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THE IMPACT OF DEPOSITING POWDERY FERROUS WASTE ON THE ENVIRONMENT

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Abstract: The capitalization of secondary mineral resources represents a sine qua non condition for the rationalization of primary resource consumption and the conservation of ecosystems. This practice, applicable across a wide range of industries, constitutes a priority axis of the European Union's policies, aiming at the amelioration of life quality and the eradication of polluting elements. The intrinsic diversity of waste materials, however, necessitates the adoption of specific, particularized processing strategies. In contrast with the linear economic model, the circular economy minimizes the generation of residues by reintroducing products into the economic circuit, thus generating multiple ecological, economic, and social benefits. The present paper investigates the potential for utilizing the sideritic sterile material stored in the decantation ponds within the Teliuc area.
Keywords: research project, batteries, waste, recycling, cobalt

INTRODUCTION

Based on the quantity used annually, as well as its multiple applications, iron is humanity's most important metal [1,2]. Iron production has increased at an accelerated rate. For example, considering only the iron produced in the form of crude steel, its production increased from 189 million tons in 1950 to 1890 million tons in 2024 (Figure 1).

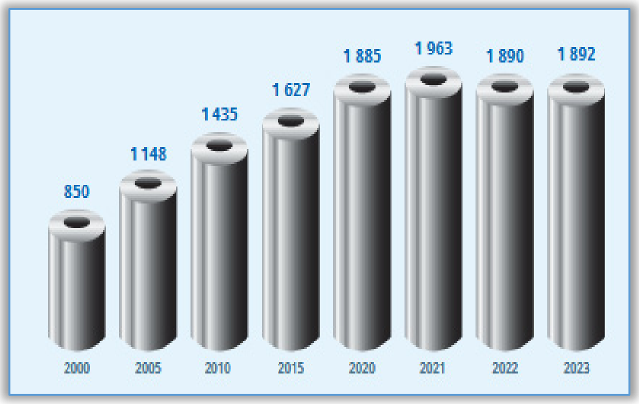

Figure 1. World crude steel production 2000 to 2023, million tonnes

Very significant iron resources are known to exist which, compared to the resources of other metals, are found in a larger number of countries and are relatively uniformly distributed geographically. The main minerals from which the metal is extracted are: hematite, magnetite, limonite, siderite, goethite, pyrite, pyrrhotite, ilmenite, magnesioferrite, ankerite, chamosite, thuringite. Like any ore, iron ores are composed of valuable (useful) minerals, sterile minerals, and associated minerals; the metal is obtained from these through appropriate technologies. The sterile minerals, also called gangue minerals, are usually useless impurities that accompany the valuable minerals in the ore. They differ from one ore to another, but are typically represented by quartz, calcite, dolomite, feldspar, epidote, hornblende, garnets, barite, gypsum, etc. Associated minerals, depending on how they influence the metallurgical process, can be either favorable or detrimental. Considering their mineralogical composition, sideritic, limonitic, hematitic, and magnetitic ores can be distinguished as being the most important. The largest reserves are found in the CIS countries (Russia, Ukraine, Kazakhstan), Australia, Brazil, Canada, South Africa, USA, India, China, Sweden, Venezuela, Liberia, France, England, Congo, Guinea, Gabon, Côte d'Ivoire, Angola, Algeria, Peru, Chile, Germany, Spain, Norway [1, 2]. To be obtained economically in blast furnaces, iron must be present in the ores at concentrations of at least 50%. If the ores have lower contents, they are subjected to preparation operations (mainly concentration) until concentrates with a minimum of 50% metal are obtained. The concentrates are often in the form of pellets or agglomerate and constitute the raw material for pig iron production in blast furnaces. Not all iron production comes from existing reserves in deposits; a substantial part is also obtained from waste recovery, which leads to a decrease in resource consumption. From waste materials, steel is obtained much more cheaply and with less effort than from the exploitation of ore deposits. In some countries, waste ensures over 50% of the required iron. Approximately 30% of steel production is obtained via the minimill route, while the remaining 70% is produced in integrated steel mills (Figure 2); the semi–finished products obtained are utilized in various industrial sectors (Figure 3) [2].

