dark green to black, or less commonly, greenish-gray and gray. The rocks are overlain by quartzite and, in part, diabase minerals. Estimated reserves of serpentinite minerals at the Arvaten deposit, based on geological data, amount to 1,363,700 cubic m³.

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The serpentinites of the Kutchinsk deposit are located in the Zirabulak Mountains of the Samarkand region of Uzbekistan [7,8]. The rocks of this deposit are gray and greenish-gray in color. The largest rock occurrence is located at the eastern end of the deposit, a mound shaped like an equilateral triangle measuring 200 meters and approximately 30-35 meters high. In terms of mineralogical phase composition, the groundmass consists of serpentine (80-90% by weight) and trace ore minerals (approximately 7-8% by weight). In addition, a small amount of amphibole is occasionally encountered. The Sultan Uvays serpentinite deposit is located in the Sultan Uvays Mountains of the Beruni district of the Republic of Karakalpakstan and ranges in color from light to dark green [9,10]. The Sultan Uvays deposit's serpentinite reserves are estimated at 5.0 million tons. The mineralogical composition is dominated

by serpentine minerals, with minor amounts of quartz and other minerals, the contents of which are very low.

The results of chemical composition determinations for the studied and imported (for comparison) serpentinite rocks are presented in Table 1. As can be seen from (Table 1), the amounts of the main rock-forming components-magnesium, aluminum, and iron oxides-of the domestic serpentinites are relatively close to those of the Shorzha (Armenia) and Shuran (Kyrgyzstan) serpentinites, but differ slightly from those of the Bazhenov (Russia). It should be noted that forsterite refractories (MgSiO_4) occupy a special place among high-temperature refractory materials and products. They have specific characteristics and chemical and mineralogical compositions, and their structure corresponds to magnesia-silicate refractories.

Table 1: Results of chemical analysis of domestic serpentinites and their comparison with imported ones.

Serpentinite Deposit	Content of Main Oxides, wt. %								
	MgO	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	CaO	Na ₂ O	K ₂ O	SO _{3обм.}	п.п.п
Arvaten	38,51	37,90	7,54	2,01	2,19	0,85	0,12	0,34	10,45
Kutchi	37,95	37,01	7,27	2,59	1,91	0,08	0,04	0,61	12,43
Sultan Uvays	38,04	39,34	6,38	1,60	1,41	0,18	0,10	0,23	12,31
Bazhenov	40,98	40,14	2,80	1,40	0,01	0,02	0,05	0,47	13,53
Shorzzhins	36,40	38,20	6,72	1,96	3,40	0,15	0,03	0,43	12,61
Shurane	39,98	39,12	5,62	2,15	1,95	0,65	0,10	0,35	10,86

Furthermore, the quality of natural magnesia raw materials for the production of magnesia, particularly forsterite, refractories are also additionally assessed by the modulus values: magnesia-silicate MgO/SiO_2 and magnesia-ferrous $\text{MgO}/(\text{FeO}+\text{Fe}_2\text{O}_3)$ (Table 2). The obtained results of the study showed that the chemical and mineralogical composition, as well as the values of the MgO/SiO_2 and $\text{MgO}/\text{Fe}_2\text{O}_3$ modules, have similar values compared to imported serpentinites, which are currently widely used for the production of magnesia refractory materials.

Table 2: Serpentinite modulus values and melting points.

Serpentinite	Serpentinite Modulus Value		Melting Point T, °C
	MgO/SiO ₂	MgO/(FeO+Fe ₂ O ₃)	
Serpentinite (standard)	1,00	4,40	1450-1550
Arvaten	1,01	5,10	1530
Kutchi	1,03	5,22	1550
Sultan Uvays	0,97	5,96	1460

Among these, the most promising are the serpentinites of the Arvaten deposit; they are fine-grained, massive rocks ranging in color from gray to greenish-gray. At the contact zone with schists within the deposit, serpentinite rocks grading into talc are observed in places. The total thickness of this altered zone does not exceed 8-10m on the northern side and 5-7m on the southern side. The process of talc formation diminishes over time, resulting instead in the foliation (schistosity) of the serpentinite rocks. In

the center of the northern part of the Arvaten deposit, a contact between serpentinite and vein quartz-reaching a thickness of up to 1.5m-is observed; notably, talc formation in the serpentinite is minimal at this contact. Several areas within the deposit contain rocks that appear dark gray but are classified as serpentinites. Rocks containing feldspar grains (up to 5-7mm in size) exhibit color variations ranging from red to pale pink. According to geological studies [11,12], virtually all rocks in the deposit-including diabases and amphibole-epidote schists-are suitable as raw materials for stone casting.

