GOLD MINING: ECONOMIC DEVELOPMENT VERSUS SUSTAINABLE DEVELOPMENT

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Abstract: Against the prolonged economic crisis, the mining resources have regained the investors' attention. Demand for gold continues to increase worldwide and the high price of gold ounce compared with historical values, indicating a favorable global context of the new gold mining projects. This paper aims to present issues related to mining, geological conditions, cyanide, protect and rehabilitate the environment, governed by European and Internationals Directives. This paper analyzes the potential economic development based on exploitation and processing of Romania non energy raw materials in a global context and directions regarding sustainable development in this area. It provides specific examples of new gold mining projects in Romania and its sustainable development.

Keywords: non-energetic raw materials, economic development, risk in gold mining, susteinability of raw materials.

1. CONCERNS OVER RAW MATERIALS

Raw materials are material or substance used in the primary production or manufacturing of a good. Raw materials are often natural resources such as oil, iron and wood that are processed or combined with other materials to create an end product. Raw materials are fundamental to Europe's economy, growth and jobs and are essential for maintaining and improving our quality of life. While the importance of energy materials such as oil and gas has often been highlighted, historically the indispensable role of metals, minerals, rocks and biotic materials has had lower profile. [10]

The European Union couldn't ignore this source of economic growth; therefore a European policy regarding this growth has been promoted, by implementing a European policy for non-energetic raw materials: The Raw Materials Initiative (RMI). This was drafted in 2008 to manage raw materials issues at the EU level, against the growth of global competition for resources and it has three major aims:

- ensuring the access to resources from third countries for European companies without distorting the markets through the interests of producing countries or the political instability in these countries;
- ensuring the supply susteinability of raw materials from Europe and efficiency growth in extracting the resources;
- promoting recycling to protect the environment.

Non-energy raw materials are intrinsically linked to all industries across all supply chain stages, and consequently they are essential for our way of life – everything is made from materials.

The consumption evolution of raw materials globally since 1900 and in our day is evident in the sense of increasing consumption. The graph is shown in Figure 1 [17], where the left axis shows global resource use between 1900 and 2009 measured in billions (10^9) of metric tons per year. The right axis (1900 = 1) shows the growth in population and Gross Domestic Product (GDP) during the same interval.

The challenges for the raw material industry for this period are recognized:

- growth of industrial nations;
- improved living standards;
- supplier consolidation;
- growing buying power;
- growing demand; which leads to the necessity of satisfying the demands of:
  - primary raw materials;
  - high quality secondary raw materials.

Further to established applications, future technological progress and improving quality of life are also reliant on access to a growing number of raw materials. Improving environmental performance is also closely linked to raw materials, both at present and in the future. Exhaust emissions from internal

combustion engines are managed through catalytic converters containing platinum group metals; no other option is viable at present. Low carbon technologies [8] also require that the correct resources are available. Many wind turbines designs use magnets containing rare earth elements, and solar panels rely on metals such as silicon, tellurium and indium amongst others [13, 14]. Similar cases are seen for electric vehicles and energy efficient lighting [15].

