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POSSIBLE IMPACT OF MINING AND PROCESSING THE ROŞIA MONTANĂ GOLD-BEARING ORE UPON SOIL

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Résumé. Les données sont présentées considérant la nature des sols de la zone de Rosia Montana (Alba Country). La situation actuelle des sols est conditionnée par leurs niveaux de charge en métaux lourds et par la capacité d`amortissement de leurs réactions. Le possible impact polluant des métaux lourds provoqué par l`exploitation et la transformation des minerais est conditionné aussi par le contenus relatif baissé des métaux lourds des roches porteuses des minerals et dans les roches mortes(terril). Les possibles types et formes d`impact sur le sols des la zone de Rosia Montana comme conséquence de la construction et des travaux d`exploitation.

1. Introduction

SA Roşia Montană Gold Corporation has been developing prospecting works and studies, as well as environmental studies, in order to mine the gold bearing ore from Roşia Montană. The target area includes most of the land surface that has not been affected by the old mining activities, but also some land where such activities have been developed, especially underground. The objective of the researches carried on was to establish the actual soil pollution level as well as the possible polluting impact of the ore mining and processing to be developed. In addition, some measures to reduce the polluting impact are proposed.

2. Material and methods

The research area, of 1,646.32 ha, mainly includes the Roşia Montană and Corna localities. It is bordered by the interfluve between Valea Roşie and the Vârtop Valley in the Northern part, by the interfluve between Corna and Abruzel valleys in the Southern part, by the interfluve between the springs of Vârtop, Roşia, and Corna brooks at East, and by an imaginary line connecting the Iacobeşti village to the Corna valley in the West.

Inside this perimeter field works were developed for soil mapping and sampling for analyses. The main physico-chemical soil indicators were determined in the laboratory in order to establish soil types and sub-types and the heavy metals contents. Soil vulnerability to base depletion, acidification, and aluminium solubilization were computed, using a method described by Holowaychuk and Fessenden in a Canadian methodology (1999), as well as the soil buffering capacity for reaction, using the Borlan et al. (1995) method. Land surfaces which will be degraded by the construction and mining activities were also computed.

3. Result and discussions

3.1. Soil nature

In Table 1 the soil types from the Roşia Montana area, determined according to the new Romanian Soil Taxonomy System (SRTS-2003), and also according to the old soil classification system in use for more than 20 years (SRCS – 1980) are presented.

Almost half of the investigated area is covered by dystricambosols, ex acid brown soils. In decreasing order, eutricambosols follow, ex brown eumezobazic soils and lithosols. All these soils are predominantly acid. Following the decreasing series, regosols occur on 6.12% of the surface, with predominantly neutral – slightly alkaline reaction, and andosols along with coluvic alluviosols, which cover only 0,4% of the surface. Rock associated with lithosols cover 1% of the surface.

Table 1

Soil types distribution in the Roşia Montană area

Nr.	Soil type		Surface	
	SRTS - 2003	**SRCS – 1980**	**ha**	**%**
1	Eutricambosol	Brown eumezobazic soil	429.52	26.09
2	Dystricambosol	Brown acid soil	786.07	47.74
3	Andosol	Andosol	4.57	0.27
4	Lithosol	Lithosol	182.53	11.08
5	Regosol	Regosol	100.80	6.12
6	Colluvic aluviosol	Colluvisol	1.73	0.12
7	Rock in association with lithosols		16.52	1.00
	Total soils		**1,521.38**	**92.42**
8	Quarries		122.38	7.43
9	Lakes		2.21	0.15
	General total		**1,646.32**	**100.00**

3.2. Soils natural heavy metals loading level

The statistical parameters of the heavy metals contents in the soils of the investigated area (Table 2) point out large content intervals which include both

Table 2

Statistical parameters of the heavy metals contents (mg/kg) in the soils of the RMGC area, as compared to the normal values (NV) and with the alert threshold (AT) and intervention threshold (IT) values for land sensitive use (MAPPM Order nr.756/1997)