The serpentinites of the Arvaten deposit consist primarily of the mineral serpentine (80-90wt.%) and ore minerals (7-8wt.%), along with minor amounts of amphiboles. The rock exhibits a blastoporphyratic, heterogeneous structure with transverse or cross-fiber textures. The serpentine mineral itself occurs in several morphological varieties, specifically fine-fibrous, platy, and disseminated forms. In all these varieties, the serpentine grains are elongated, differing in size and mutual orientation. Small amounts of fine-grained magnetite occur within the serpentine aggregates; this magnetite is associated with the formation of the magnesian mineral olivine in the parent rock. The ore minerals form somewhat rounded, elongated, and discontinuous grains or chains, as well as dust-like inclusions that often mirror the outlines of the primary mineral. The rock is transected by discontinuous micro-fractures that are not always clearly discernible. Iron hydroxides are typically associated with a system of minute, discontinuous quartz micro-veinlets.

The mineralogical composition of the studied Arvaten serpentinite samples was determined using X-ray phase analysis; the results are presented in the Figure 1. The X-ray diffraction patterns reveal peaks corresponding to the rock-forming minerals of the serpentinite-specifically serpentine (up to 85wt.%) -with d-spacings of 0.738, 0.478, 0.357, 0.285, and 0.253. 0.243; 0.216nm),

as well as fine-grained magnetite ($d=0.478; 0.296; 0.253; 0.243\text{nm}$). In addition, quartz, chlorite, and talc are present as minor minerals. Melting point determinations for the serpentinite samples yielded values ranging from 1260 to 1275 °C; this melting temperature range is likely attributable to the material composition-specifically, the heterogeneity of the original natural mineral rock.

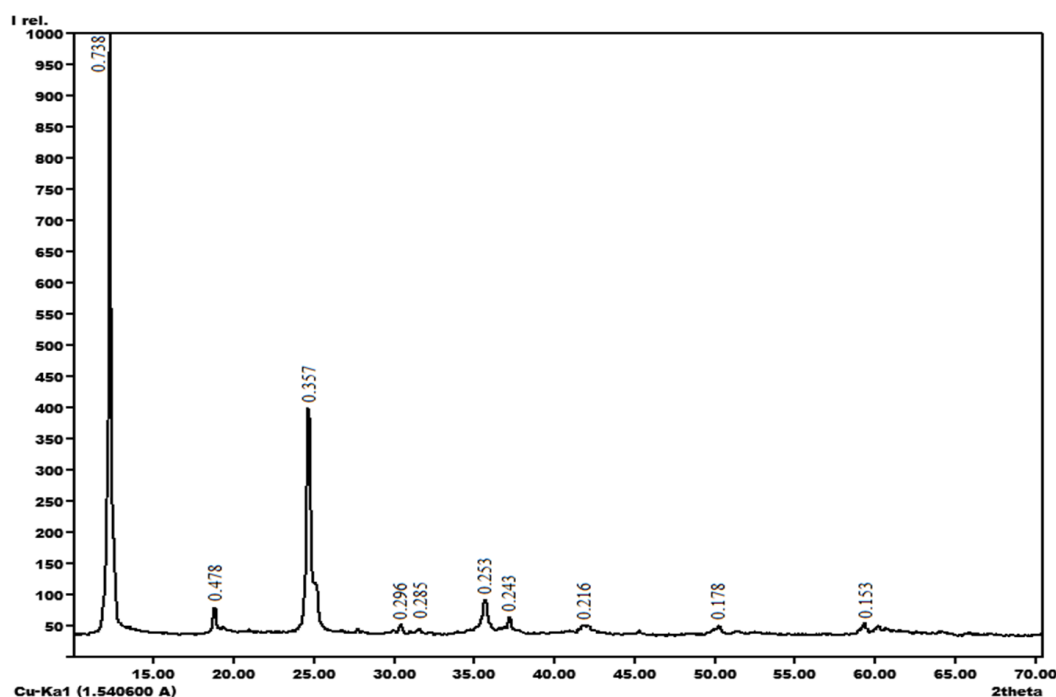


Figure 1: X-ray diffraction pattern of an Arvaten serpentinite sample.

Conclusion

Thus, the results of determining the chemical and mineralogical composition, MgO/SiO_2 and $\text{MgO}/\text{Fe}_2\text{O}_3$ total modulus values, and the morphology of serpentinite minerals from the Arvatin, Kutchin, and Sultan-Uvai deposits in Uzbekistan demonstrate that they can be used in both unprocessed and processed forms to produce magnesite refractory materials with forsterite and magnesioferrite compositions. Furthermore, given the potential and favorable infrastructure of the aforementioned serpentinite deposits, they can be recommended as the primary natural magnesite raw material for the production of magnesia-silicate refractory materials for various functional purposes.

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