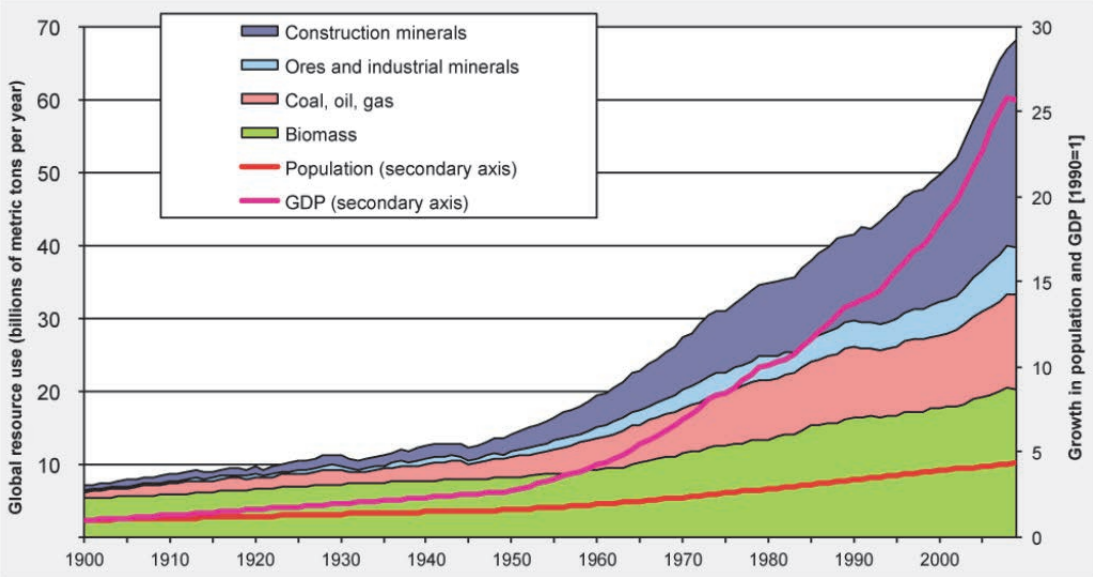

Fig. 1. Increasing consumption.

Only a few examples are provided above, however, it is apparent that if the quality and way of life within the EU Member States is to be maintained and improved, continued access to non-energy raw materials is essential. All countries are dependent on raw materials. This is particularly true for Europe which is highly dependent on non-energy raw materials to sustain businesses and the economy. It has been estimated that 30 million jobs in the EU are directly reliant on access to raw materials [11].

However, very little primary production occurs within Member States themselves, with the majority produced and supplied from third countries. The total EU28 contribution to overall materials supply can be estimated at around 9%, with France, Germany and Italy ranked the highest individually, largely due to industrial mineral production [2].

The EU has many and uncharacterised and unexplored deposits; however, the existing economic and regulatory climate, combined with growing land use competition limits the exploitation. Secondary supplies can reduce the demand for primary materials. However, for many materials very little recycling and recovery occurs. Therefore much of Europe's industry and economy is reliant on international markets to provide access to essential raw materials.

2. EU RAW MATERIALS POLICY

The original RMI communication has been followed up further communications on "tackling the challenges in commodity markets and on raw materials" in 2011 [3], and reporting on the progress of the RMI in 2013 [4].

Together with the current report, the Commission has also published the list of critical raw materials through a Commission Communication on 26 May 2014 on the review of the list of critical raw materials and the implementation of the Raw Materials Initiative.

Raw materials are also an integral part of the Europe 2020 strategy to ensure smart, sustainable and inclusive growth and is closely linked to the flagship initiatives – "Industrial policy for the globalisation era" [5] and "Resource efficient Europe" [6].

The list of critical raw materials helps defining the forward looking EU policies in different areas including research and innovation, industrial policy, trade, development and recently also in the communication on the Defence and Security Sector [7].

The materials under consideration include industrial minerals, ores, biotic materials, and processed or refined materials. Each of these may have different grades or types, particularly for industrial minerals and wood based materials. Only non-energy and non-agricultural biotic materials are under consideration in this report. The raw material supply chain using the example of ore mining is presented in Figure 4.

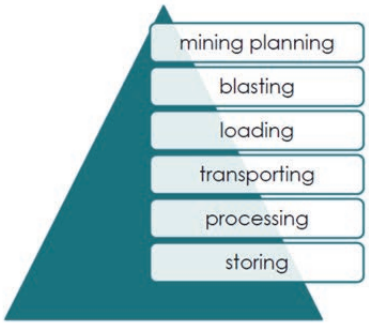

Fig. 4 Logistic chain in the mining industry.

