ГІРНИЧІ ТЕХНОЛОГІЇ

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GERMANIUM IN DONBAS COAL AS A STRATEGIC ELEMENT

Critically important minerals find wide application in modern high-tech sectors, and one of the metals that is considered critical for both the United States of America and the European Union is germanium [1,2]. It is a solid, brittle semimetal that was first used approximately 70 years ago as a semiconductor material in radar systems and as a material for the first transistors [3]. As a strategic and critical material, germanium was added to the U.S. National Defense Stockpile as early as 1984 [3]. Due to rapid technological progress, germanium has gained the status of a key material of the 21st century, and today this metal and its derivatives are indispensable in a wide range of fields, including fiber optics, infrared systems, solar energy, detectors, optoelectronics and microelectronics, catalysis, as well as applications in metallurgy, medicine, pharmaceuticals, cosmetics, and phosphor production [4].

Germanium possesses a number of exceptional properties, making it one of the primary materials in semiconductor technology. It is used for the production of diodes, various types of triodes, thermistors, α-particle counters, phototransistors, photoresistors, as well as optical lenses, filters, Hall sensors, and more [5]. Global imports of metallic germanium and germanium dioxide show steady growth. The People's Republic of China maintains its position as the world's leading producer and exporter of this element. The government continuously strengthens export control by implementing licensing programs. Under these regulations, exporters are required to obtain an export license for each batch of products and provide authorities with complete information about the foreign buyer and the final use of the germanium [2].

Coal is considered as a potential source of a number of critically important elements and deserves special attention due to its elevated content of various trace elements, including germanium [6]. The significance of research on germanium is further underscored by the decision of the National Security and Defense Council of Ukraine dated July 16, 2021, "On Stimulating the Exploration, Extraction, and Enrichment of Minerals of Strategic Importance for Sustainable Development and the Defense Capability of the State," as well as by Presidential Decree No. 306/2021, which implements this decision. After reviewing a range of issues related to meeting the national economy's needs for strategically important raw materials, with the aim of protecting national economic interests and enhancing the country's defense capability, the National Security and Defense Council of Ukraine decided to approve a list of metallic ores and non-metallic minerals that are of strategic importance for the sustainable development of the economy and the country's defense capability [5]. In these documents, germanium ores are included in the list of minerals recognized as having strategic significance for sustainable development and the defense capability of the state.

In the past, Ukraine had developed a substantial germanium production complex, which was driven by two factors: the presence of coal seams rich in germanium and high demand from the semiconductor and opto-mechanical enterprises of the former USSR, which were oriented toward the defense sector. This complex included the workshop of the Zaporizhzhia Titanium-Magnesium Plant, the Sievierodonetsk Chemical-Metallurgical Plant, and more than ten domestic coking plants [4]. During the soviet period, Ukraine was the single monopolistic producer of germanium in the USSR, producing up to approximately 5 tons of this metal annually [1]. Production was carried out at 13 coking plants, which operated chemical units for the by-product extraction of germanium from coal coking wastewater [7].

In the early 2000s, the Zaporizhzhia Titanium-Magnesium Plant was one of the five leading global producers of germanium. At the same time, domestic scientists and industry specialists, particularly from the Institute of Engineering Thermophysics of the National Academy of Sciences of Ukraine, were actively working on implementing a new technology for obtaining ash-derived germanium concentrate from coal combustion at thermal energy enterprises [4].

As a result of the depletion of argillite reserves at the Novikovske deposit and the physical deterioration of equipment at coke-chemical plants, the domestic germanium production complex came to a complete halt. Ukraine not only lost its status as a global exporter of germanium products but was also forced to import this element and its compounds, which led to a reduction in the production of its own high value-added product range [4].

Ukraine possesses significant overall germanium resources as an accompanying component in the coal of the Donbas and the Lviv–Volyn coal basins. According to estimates, germanium reserves in coal across 204 mine fields and sites exceed 91,000 tons, with its content ranging from 0.3–1.3 g/t in anthracite to 3.8–9.2 g/t in coal with a low degree of coalification [1].

Currently, coal deposits in Ukraine that are characterized by germanium metal content are not being fully and comprehensively exploited, the reserves of this strategic metal are written off in accordance with coal extraction. To relaunch the domestic germanium production complex, it is critically necessary to conduct continuous monitoring of the germanium content in commercial coal and in the coal seams under development, as well as to modernize and restore the units at coke-chemical plants used to obtain germanium concentrate, employing advanced resource-saving technologies for processing coal tar wastewater.

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