Statistical parameter	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn
N	153	153	153	153	153	153	153	153
x_{min}	0.5	11	11	8	80	13	12	26
x_{max}	10.1	67	79	39	2187	114	90	272
$\bar{X}$	1.2	30	30	18	645	49	36	88
Σ	1.1	12	14	5	340	25	14	35
Xg	1.1	28	27	17	331	43	33	82
Me	1.0	27	26	17	573	44	35	83
Mo	1.1	26	22	16	519	39	33	82
NV	***1.0***	***15***	***30***	***20***	***900***	***20***	***20***	***100***
AT	***3.0***	***30***	***100***	***100***	***1500***	***75***	***50***	***300***
IT	***5.0***	***50***	***300***	***200***	***2500***	***150***	***100***	***600***

Table 3

Percentage repartition of the soil samples (n = 153) in the Roşa Montană area, on heavy metals abundance classes, depending on the alert threshold (AT) and intervention threshold (IT) values, according to the MAPPM Order nr.756/1997

Chemical element	**Value classes**			
	normal	**up to the alert threshold limit (AT)**	**great, between the alert threshold (AT) and the intervention threshold (IT) limits**	**over the intervention threshold (IT) limit**
Cd		97	1	2
Co		34	53	13
Cr	50	50		
Cu	64	36		
Mn	80	17	3	
Ni		83	17	

Pb		84	16
Zn	52	48	

normal values, values ranging up to the alert or intervention threshold limit, and greater than these (Table 3). But most of the samples have normal values, included in the background range or up to the alert threshold limit. Only 66% of the Cd values and 17% of the Ni values or 16% of the Pb values are included in the interval between the alert and intervention thresholds, or greater than the latter.

Therefore, the soil cover from the investigated area has a heavy metal loading level equivalent to the region's pedogeochemical background.

3.3. Soil vulnerability to base depletion, acidification, and aluminium solubilization

The predominantly acid soils from the Roşia Montană area have, by nature, a high percentage of base depletion and aluminium solubilization. As a consequence, their further vulnerability to these processes can't be too high. Indeed, our data regarding these processes, in the possibility of their release under the influence of an acidifying anthropic impact, separated by main soil types (Table 4), point out low and medium domains, except for the aluminium solubilization, which shows a medium and high intensity in dystricambosols. But these vulnerability levels, corroborated with similar processes in natural conditions, determine a large range of processes and chemical reactions in acid medium which demand measures for the rectification of the acid reaction in order to preserve the usual pedo- and bio-geochemical equilibriums.

3.4. Soils reaction buffering capacity, assessed by the values obtained through logarithmation of the ratio between the sum of exchangeable bases and hydrogen ions activity, has different intensities, from low to medium, for each soil type except for the brown eumezobazic soils. These buffering capacities have values up to 5.1, as compared to those specific for the high and very high domains, which reach 5.6 and even more.

Therefore, in quasi-natural conditions, the soils from the Roşia Montană area, on which mining and industrialization of the gold bearing ore is intended, are predominantly acid, with a low up to medium vulnerability to base depletion, acidification, and aluminium solubilization, with a low up to medium reaction buffering capacity, and with a normal heavy metals content, within the pedogeochemical background of the region.

Table 4

Percentage repartition of the general vulnerability and of the vulnerability to base depletion, acidification and aluminium solubilization of the soils from the Roşia Montană area, depending on the soil type

Nr.	Soil type	Values significations	Vulnerability to:			General vulnerability
			base depletion	acidification	aluminium solubilization	
		low	87	91	-	91
1.	Dystricambosol	medium	13	9	35	9
		high	-	-	65	
		low	80	70	60	80
2.	Eutricambosol	medium	20	30	40	20
		high	-			
		low	40	80	40	40
3.	Lithosol	medium	60	20	60	60
		high	-			

Table 5

Average heavy metals content (mg/kg) of the Roşia Montană mineralization bearing rocks as compared to the Clark values* (according to the analytical data provided by RMGC)

Localization	Nr. of samples (n)	Cd	Co	n	Hg	n	Pb	Zn
Cârnic	394	0.51	7.05	229	0.17	394	41	129
Cetate	402	0.51	7.15	173	0.08	402	39	136
Jig	194	0.33	16.10	194	0.07	194	56	147
Orlea	118	0.40	11.30	118	0.03	118	42	132
TOTAL */ average value*	***1108***	*0.47*	*9.13*	***714***	*0.10*	***1108***	*43*	*135*
Clark*		***0,13***	***18***		***0.05***		***16***	***83***

- From Fiedler and Rösler (1988)

Table 6

Statistical parameters of heavy metals content (mg/kg) of the Roşia Montană dead rocks, as compared to the Clark values