3. CRITICALITY IN CONTEXT

Materials security issues have been of growing interest to researchers, governments, industry and other organisations alike due to increasing concerns over access to raw materials and the impact supply shortages may have. A central part of many initiatives identified above and elsewhere is to assess which materials are most "critical", allowing the most appropriate actions to be identified and taken. [16]

In addition, assessments may evaluate different set of materials chosen for context and use different criticality measures and methodologies. Whilst the aims and scopes of these analyses do vary, they all apply a selection of indicators to a group of materials to identify a list of critical materials, often combining a measure of supply risk against one of relative importance. [10]

The EU methodology used to assess criticality has a combination of two assessment components shown in Figure 2, was developed by the AHWG, assessing economic importance to the EU against supply risk [10]:

- economic importance;
- supply risk – poor governance.

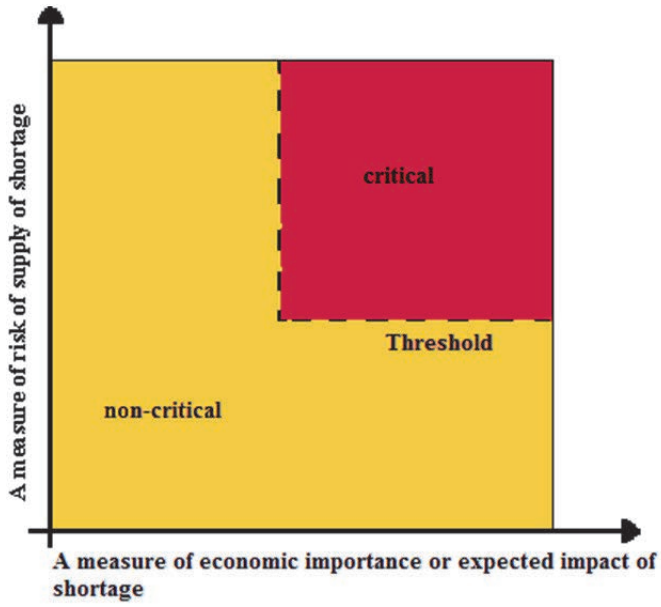

Fig. 5. EU Criticality Methodology.

Compound indicators are used for each of these two assessment components; therefore each takes multiple factors into account. The result is a relative ranking of the materials across the two

assessment components, with a material defined as critical if it exceeds both the threshold for economic importance and the supply risk.

The abiotic materials considered include all the forty one materials included in the 2010 report, with coking coal, gold, hafnium, potash, phosphate rock, selenium, silicon metal and tin added. In line with the previous report, the abiotic raw materials consist of metals (or metallic ores) and industrial minerals using the following definitions [10]:

- metallic ore: a rock or sediment containing one or more minerals from which one or more metals can be extracted;

- industrial mineral: mineral, which may be used in an industrial process directly due to its chemical/physical properties. Industrial minerals are used in a range of industrial applications including the manufacture of steel, chemicals, glass, fertilisers and fillers in pharmaceuticals and cosmetics, ceramics, plastics, paint, paper, and the treatment of gases and waste, etc. Industrial minerals include barites, bentonite, borates, clays, diatomite, feldspar, fluorspar, gypsum, limestone, silica sand, talc, and many others.

Biotic raw materials are materials which are derived from renewable biological resources that are of organic origin but not of fossil origin. Biotic materials have been included within this criticality report as a result of concerns over limited supply and issues relating to responsible and sustainable sourcing, as seen for other raw materials.

This issue brings into discussion the common concerns of stakeholders in the process of exploitation and utilization of mineral resources: government, companies and businesses interested in this area, education, research, without neglecting the social and sustainable development of areas.