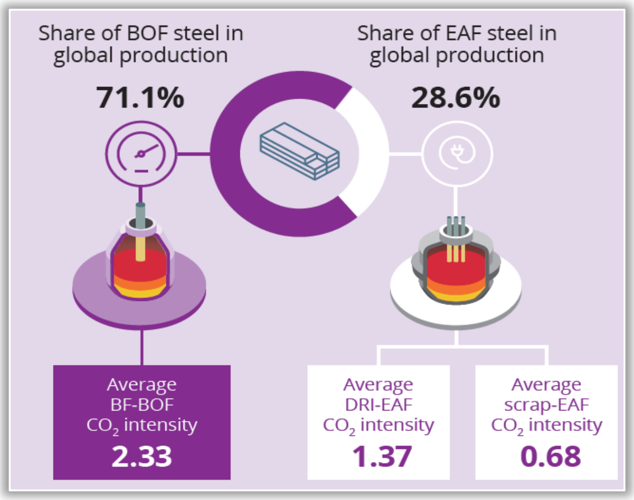

Figure 2. Crude steel production by process

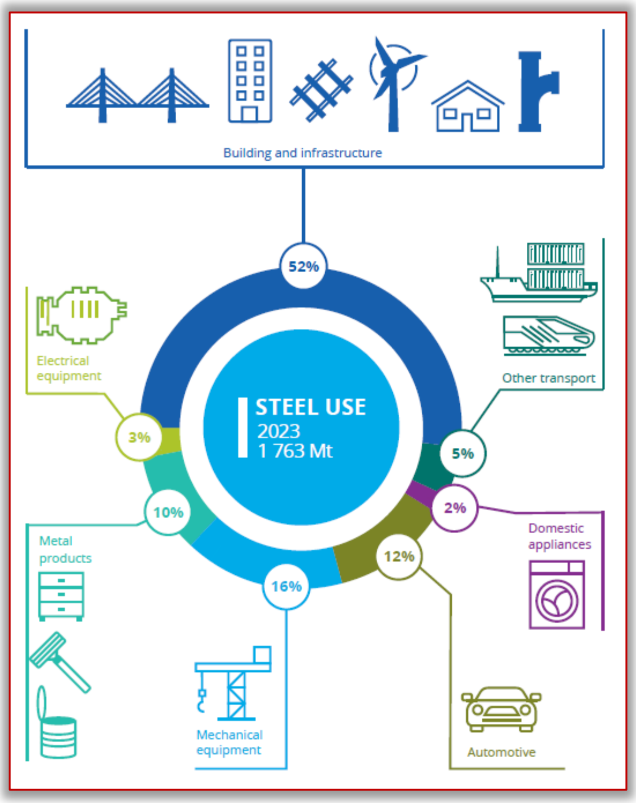

Figure 3. Steel use by fields

Although the global geological reserve picture for minerals is relatively rich and will continue to be enhanced by new geological discoveries and technological advancements, the actual supply often remains below the potential of the reserves. This is not so much due to their physical depletion, but rather primarily for economic reasons. For example, the development of geological prospecting and research, extraction, processing, and transportation of materials to the point of consumption requires investment expenditures that countries, especially developing ones, find difficult to bear. Furthermore, foreign capital often has certain reservations about undertaking such projects due to the increased investment risks and price fluctuations on the world market.

The integrated management of waste streams is critical for the materialization of circular economy principles and for guaranteeing long–term sustainability. By reintroducing materials into the economic circuit, the protection of natural resources is ensured, the negative ecological impact (pollution) is reduced, and the energy balance is optimized, compared to the effort required to obtain primary raw materials [4].

METHODOLOGIES

Currently, a special emphasis is placed on saving mineral resources, especially scarce ones, on their recycling and reuse, and on increasing the degree of capitalization. Furthermore, the structural changes occurring in the world economy, the emergence and development of new branches with reduced metal consumption but incorporating an increased volume of human resources, determine new orientations in the economic policies of states.

In waste treatment, two main methods are distinguished: neutralization, which involves the elimination of waste from the economic circuit, and recovery, which reintroduces waste into the economy. Industrial waste can pose a high risk to human health and the environment if not managed and disposed of safely. In the EU, approximately 60% of waste is treated in recovery operations (recycling or energy recovery), while the remainder is landfilled or incinerated without energy recovery.

The mining industry exerts significant influences on the environment, which manifest in all phases of the exploitation and preparation technological processes. Regardless of the method applied, numerous and diverse physical and chemical operations are necessary for the capitalization of a deposit, resulting, on the one hand, in the useful mineral substance, and on the other hand, in the sterile material extracted from the deposit along with the useful material. The actual useful mineral substances contained in the raw ores almost always represent low percentages relative to the total mass of the ores extracted from the deposit. These values differ. For metalliferous ores, the proportion of clean useful substance is the lowest, often starting from tenths of a percent for non–ferrous ores, and increasing for ferrous ores to 25–50% and sometimes even more. For non–metalliferous ores, the proportion of useful mineral substance can reach tens of percentages under certain conditions. For example, sideritic ores (FeCO3), due to their low iron content (30–40%), are not processed as such, but are subjected to roasting operations during which the iron content increases, they become porous, friable, and at the same time easily reducible [5].

