DO THE ACTIVITIES OF THE ROȘIA DE JIU QUARRY CONTRIBUTE TO THE CLIMATE CHANGE IN THE RELATED AREA ?

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Abstract: *Greenhouse gases (GESs) are gaseous constituents of the atmosphere, both natural and anthropogenic, which absorb and emit infrared radiation, being responsible for climate change. Currently, carbon has become the focus of scientists, politicians and the media, due to anthropogenic activities that generate large amounts of carbon, which has a significant impact on the global climate. In the Roșia de Jiu quarry, greenhouse gases are emitted by the fuel consumption of the mining equipment, as well as by the trucks for transporting the materials. Research on climate change due to the Roșia de Jiu quarry expansion activity includes calculations on greenhouse gas emissions from quarry equipment in 2019 and the capacity to store CO2 vegetation by type of land use.*
Key words: *greenhouse gases, climate change, carbon emissions, quarry*

1. The impact of the project on climate change

Climate change is a global challenge that requires a responsible approach, as well as the implementation of concrete actions at international, regional, national and local levels. [1]

The distribution of the impact caused by climate change highlights different risks, determined by vulnerability and exposure, by non-climatic factors (geological characteristics of regions, uneven distribution of solar heat, interactions between atmosphere, oceans and land surface) and economic and social differences.

In accordance with Commission Decision (EU) 2017/1471 of 10 August 2017 amending Decision 2013/162 / EU in order to review the annual emission levels allocated for the period 2017-2020, the level of emissions allocated to Romania at national level, covering all sectors are not covered by the greenhouse gas certificate trading system, it is presented in table 1.

Table 1. *The level of CO2 emissions allocated to Romania*

Member State	Tone CO_2 equivalent		
	2018	2019	2020
Romania	92 739 954	94 521 231	96 302 508

Permitted GES emissions have increased by 19% compared to 2005 emissions. Romania is expected to meet its GES emission targets for both the sectors covered by the greenhouse gas trading system and the which are not included.

In Romania, in 2016 it was approved by GD no. 739/2016, the National Strategy on Climate Change and Growth Based on Low Carbon for the period 2016-2020 and the National Action Plan for the implementation of the National Strategy on Climate Change and Growth based on low carbon for the period 2016-2020.

National legislation does not set permitted limit values for CO_2. For the industrial sector, Law no. 278/2013 on industrial emissions transposing Directive 2010/75 / EU, CO_2 is not included in the list of pollutants for which limit values are set.

As a member state of the European Union, Romania is committed to reducing GES emissions, in line with European obligations. All energy-intensive installations in Romania must participate in the European GES emissions trading scheme, EU-ETS. Romania has committed that, by 2020, 24% of final gross energy consumption in Romania will come from renewable sources.

2. Carbon footprint

Recently, a definition of „*carbon footprint*”, also called CO_2 footprint, is „*the total amount of greenhouse gas (GES) emissions caused by an organization, event or product*” [4].

The term carbon footprint is often used to indicate the contribution of human and industrial activities in terms of carbon emissions. Greenhouse gases which are taken into account in the calculation of the carbon footprint and which are considered to have an impact on climate change, are represented by [6]: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

The approach used to integrate climate change externalities, such as the carbon footprint, is based on the European Investment Bank's Carbon Footprint Methodology, which was developed in line with the European Union's carbon reduction proposals by 2050.

The steps in determining greenhouse gas emissions involve:

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- Quantification of greenhouse gas emissions (in this case CO_2) into the atmosphere due to project components; emissions are quantified on the basis of project-specific emission factors and are expressed in tonnes / year. The total amount of greenhouse gas emissions is calculated by summing the greenhouse gas emissions CO_2, converted into CO_2 equivalent.
- In order to be able to compare the environmental impact in terms of 'climate change' of different GES emissions, as the heating potential differs from gas to gas, international experts have agreed to use the term CO_2 equivalent (CO_{2eq}), using equivalence factors that refer to the heating potential. The equivalence factors between GES and CO_2 are defined for a given period of time (20, 100 or 500 years) and are regularly updated by IPCC references. The equivalence describes, for a given mixture and quantities of gases, the same heating potential in W / m^2 - („*global warming potential*” = GWP), when the measurements refer to a certain time interval (usually 100 years). Emissions of non-CO_2 GESs are converted to CO_{2-eq} by multiplying the value of GES emissions by a related global warming factor. [5]