4. GOLD MINING IN EUROPE AND ROMANIA

In the list of materials included in the 2010 EU report on critical materials, the abiotic materials considered include the gold also [9]. Thus, in 2011, global gold demand was a record, worth 205.5 billion dollars, and the price of ounces of gold was very high compared to historical values, indicating a favorable global context of new mining exploitations. [22]

In 2011 Europe produced 49.8 tonnes of gold, meaning 1.24% of world production. The top of gold producing countries is as follows: Turkey – 24.4 tons, Sweden – 8.9 tons, Finland – 8.46 tons. European countries who have substantial gold reserves had invested in the construction of modern and efficient operations to extract gold ore. The most relevant examples are Turkey, Sweden, Finland and Greece.

The price of gold has been steadily increasing in recent years, in the context of international economic crisis. Both in developed countries, and the emergent ones, national banks are buying gold to cope with the financial market volatility and to win investors' confidence. Central banks demand for gold has increased to 439.7 tons in 2011 compared to 77 tons in 2010.

Mining Strategy for 2008-2020, developed by the Ministry of Economy and approved by the Romanian Government, provides that one of the measures to be taken in this period is the gradual reduction of the state role in the mining activities of exploration and exploitation [21].

There are currently two valid operating license and seven exploration licenses for gold and silver, according to the National Agency for Mineral Resources. The operating licenses are:

- Roşia Montană, Alba – Roşia Montană Gold Corporation S.A, RMGC;
- Certej, Hunedoara – Deva Gold S.A.

Exploration licenses are:

- Băişoara, Alba – Rom Aur S.R.L.;
- Băişoara, Cluj – Rom Aur S.R.L.;
- Rovina, Hunedoara – Samax România S.R.L.;
- Aluniş, Piatra Handal – East area, Maramureş – Romaltyn Exploration S.R.L.;
- Poprad, Maramureş - Romaltyn Exploration S.R.L.;
- Aluniş, Piatra Handal – West area, Maramureş – Romaltyn Exploration S.R.L.;
- Camarzana Nord, Satu Mare - Romaltyn Exploration S.R.L.

If the two projects that have operating license would start gold production, Romania would go first in the ranking of the largest gold producing countries in Europe.

Along the perimeter of the Golden Quadrilateral are proposed three new mining projects which will operate gold and silver deposits: Rosia Montana, Rovina and Certej all of them are companies established in Romania, with majority private shareholders.

5. CYANIDE IN MINING

In nature, cyanide is found in various plants and fruits: almonds, apricots, cherries certain, some varieties of beans etc. Only 13% of cyanide produced in the world is used in the mining industry. The rest is used in the manufacture of some widespread products, such as: plastics, pharmaceuticals, cosmetics, food additives, textile. Cyanide is used over 100 years in mining, one of the few chemical reagents that dissolves gold and silver makes it possible to separate them from other minerals.

About 90% of the gold extracted worldwide is produced safely and efficiently through technology with cyanide: USA, New Zealand, Canada, Italy, Finland, Spain and Sweden.

Currently in Europe are operating 11 mining exploitations which extract gold through the cyanidation:

- Spain - El Valle-Boinás & Carles. Company: Orvana Minerals;
- Finland - Kitilla. Company: Agnico Eagle Mines;
- Finland - Pahtavaara. Company: Lappland Goldminers;
- Sweden - Aitik. Company: Boliden Mineral;
- Sweden - Boliden Area Operations (5 mining exploitations). Company: Boliden Mineral;
- Sweden - Svartliden. Company: Dragon Mining;
- Sweden - Garpenberg.

The study *Framework for Responsible Mining* (2005) states that:

- if the use of cyanide would be prohibit, gold processing should be done through other equivalent chemical catalysts, such as: mercury, lead, with much greater potential impact on the environment and human health and with efficiency much lower;
- the study acknowledges the efforts for regulating the use of cyanide, particularly by the International Cyanide Management Code issued by the United Nations Environment Programme and the International Council of Metals.

EU Directive for *Waste Management from the Extractive Industries* 2006/21/EC, implemented in Romania by GD 856/2008: at discharge into the pond, the maximum level of cyanide is set at 10 mg/l. Countries like USA, Canada, New Zealand, had a maximum limit of 50 mg/l.