Besides solid residues, the mining industry also generates liquid and gaseous waste in impressive quantities. Quantitatively, these exceed the solid ones several times over. For example, wastewater is in a ratio of 3.0:1 up to 12.0:1 compared to the quantities of processed ores. Gaseous residues in the form of powders, gases, and vapors come from all sectors of the mining industry and especially from the preparation sector [6,7].

The negative effects that preparation activities can produce on the environment are just as severe as those produced by exploitation operations. At the same time, it can be said that, although much more complex, the effects of preparation operations are still easier to control. In addition, installations for ore treatment are characterized by a lower degree of rigidity related to their location relative to a mine, in the sense that it is possible to choose a more advantageous site for the preparation plant from an environmental protection point of view. At the same time, the choice is also determined by economic considerations, in the sense that these installations should ideally be located near the mine and thus constitute a chain of economic units, but this leads to an accentuation of environmental pollution in the area.

Consequently, there is a need for adequate techniques for protection against pollution originating from all types of waste resulting from the preparation activity, which can ultimately constitute the source of very high risks of altering the environment.

The iron deposit at Ghelari belongs to a mineral–rich mountain region that stretches between Teliuc and Rușchița (Banat) and includes the Ghelari, Arănieș, Ruda, Alun, Sohodol, Runc, Florești, and Vadu Dobrii mines. The extracted ore was siderite, which contains 36–41% Fe, and rich limonite, which contains 45–47% Fe. The siderite–type iron ore is practically subjected to the roasting operation to remove carbon dioxide, and subsequently, to the magnetic concentration operation. During the roasting operation, iron carbonate transforms into iron oxides, so the iron concentration in the roasted ore increases, an increase that is accentuated by magnetic concentration. The resulting concentrate has an iron content between 49–51% and is used in the agglomeration charges [8].

In the Hunedoara area, following the preparation of the sideritic ore used in the agglomerate processing, there are three decantation ponds with sideritic waste at Teliuc (Figure 4). The characteristics of the sterile material are given by the ore from which it originates and the grinding fineness determined by the preparation process; sometimes it is possible for some characteristics of the sterile material to be worsened by the additives used in the preparation process.

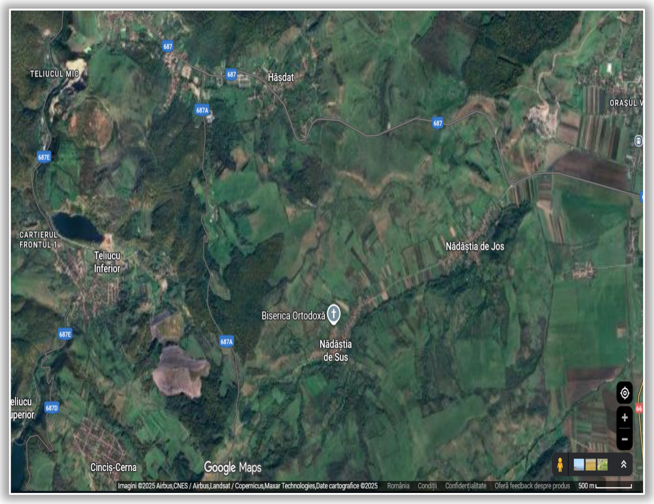

Figure 4. Teliuc tailings ponds

During the operation of the preparation plant, the Teliuc sterile material resulting from the process was deposited in three ponds [2,9]: decantation pond no. 1 (commissioned along with the plant in 1965, located on the opposite slope of the plant) and decantation ponds no. 2 and 3, located at a distance of approximately 5 km from the processing plant.

The monitoring system in Romania comprises two activities, namely:

— Operational activity: data collection, warning regarding accidental pollution, and protective measures;
— Activity for long–term environmental quality characterization, evaluation of development

trends, and taking adequate protection measures.

Regarding the organization of the integrated monitoring system, based on the nature and type of parameters that need to be monitored through this system, the following specific elements exist:

- Immission surveillance networks;
- Control of pollutant emissions;
- Evaluation and control of the general effectiveness of environmental protection measures.

The Ghelari area has a monitoring system for the impact of environmental pollution. The three environmental factors studied are water, air, and soil, but flora and fauna are also included.

RESULTS

Topographic measurements were carried out to determine the quantities of waste deposited in the ponds. These measurements used the Stereographic 1970 coordinate system and the Black Sea elevation reference system, as part of a research contract conducted by the team coordinated by Professor Teodor Hepuț, PhD Eng. Leica TCR 307 electro–optical measuring equipment was used for the measurements. The measurements were performed at Decantation Ponds no. 1, 2, and 3 – Teliuc Mining Exploitation.