Greenhouse gases have a different global warming potential. For example, one tonne of methane is equivalent to 21 tons of CO_2 and one tonne of nitrous oxide is equal to 310 tons of CO_2. To take this into account, the amount of emissions for each greenhouse gas is converted to carbon dioxide equivalent (CO_{2eq}), so that the total impact of the sources can be aggregated into a single figure. The impact of lignite mining in the Roșia de Jiu quarry on climate change is given by the greenhouse gas emissions resulting from the activity carried out. [3]

Considering the specificity of the works proposed by the exploitation of lignite in the Roșia de Jiu quarry, the following sources of GES emissions were taken into account:

Direct broadcasts:

a. CO_2 emissions from technological combustion processes;

Indirect emissions:

b. CO_2 emissions from electricity consumption - in particular from the use of fossil fuels for the production of electricity from the national grid;

c. CO_2 emissions from the combustion of fossil fuels in the engines of vehicles used for the transport of various auxiliary materials, waste and personnel.

Carbon storage and GES mitigation functions have become an international priority, as the Green Paper puts it, on „preparing forests for climate change”.

3. Potential sources of impact Roșia de Jiu quarry

- Land use change: these changes (removal of plant cover, occasional soil waterproofing, exposure of mineral surfaces, development of tracks) contribute to changing the energy balance at ground level. These variations remain microclimatic. (Table 2). [3]

- Road traffic related to the use of the site will contribute to the reduction of the ozone layer through the emission of greenhouse gases and energy consumption.

The activity of the Roșia de Jiu quarry in the Rovinari mining basin will probably not directly change the climate on a local or regional scale.

Table 2. *The situation of the lands on 1.03.2019 in the Roșia de Jiu perimeter,* [3]

Emplacement	Total area (ha)	UAT Fărcășești	UAT Bâlteni	Total license
Quarry	300.40	300.40	0.00	300.40
Internal dump	689.26	665.46	23.80	689.26
Outside dump	486.98	408.73	78.25	486.98
Surface mining unoccupied flow	**514.66 of which:**	**514.66**	**0.00**	**514.66**
Arable	3.95	3.95	0.00	3.95
Orchard	0.75	0.75	0.00	0.75
Grassland	121.67	121.67	0.00	121.67
Shrub pasture	47.70	47.70	0.00	47.70
Forest	337.12	337.12	0.00	337.12
TMS Pinoasa-Negomir circuit	2.24	2.24	0.00	2.24
DJ 675 B	1.23	1.23	0.00	1.23
TOTAL	**1,991.30**	**1,889.25**	**102.05**	**1,991.30**

4. The impact of the career on the microclimate

Up-to-date exploitation of the land changes the topography of the site by creating a space below. This can have several indirect consequences on the microclimate:

- *Modification of air flows*. Sudden variations in the relief of the excavations affect the air circulation, an amplified change as the depth and surface exploited increase;

- *Change in albedo*, ie the percentage of light reflected by the ground and the day-to-day operation and therefore by the returned solar heat. This impact is amplified by the absence of shadow (fig. 1);

- *Change in energy balance at ground level*, resulting from changes in land use (removal of plant cover, punctual waterproofing of soils, exposure of mineral surfaces, technological roads). Removing the plant carpet leads to the loss of CO_2 storage in the soil. These variations remain microclimatic;

- *Secondly*, we can finally observe a change in the infiltration of rainwater and, therefore, in soil moisture. [7]

Fig. 1. *Roșia de Jiu quarry - albedo modification*

All of these factors can cause changes in temperature and humidity.

The large exploitation area of 1991.3 ha, as well as the large extraction depth (from 200 ÷ 400m), by the fact that the filling of the remaining gap is coordinated with the exploitation, will not change the climate, even on a small scale.

Microclimatic variations remain imperceptible.

5. Impact on the global climate

On a large scale, like any anthropogenic activity, the Roșia de Jiu quarry, through the energy consumption of the equipment, contributes in part to the change of the terrestrial climate. This climate is changing:

- directly from the heat emitted by equipment, machinery and people;
- indirectly, through the emission of greenhouse gases.

The greenhouse effect is the consequence of the action of certain gases on the absorption of solar thermal energy by the Earth's atmosphere. Although this effect is becoming better known, there are still many uncertainties about the consequences.