After 6 to 12 months after filing in the Tailling Dam, a tailings with a concentration of 6 mg/l degrades in natural conditions and reaches a concentration of 1-2 mg/l.

Rosia Montana Gold Corporation (RMGC) by Gabriel Resources, is signatory to the Code since 2007. It is the first mining company with operations in Europe that joined the Code. Rosia Montana Mining Project proposed that from the first day operation, the concentration will be 5-7 mg/l, half from the maximum allowed by European and national legislation.

The Code refers to: production, transport, handling and storage; operational and closure phases of the exploitation; safety of workers; arrangements for response to emergency situations; personal training, consultation and information, monitoring of independent experts.

6. ROSIA MONTANA MINING PROJECT

Rosia Montana Gold Cororation, RMGC obtains the concession license for exploitation in 1999, for the exploitation of gold and silver ores in the Roşia Montană area. The mining perimeter of RMGC has a surface of 21.45 square kilometers and it overlaps the area of Valea Roşia River and its junction with Abrud River. The project covers 25% of the surface of Roşia Montană, a traditional mining community, located in Apuseni Mountains. [1]

Gold mining project from Rosia Montana is one of the most important investments in Romania last years. Implementation of this project may lead Romania in the top of gold producers in the

European Union. The project is operated by Rosia Montana Gold Corporation (RMGC), which is a association of 76% Canadian company Gabriel Resources and the Romanian state, through company Minvest Deva 24%.

Geological and metallogenetic context of Rosia Montana is the key factor of current natural and anthropogenic processes, Figure 3 [23]. By explaining and understanding the genesis and type of deposit it can be obtained a better image of the sources of contamination, upon the migration pathways of contaminants and how they affect the final receptors, facilitating the environmental impact assessment.

The complex geological structure of the Carpathians explains the large variety of genetic and paragenetic metalliferous types, resulted during a long evolution from Precambrian to Quaternary. The inheritance and metallogenetic evolution, in association with several events of Wilson orogenetic cycles, represent the fundamental concepts that allow a correlation between geological characteristics that control the pulsatile deposition of the deposits during mechanical cycles, and the inherent geochemical behavior of the main metals. Gold-silver deposit from Roşia Montană is composed of vein structures and "bindweed" or stockwork's, lenticular masses of breccia, cemented with metallic and gangue minerals. [23]

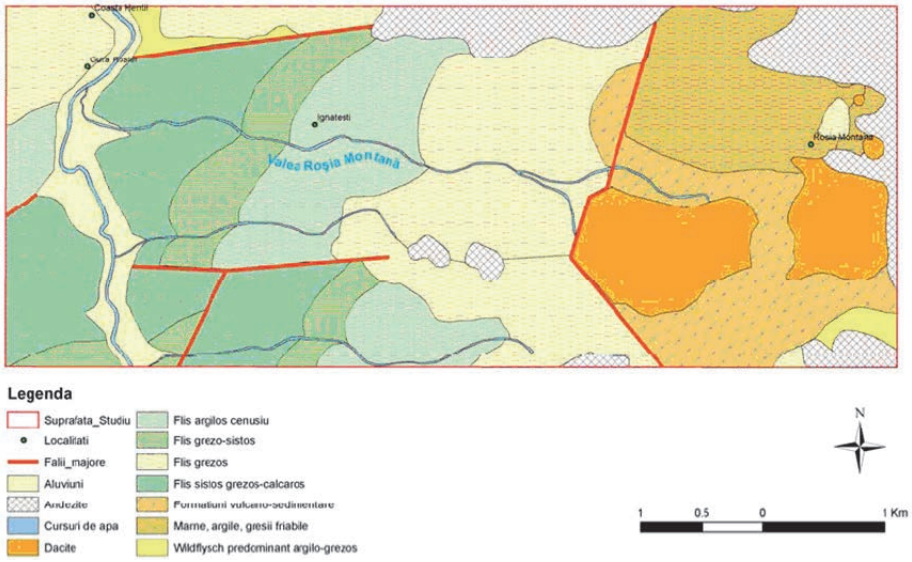

Fig. 6. Geological map of the Rosia Montana Area.