Chemical element	n	x_{min}	x_{max}	$\bar{x}$	σ	cv (%)	Clark*	Enrichment factor
Cd	64	0.03	1.20	0.27	0.38	142	0.13	2.08
Co	64	1.8	31	14	10	71	18	0.78
Cr	64	1	79	33	16	49	83	0.40
Cu	64	12	129	59	42	74	47	1.26
Mn	64	147	7380	1504	1430	95	100	1.50
Ni	64	2	95	25	26	104	58	0.43
Pb	64	8	133	29	20	67	16	1.81
Zn	64	6	424	116	89	77	83	1.40

3.5. Possible heavy metals impact due to the ore mining and industrial processing

A possible preceding heavy metals contamination of soils could take place during mining works in the quarry and industrial processing of the ores and bearing rocks, should these ones contain significant quantities of such chemical elements. But chemical analyses performed on 1,108 mineralization bearing rocks samples (Table 5) and on 64 dead rocks samples (Table 6) showed that these materials contain heavy metals at the geochemical background level of the area. Thus, the mineralization bearing rocks have an enrichment factor below 1 for Co, and above 1, but with low values, for the other chemical elements, namely: Cd (3.6), Hg (2.0), Pb (2.7), and Zn (1.6). This parameter's values are even lower in the dead rocks (Table 6).As a consequence, the possibility of soils heavy metals contamination during ore mining and industrial processing is slight.

3.6. Forms of soil impact as a consequence of construction and mining works

Different field surfaces will be stripped, which totalize 973.47 ha, in order to carry on the construction and mining works. A mine waste and waste water mud-setting pond takes up most of it (37.3%). The quarries (22.7%), depositions (18.2%), roads (9.5%), the processing factory (5.3%), deposits (2.9%), collecting channels (2.3%), an acid waters lake (1.7%), and works organization (0.1%) follow, in a decreasing order.

11.5 million m^3 will be stripped from the upper horizons, and 5.8 million m^3 from the lower ones. It results that soil removal from the areas where different industrial units will be built represents the main negative effect on soil. Deposition of stripped soil, for a few years period, leads to chemical and microbiological modifications in its mass. The possibilities to ecologically reclaim the land come along with the deposited soil recycling for the reconstruction of the soil profile.

Taking into account the whole technological cycle involved by the constructions, mining, and industrial processing of the Roşia Montană gold bearing ore, the soil can stand ten impact types (Table 7). Each type has been assessed according to its nature, intensity, direction, and duration. Out of the ten impact types, six are direct, and four indirect, most of them do not last long, all have negative meaning, six of them are reversible, and only four are irreversible. Two impacts regarding stripping and landslides are permanent, the others are temporary.

Measures of intensity diminution have been foreseen for all the ten negative impact types (Table 7).

Conclusions

The soil types and subtypes which were delimited in one type units or in associations are represented by: a) eutricambosols (brown eu-mezobasic soils) with the typical, andic, and andic-lithic subtypes; b) dystricambosols (brown acid soils) with the typical, andic, lithic, and andic-lithic subtypes; c) typical regosols; d) typical lithosols; e) typical coluvisols.

At the present, the soil cover is slightly polluted with Cd, Co, and Ni. Most of it has a heavy metals loading level equivalent to the region's pedogeochemical background.

Generally, soils are relatively acid, with a low up to medium reaction buffering capacity and a low up to medium vulnerability to acidifying impacts.

Taking into account the heavy metals abundance in the mineralization bearing rocks and in the dead rocks, as well as the technology to be applied in construction and mining, there is a slight possibility that the soil from the un-stripped areas be highly polluted with heavy metals, so that the values of alert or intervention thresholds are reached.

Accidentally, in the operation, closing, and after closing phases local pollution incidents can occur, with different technological chemical substances or fuels.

Most of the solid particles released during operation, due to detonations and transport, return to the quarry site. The possibility of surrounding soil pollution with heavy metals or by acidification is slight.

Stripping the soils on a 973 ha surface is proposed for the construction and operation works. The soil will be deposited in stockpiles.

As a consequence of the construction, operation, and ore industrial processing works, ten types of direct or indirect impact were separated, of low and medium intensity, with negative effect, partially reversible, and most of them temporary.

Measures to diminish each impact type have been proposed.

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