In the Roșia de Jiu quarry, these gases are emitted by the fuel consumption of the mining equipment, as well as by the trucks for the transport of materials. The operator shall supply the entire exploited mass as far as possible and limit the movement of the equipment by using a conveyor belt which brings the extracted lignite directly to the coal deposit to reduce these impacts.

On the other hand, road traffic related to the use of the site will contribute to the reduction of the ozone layer through greenhouse gas emissions and energy consumption (Table 3).

Table 3. *Equipment engaged in Roșia de Jiu quarry activities*

Machine type	Cod SNAP	Specific consume
Bulldozer	080810	13÷16 l/h
Excavator	080805	28 l/h
Front loader	080823	15 l/h

However, at the local level, the impact on the climate remains insignificant.

Emissions of dust and gases specific to the activity of the equipment are assessed by the consumption of fuels and the area on which these activities take place (pollutants, suspended particulate matter and sedimentable).

Air pollution in the activities of refueling, maintenance and repair of means of transport is reduced.

The mobile equipment engaged in the activity carried out in the perimeter will generate emissions in the form of dust and flue gases (NO_x, SO_2, CO, CO_2, CH_4, NMVOC).

According to the Corinair methodology, the machines engaged in the quarry activities can be found in the chapter „*Other mobile sources and machine-activities 080100-081000*" in the category of machines in industry code SNAP 0808.

For transport activity performed with transport equipment larger than 3.5 tons and using diesel fuel, the emission factors are shown in Table 4.

Table 4. *Emission factors for flue gas components resulting from transport equipment of more than 3.5 tonnes*, [3]

Emission factors	NO_X	CH_4	VOC	CO	N_2O	PM	CO_2
g/km	10,9	0,06	2,08	8,71	0,03		800
g/kg diesel fuel	42,7	0,25	8,16	34,2	0,12	4,3	3138
g/MJ	1,01	0,006	0,19	0,80	0,003		73,9

Mobile emission sources, regardless of their type, run on diesel engines, the exhaust gases released into the atmosphere contain the whole complex of pollutants specific to internal combustion of diesel: nitrogen oxides (NO_x), nonmethane volatile organic compounds (VOC), methane (CH_4), carbon oxides (CO, CO_2), ammonia (NH_3), heavy metal particles (Cd, Cu, Cr, Ni, Se, Zn), polycyclic aromatic hydrocarbons (PAH), sulfur dioxide (SO_2).

The complex of organic and inorganic pollutants emitted into the atmosphere through the exhaust gases contains substances with different degrees of toxicity. Thus, in addition to common pollutants (NO_x, SO_2, CO, particles), there are substances with carcinogenic potential highlighted by epidemiological studies conducted under the auspices of the World Health Organization, namely: cadmium, nickel, chromium and polycyclic aromatic hydrocarbons (PAHs). There is also the presence of nitrous oxide (N_2O) - the substance incriminated in the depletion of the stratospheric ozone layer - and methane, which, together with CO_2, have global effects on the environment, being greenhouse gases.

The amounts of pollutants emitted into the atmosphere by machinery depend mainly on the following factors:

- technological level of the engine;
- engine power;
- fuel consumption per unit of power;
- machine capacity;
- age of the engine / machine.

Pollutant emissions decrease the more advanced the engine's performance, the trend in the world being the manufacture of engines with the lowest possible consumption per unit of power and with the most restrictive control of emissions. Moreover, these two elements are reflected by the dynamics of both EU and US legislation in the field. For the means of transport, the above assessments regarding the correlations between pollutant emissions and the technological level of the engine, fuel consumption per unit of power or per 100 km, age of the vehicle, etc. are also valid. [3]

Mass concentrations of pollutants in the emission / exhaust are imposed by NRTA 4/1998 (Car Transport Rules). By law, all vehicles are technically checked periodically, the proof of this verification being mandatory for traffic. This proof attests to the proper technical condition of the vehicles, including the classification within the permissible limits of the exhaust fumes.

The main emission area of the pollutants resulting from the transport activity is considered the range of the activity area extended laterally, on one side and on the other of the road axis by approx. 25m, which leads to an impact area of approx. 50m wide.

The equipment (excavator, bulldozer, front loader, tractor) instead moves over short distances in the work area; there is an even distribution of emissions across the work areas. Maximum concentrations of pollutants are achieved within this area.