Roşia Montană Mining Project includes the following objectives: the processing plant, Corna Valley Taillinsgs Dam, 4 open pits: Cetate, Carnic, Jig and Orlea, the waste dams of Gura Roşiei and Valea Săliştei. In addition to these main access roads, service roads will be constructed to connect the plant site, four open pits (Cetate, Cîrnic, Jig and Orlea), waste rock dumps (Cetate and Cîrnic) and the TMF, Corna Taillings Dam [1, 23].

The 4 pits will be mined in two stages: Cetate and Carnic during the first 9 years, whereas the pits from Orlea and Jig will be open after the 9th year, and the mining in Cetate pit will continue. Ore mining in the pits will be carried out until year 14. The closure of the pits and stockpiles will take place gradually, with Cetate stockpile as of year 5, the stockpile and pit of Carnic as of year 9, and Orlea and Jig pits during years 12 – 14. The tailings dams of Gura Roşiei and Valea Săliştei are located in the Western part of the area, on the left bank of Abrud River, the tailings dam of Gura Roşiei, and, respectively, the tailings dam of Valea Săliştei in the valley of Sălişte Creek. They have a surface exceeding 40 hectares and they store a total volume of waste of 3.4 millions m^3 [23].

A series of investigations were carried out in view of developing a detailed understanding of the TMF site characteristics which provided information on the geology, hydrogeology and geotechnical conditions of the region and location of TMF's.

7. PROTECTION AND REHABILITATION OF THE ENVIRONMENT

Today, as a result of old mining exploitations at Rosia Montana area, water surfaces contain heavy metals in concentrations well above the maximum allowed by law. For example, the iron concentration is 73 times higher than the maximum limit. As a consequence of RMGC mining project implementation, will be used the most advanced technology for treating wastewater and pollution sources in the area.

Even before starting exploitation, the company will plant 1,000 hectares of forest, 400 hectares in the project area and 600 hectares outside the area of exploitation, although the project will cause only 255 hectares of forest deforestation. The project will treat acidic waters, facilitating the resettlement of aquatic life. As a result of former mining exploitations remained 100 hectares of land affected by 18 dumps and 2 careers, while the old galleries generate ARD (acidic waters). The project will rehabilitate 500 hectares of land, including a lake of 70 acres on the site of a quarry and other 3 backfilled and revegetated open pits.

The project proposes measures to reduce the impact on soil: fertilization of top layer, keeping the vegetation cover, monitoring and treatment of acid soils, soil ecological restoration. [23]

Biodiversity in the area is already affected by former mining exploitations. The project can provide a progressive ecological restoration, by introducing specific measures for the protection of protected wildlife, making curtains of vegetation in ecological corridors and increasing the area covered by vegetation.

The impact on air in the inhabited area can be controlled and minimized, due to wet maintenance of exploitation roads, progressive ecological restoration and keeping wet tailing pond beach. In terms of noise and vibration in the operation site, the impact will be minimal, within the limits of legal standards.

Regarding the use of cyanide in mining, the project complies with European legislation, which is the strictest in the world.

There have been 39 changes to increase environment performance and socio-economics, following public consultations and environmental assessments. The TMF dam is one of the safest, 100 times safer than the average existing dams worldwide.

8. CONCLUSIONS

The European Union couldn't ignore this source of economic growth, therefore a European policy regarding this growth has been promoted, by implementing a european policy for non-energetic raw materials: The Raw Materials Initiative (RMI).

Apart from agriculture, mining is the only method of procuring raw materils which ensure the humanity's future. It is incontestable that sustainable mining of natural resources is a valuable asset for economic growth which cannot be wasted! Studies in the field as well as examples and european tendencies have shown that mining has still potential in Romania too. The European Union is preocuppied with decreasing the dependency of our continent and Romania in particular on the massive raw materials import, therefore it is reasonable for each country to make a greater effort, on both legislative and decision-making levels.