Aspects concerning the ponds, the surfaces occupied by the sideritic waste, and the quantities deposited are presented in Figure 5.

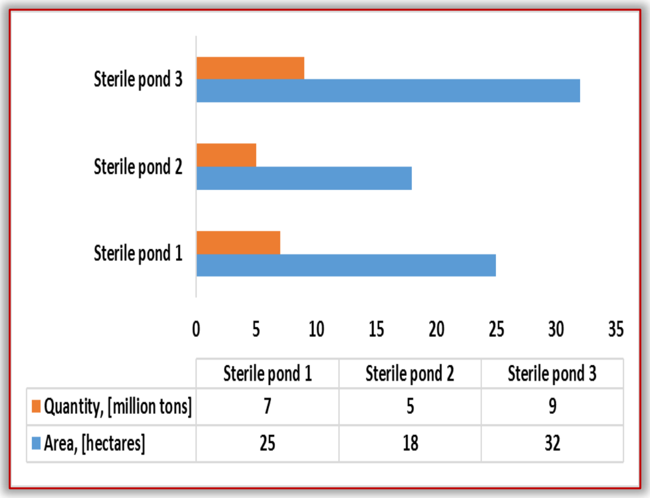

Figure 4. Occupied area /stored quantities – Teliuc siderite waste ponds

The occurrence of a temporal variation in the characteristics of the sterile material is inevitable. The evolution over time of the material's properties is also encompassed within the same issue regarding the characteristics of materials upon which the state of the sterile deposit depends.

Typical chemical composition: 20–35% total Fe (Fet), 30–50% SiO_2, 5–15% CaO and MgO, 2–8% Al_2O_3, while S and P have low values. Granulometric composition: varied particle size, from lumps to fine particles. The sterile material can be partially cemented or friable. Its color is grey–brown, with rusty spots (oxidation). Humidity and cohesion are variable depending on age and exposure.

Problems encountered during deposition are: potential acid mine drainage from residual sulfides, heavy metal pollution, and land occupation.

Possibilities for capitalizing on the sterile material:

- Recovery of iron and useful elements for different industrial sectors, especially the steel industry and the construction materials industry;
- Inert material for backfills and embankments;
- Land reuse/recultivation.

Waste management occupies a significant position within the concept of sustainable development, granting certain categories of waste an important role as a source of secondary raw material, as well as minimizing others that are considered responsible for environmental pollution. The modern strategy of waste management lays the foundation for a hierarchy of actions in this field by following specific stages, among which waste recovery and disposal have particular significance for the health and safety of the environment and the population.

CONCLUSIONS

The increase in ore production, as well as the reduction of world raw material reserves, have led to the search for efficient methods of processing and preparing waste for metallurgical processing. In Romania, the iron ore reserves, located mainly in the Poiana Ruscă Mountains and the Gilău Mountains, which are industrially exploitable, are relatively small, and those at Palazu Mare lack the technical and economic conditions for exploitation. Currently, exploitation activity is ceased. The overwhelming share (83%) of the iron ore reserves consists of prospective reserves, which are unrecoverable. The quality of the iron ore reserves is much inferior to those exploited globally (the content of useful substance is approx. 27% Fe, compared to over 50% Fe in other countries).

The increasing dependence of national industries on the world raw material market, especially for scarce ones, may at some point lead to new imbalances and disruptions of the world economy. Considering the policy of developing countries possessing mineral resources to protect their own raw material base and to develop processing branches that make superior use of indigenous natural riches, specific problems arise regarding the restructuring and reorientation of their economies towards high–tech branches with reduced material and energy consumption. The decrease in specific consumption due to the introduction of technical progress into production leads to a reduction in resource demand.

Globally, both currently and in the medium and short–term forecasts, the world demand for metals, especially basic ones, is satisfied. Although disruptions may sometimes occur due to the postponement of project execution because of a lack of financial means, or due to a decrease in the absorption capacity of the volume of metal production by industry, the issue of ensuring metal resources probably does not arise even in the longer term.

Economic development and the use of advanced primary processing technologies have determined a new division of world mineral production. Thus, an increasing share of world mineral raw material production is processed in developed countries, and a relatively limited share in developing countries that possess important deposits of non–energy mineral resources.

The CARBOFER process represents a possibility for capitalizing on powdery waste (sterile materials from the mining industry, sludge's and dusts from the steel industry, slags resulting from secondary steel treatment, etc.) resulting from the steel and mining industries. A part of this waste can be successfully used for the production of the carbofer by-product. This is used as an agent for foaming the slag during steel production, thus the waste is recycled in an ecologically, technically, and economically satisfactory manner.

These valuable technological wastes require additional research that can contribute to their use as components of the iron–containing charge or as auxiliary materials in steelmaking aggregates.

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