PETROGRAPHIC ANALYSIS OF LOW-CARBON FERROCHROME SLAG

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ABSTRACT

Mineralogical composition of low-carbon ferrochrome slags was studied by means of petrographic analysis. Ferrochrome was produced with ferrosilicoaluminum used as a reductant. Petrographic analysis of slags indicates the presence of helenite in various forms. Isolated impregnations of melilite, larnite and vitreous phase are distinctly separated which proves the possibility of their separation from helenite phase in further processing.

Complex processing of industrial wastes is an important part of development in ferroalloys production. One of examples of such approach is an extraction of alumina from ferroalloy slags with high content of aluminum oxide. In case of substitution of ferrochrome silicon (used as a reductant in low-carbon ferrochrome production) for less expensive ferrosilicoaluminum, made of industrial wastes, it is possible to have a slag with a near-helenite phase composition. Previous researches have shown that the content of alumina in such slag can be as high as 29%. According to our estimation, the slag would have high concentration of helenite ($2CaO \cdot Al_2O_3 \cdot SiO_2$). The results of the research work described in the paper are of certain interest for new methods of ferrochrome production with complex processing of secondary raw materials, such as ferrochrome slags.

It was concluded in the work [1] that helenite slag containing more than 25% of Al_2O_3 is a convenient raw material source for the production of alumina or construction materials by means of hydrochemical alkali treatment.

In order to confirm the calculations we have carried out a petrographic analysis of mineralogical composition of a low-carbon ferrochrome slag. Ferrochrome was produced with ferrosilicoaluminum used as a reductant instead of ferrochrome silicon, which explains substantial amount of various forms of helenite revealed by petrographic analysis. Isolated impregnations of melilite, larnite and vitreous phase are distinctly separated which proves the possibility of their extraction in further processing. The results of the research on application of complex silicon-aluminum alloys for ferrochrome smelting are described in previous works [2, 3].

The phase composition of slags used in our work was determined by means of petrographic analysis. Table 1 represents the chemistry of slag samples.

Table 1: Chemical composition of slag samples

Index	Composition, %						
	Cr_2O_3	SiO_2	CaO	MgO	FeO	Al_2O_3	CaO/SiO_2
Sample 1	6,06	23,45	32,38	10,98	0,59	26,54	1,38
Sample 2	4,99	22,28	30,28	12,91	0,52	29,02	1,36
Sample 3	8,42	25,18	33,19	10,87	2,72	19,62	1,32
Sample 4	2,64	26,35	37,01	9,91	1,28	22,81	1,40

The phase composition of slags was calculated by balance method [4] using the thermodynamic-diagram analysis (see table 2). The results of calculation show high helenite content (up to 51%) in the slag.

Table 2: Phase composition of slags

Index	$CaO \cdot MgO \cdot SiO_2$	$2CaO \cdot MgO \cdot 2SiO_2$	$2CaO \cdot Al_2O_3 \cdot SiO_2$	$MgO \cdot Al_2O_3$	$MgO \cdot Cr_2O_3$	$FeO \cdot Cr_2O_3$	$3CaO \cdot MgO \cdot 2SiO_2$
Sample 1	20,742	9,611	51,356	10,37	6,083	1,838	
Sample 2	24,624	6,025	46,426	16,387	4,918	1,620	
Sample 3	34,241	3,728	47,432	2,755	3,371	8,474	
Sample 4	29,861		53,460	4,090		3,888	8,700

Petrographic analysis was carried out by means of polished section study in reflected light on Neophot 21 microscope. The slags are related to macrocrystalline type which includes helenite and anorthite slags.

The sample 1 (fig.1) has grey to black color with dull luster. The sample has heterogeneous porous structure and hard surface with isolated reguluses. Sample phases are mostly represented by cryptocrystalline helenite $2CaO \cdot Al_2O_3 \cdot SiO_2$. Light-colored spots are $MgAlCrO_4$ (according to X-ray phase analysis) represented by fine grains clustered in vitreous matter. A small amounts of larnite can also be seen.

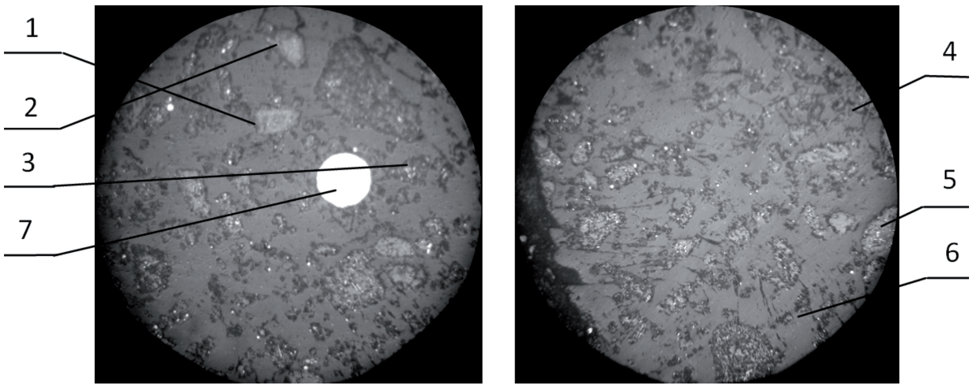

Figure 1: Polished section of sample 1 (reflected light, ×100)

1 – helenite; 2 - $MgAlCrO_4$; 3 – ore relict; 4 – larnite; 5 – chromian spinel; 6 – vitreous matter; 7 – regulus.

The sample 2 (fig. 2) has heterogeneous and porous structure. The color is grey with silky luster.