Non-energy raw materials are vital inputs for the EU’s economy, and are particularly crucial for the development of modern environmentally friendly technologies such as electric cars and photovoltaics.

In terms of the new mining project at Rosia Montana can conclude that:

- the proposed operation of the environment greening would result in almost entirely removing of existing pollution generated by mining objective;
- cyanide concentration is not dangerous to humans, animals, birds and not for most of plants and animals in the aquatic environment. Because cyanide is not bio-accumulate, any pollutant that has been absorbed into an organism will be removed or oxidized by these bodies, partly affected, so that they will recover completely in a short time.

In most conditions, the concentrations of pollutants would be reduced immediately due to dilution and dispersion of the said river to the legal standards.

The studies made by independent experts show that the dam has a very good technical project, with a high storage capacity and operating criteria of TMF very strict. Therefore, any scenario of a worst potential discharge is unrealistic. Also, there was made a risk assessment for the probability that the TMFs' sistem to operate under the projected parameters. This risk is 100 times smaller than the calculations for accumulation dams, and the analysis was made on the basis of performance observed at dams worldwide.

The probability of an accident with discharge of water and sterile from the pond is very low, 1 in a million years.

Generally, it has become clear that development of deposits is possible only by obtaining of social licence to operate and mutual treating companies and local communities as partners or even strategic partnership in the form of corporate-community investment programs.

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EXPLOATAREA AURULUI: DEZVOLTARE ECONOMICĂ VERSUS DEZVOLTARE DURABILĂ

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Rezumat: Lucrarea analizează potenţialul dezvoltării economice pe baza exploatarii si procesarii materiilor prime non energetice din Romania in context global si directiile ce privesc dezvoltarea durabila in acest domeniu. Se prezintă exemple concrete din mineritul aurifer din zilele noastre şi contribuţia acestuia la dezvoltarea durabilă a UE. În 2011, cererea de aur la nivel mondial a fost una record, în valoare de 205,5 de miliarde de dolari, iar preţul unciei de aur a fost foarte ridicat în comparaţie cu valorile istorice, indicând un context mondial favorabil noilor exploatări miniere. Uniunea Europeană nu putea să ignore această sursă de creştere economică, astfel că s-a decis promovarea unei politici europene de creştere economică, prin implementarea unei politici europene a materiilor prime non-energetice: *The Raw Materials Initiative* (RMI). Alegerea tehnicilor de extragere si valorificare a resurselor minerale depinde de diferiţi factori, în special, locaţia zacamantului şi caracteristicile minereului. Tehnicile miniere sunt un element-cheie, fără de care Europa nu ar fi în poziţia de a beneficia de bogăţia de minerale. Industria minieră European dispune de know-how-ul necesar pentru a pune în aplicare şi să dezvolte în continuare tehnicile de exploatare care să permită extragerea durabila şi prelucrarea minereurilor în condiţii tehnice şi economice viabile şi respectarea standardelor stricte de mediu. Industria mineritului din Europa este reprezentată de asociaţia Euromines, fondată în 1996. Din Euromines fac parte 19 federaţii europene şi 28 de companii. In preocuparea UE de a scadea dependenţa continentului nostru de importul masiv de materii prime si a Romaniei in particular se justifica ca fiecare ţară să facă un efort mai mare, la nivel decizional şi legislativ. De o importanţă deosebită este Reference Document , document de referinţă pe cele mai bune tehnici disponibile (BAT) cu privire la managementul sterilului şi a rocilor sterile în cadrul activităţilor miniere. Acest document, denumit in Directive 2006/21/EC document privind gestionarea deşeurilor din industria extractive, oferă exemple de BAT pentru prelucrarea minereurilor, depozitarea in iazuri şi de gestionare a sterilului de roca din minereuri.