6. Emission calculation for Roșia de Jiu quarry equipment

Calculul emisiilor cu efect de seră s-a realizat The calculation of greenhouse gas emissions was performed for the equipment used in the 9 quarries within SCE Oltenia SA, taking into account that in 2019 in the production and transport process were used approx. 208,000 l/year fuel (diesel). Table 5 shows the equipment used in the quarries and the GES emissions were calculated during the activity carried out. The GES emissions were taken into account when determining the emission factor for each greenhouse gas (see Table 5). At the level of the Roșia de Jiu quarry, the fuel consumption of 57 t/year of diesel.

The calculation ratios (1), (2) and (3) for CO_2, CH_4 and N_2O were used to calculate GES emissions. [8]

- for CO_2

$$E = \frac{C \cdot D}{10^6} \tag{1}$$

where:

D – emission factor CO_2, g/kg;
C – fuel consumption, t/an;
$C = A \cdot B$
A – fuel consumption, t/an;
B – diesel fuel emission factor, 74,1 t CO_2/TJ.

- for CH_4

$$G = \frac{C \cdot F}{10^6} \tag{2}$$

where:

F – emission factor CH_4, kg CH_4/TJ;
$C = A \cdot B$
A – fuel consumption, t/an;
B – diesel fuel emission factor, 74,1 t CH_4/TJ.

- for N_2O

$$I = \frac{C \cdot H}{10^6} \tag{3}$$

where:

H – emission factor N_2O, kg N_2O /TJ;
$C = A \cdot B$
A – fuel consumption, t/an;
B – diesel fuel emission factor, 74,1 t N_2O/TJ.

Table 5. *Calculation of GES emissions for quarry equipment, t/TJ*

Extractive industry	CO_2	CH_4	N_2O	Total
Equipment that serves the quarries from SCE Oltenia SA	43,515	14,680	7,046	**65,241**
Equipment that serves the Roșia de Jiu Quarry	4,835	1,631	0,782	**7,241**

7. CO2 storage and its recovery through greening processes

Globally, greenhouse gas emissions have been found to increase, thus concluding that efforts are needed to increase carbon sequestration as much as possible, both through forest ecosystems (forests) and pastures, which have grasslands. ability to act as carbon sinks. Carbon dioxide is the gas with the largest quantitative contribution to the greenhouse effect, the role of forest ecosystems in reducing the effects of GES emissions has always been appreciated.

The IPCC (International Panel on Climate Change) strategy, developed in 1992, suggested the creation of forests through plantations on very large areas that would lead to an absorption of carbon every year.

And in this situation, regarding the extension of the Roșia de Jiu quarry, in order to balance GES emissions, through a well-thought-out forestry policy, deforestation will be carried out in stages with the afforestation of tailings dumps, approximately the same area that will be removed from the forest fund. The contribution of forest ecosystems to carbon storage, respectively their capture and sequestration capacity. The research carried out in this field presented the capture capacity and the storage capacity in fact as some dynamic characteristics, potentially affected by climate variations. [8]

To study the impact of management on the GES budget, a management gradient of beech forests will be established, from equine stands to relatively perennial and perennial, with soil, growth and productivity conditions whose variability is minimized, including rare and relevant situations for Romania, such as natural forests or forested pastures.

For the extension of the mining field of the Roșia de Jiu quarry, it is necessary to remove from the forestry, agricultural and arable circuit an area of 295.62 ha, which will be spread over six years (see table 6).

In 2021, an area of 68.04 ha will be cleared, ie approx. 23.01% of the forested area. Simultaneously with the deforestation activity, afforestation works will be carried out on the inner tailings dump, on an area of 65.90 ha which represents approx. 9.56%. [3]

Deforestation of forest vegetation is done by distribution, strictly to ensure the work front in the current year for the following year. Removing from the forestry the entire area necessary for the advancement of the quarry in the following year is often difficult and also from the reasoning to protect the ecosystems will be removed from the forestry strictly the land areas necessary for the current activity in that year.

These are related both to obtaining wood in a wood-deficient area, and to the possibility of storing CO_2 and exploiting it on the international market.

On the other hand, by carrying out the provisions of this rehabilitation, a series of effects are obtained whose material value is difficult to establish, but which have a special importance:

- biodiversity conservation;
- creating a favorable climate for fauna;
- stopping rain and wind erosion on the soil;

The economic effects can be calculated taking into account the value of the wood obtained and the value of carbon storage on the international market.