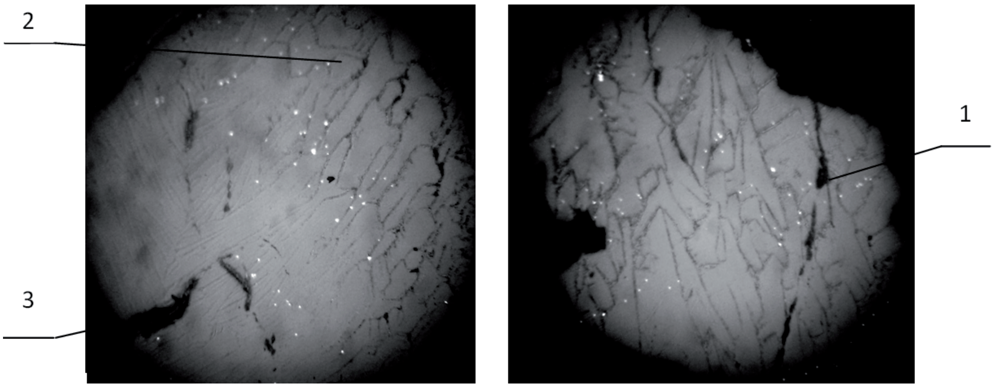

Figure 2: Polished section of sample 2 (reflected light, ×125)

1 – helenite; 2 - melilite; 3 – silicate cement.

The products of solid solution decomposition are visible in the sample 2 (fig. 2). Acicular forms of helenite and silicate cement are seen among melilite grains. Vitreous matter is mostly located around pores. Fine reguluses are evenly distributed on the surface of the section.

The sample 3 (fig. 3) has grey color with luster from dull to silky. The structure is finely porous.

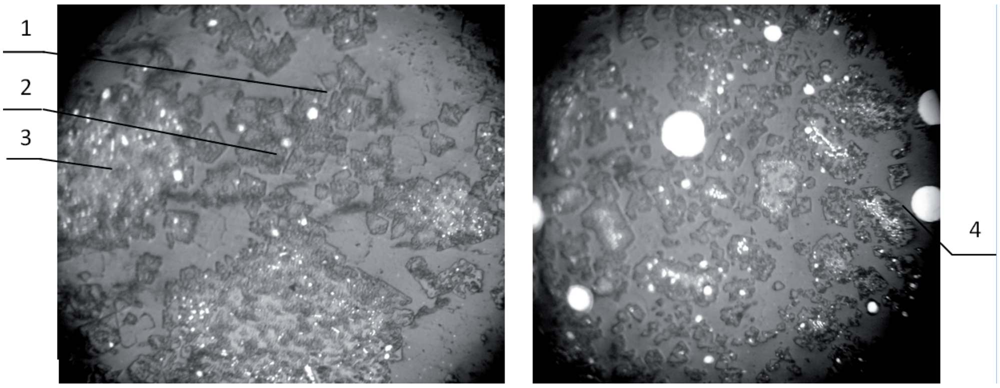

Figure 3: Polished section of sample 3 (reflected light, ×200, ×150)

1 – helenite; 2 - melilite; 3 – alumina-calcium-magnesium silicate; 4 –regulus.

The microstructure of the sample 3 is partially crystalline. Helenite grains are very fine and are characterized by xenomorphic form. Grains of melilite are short-prismatic. Due to decomposition of solid solution, amount of vitreous matter is extremely low, reguluses are distributed unevenly. Isolated grains of larnite are seen on the surface.

The sample 4 (fig. 4) has partially crystalline structure, heterogeneous with isolated pores. The color is grey with vitreous luster.

The intergranular space of melilite of sample 4 (fig. 4) is filled with acicular helenite grains. The sample is formed by dendritic melilite. Aside from helenitre and melilite the sample contains small amounts of alumina-calcium-magnesium silicate in xenomorphic form. Vitreous matter is very rare and found in the space between crystalline phases.

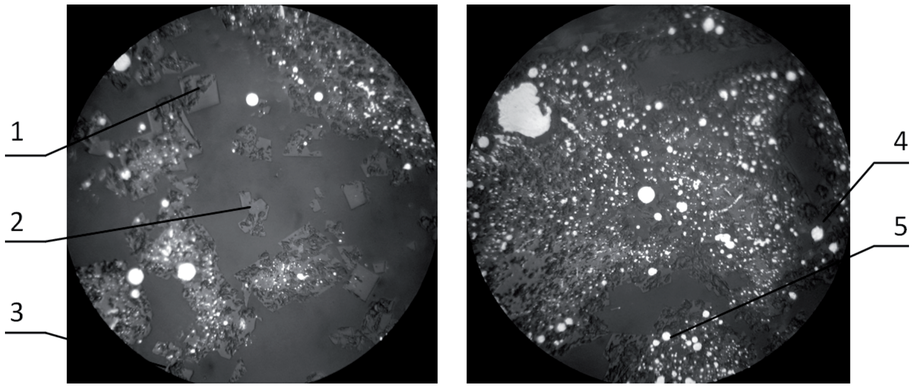

Figure 4: Polished section of sample 4 (reflected light, ×200, ×500)

1 – helenite; 2 - melilite; 3 – alumina-calcium-magnesium silicate; 4 – vitreous matter; 5 –regulus.

Crystallized and incompletely devitrified helenite is found in all samples. The Al_2O_3 content is similar to blast furnace slags. The data on mineralogy of slags obtained indicate the necessity of metallurgical evaluation of slag suitability for alumina production.

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