The total carbon footprint at the Roșia de Jiu quarry extension is as follows:

4,835 t CO_2/year (quarry emissions) + 782.8 t CO_2/year (deforestation equipment emissions) + 44,521 t CO_2/year (deforestation) + 1,525.71 t CO_2/year (cereal crops) + 20,847.03 t CO_2/year (afforestation) = **67 681.375 t CO_2/year**

Table 6. *Closure and greening works according to the initial Plan for cessation of activity Roșia de Jiu quarry, sb. 805-840 / 2015*

Location / Period	Forest use (ha)		Arable agricultural use (ha)		Directions for use agricultural pasture / meadow (ha)	
	Step I modeling	Step II recultivation	Step I modeling	Step II recultivation	Step I modeling	Step II recultivation
Interior dump						
2021		65,90	20,00			
2022		50,10		20,00		
2023			39,70			
2024	55,60		58,75	39,70		
2025		55,60	119,00	58,75		
2026			27,37	119,00		
2027	168,00			27,37		
2028	168,00	168,00				
2029		168,00				
Total dump	**391,60**	**507,60**	**264,82**	**264,82**		
Quarry						
2027	204,00					
2028	204,00	204,00				
2029		204,00				
Total quarry	**408,00**	**408,00**	**0,00**	**0,00**		
Utilities						
2026					8,50	
2027					42,05	8,50
2028						42,05
Total utilities (enclosure, coal depot, etc.)	**0,00**	**0,00**	**0,00**	**0,00**	**50,55**	**50,55**
Grand total	**799,60**	**915,60**	**264,82**	**264,82**	**50,55**	**50,55**

8. Conclusions

For a correct analysis of the effects of the project on climate change, the project proposed by the Roșia de Jiu quarry extension must also be considered. The reduction of greenhouse gas (GES) emissions will be achieved by reintroducing degraded lands into the economic circuit through afforestation to the detriment of degraded lands is significant.

It is estimated that by using the equipment in the Roșia de Jiu quarry of diesel in the internal combustion engines of vehicles, a quantity of 4,835 t CO_2 emissions / year is saved.

It has been scientifically proven that by deforestation of 277.7 ha of forest, which will take place over 6 (six) years, the stored amount of CO_2 decreases from 21462 t CO_2/year to 289 t CO_2/year with the disappearance of the forested area. In compensation with the reintroduction in the economic circuit of 264.82 ha by the installation of cereal crops, the stored quantity of CO_2 starts to increase from 116.04 t CO_2/year to 688.37 t CO_2/year. By afforesting an area of 915.60 ha, the stored amount of CO_2 will be progressively increased by 127.80 t CO_2/year in order to reach 16159.73 t CO_2/year in the last planting year.

How the proposed project influences climate change is presented in Table 7.

Table 7. *Effects of the project on climate change*

Positive effects	Negative effects
Rehabilitation and conservation of soils through cereals, pastures and afforestation of **1230.97** ha of degraded land, and as a major goal - contributing to the implementation of the provisions of the United Nations Framework Convention on Climate Change (UNFCCC, 1992), as well as of the mechanisms of the Kyoto Protocol (1997). Amount of CO_2 estimated to be saved: **22,372.74** tons of CO_2 / year.	GES emissions from production activity (excavators, bulldozers etc.), deforestation activity, energy consumption in the network, transport of auxiliary materials and waste. The total amount of GES emissions estimated for the year of operation will be **787.635** tons / year. Deforestation of an area of **277.72** ha which will contribute to reducing the amount of stored CO_2 by **10%**.

Although there are several objectives that can lead to GES reduction (such as ecological rehabilitation of land degraded by crops that develop rapidly in the first years after installation) we will focus on those implemented by the project proposed by the extension of the Roșia de Jiu quarry.

The composition of planted species will help restore land productivity. For the project were selected tree and shrub species, which are effective for restoring degraded land, meet the socio-economic requirements of municipalities and contribute to increasing biodiversity. Species with similar characteristics and care requirements are grouped into species types, as follows:

Acacia type: Robinia pseudoacacia, Gleditsia spp., Acer spp., Cornus mas, Prunus spp., Rosa canina, Ribes spp., Crataegus spp .;

In addition to harvested forest products, the net reduction of CO_2 emissions into the atmosphere in the first 20 years will be 416,940 tons.

By afforestation of unproductive land, the application of agro-forestry practices, the creation of forest protection curtains, carbon sequestration and the reduction of greenhouse gas concentrations, the project will contribute to improving regional and local forest and pastoral resources, timber supply and developing the basis for sustainable development. local / regional.

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