4.4. Soil

Authors:

I.NC.D.P.A.P.M. Bucureşti

Prof. dr. R. Lăcătuşu
Prof. dr. M. Dumitru
Dr. C. Simota
Dr. I. Piciu
Gh. Curelariu
Dr. I. Rîşnoveanu
Dr. I. Seceleanu
Beatrice Kovacsovics
Dr. Nineta Rizea
Nicolata Vrînceanu
Rodica Lazăr
Dr. Mihaela Lungu
Dr. S. Matei
Dr. Mirela Matei
Dr. Gabriela Mihalache
Dr. Anca Voiculescu
George Cojocaru
Dr. Roxana Enache
Ioana Nilca
Dr. Elisabeta Dumitru
Irina Calciu
Lucica Mihaela Dragotă
Dr. M. Mihalache
Dr. Sp. Chivulete
Il. Calciu
C. Lazăr

O.S.P.A. Piteşti

I. Creangă
D. Bucur
R. Buşu

O.S.P.A. Alba

I. Mărginean
I. Ilie

AMEC Earth & Environmental

George Citu, M.Sc., A.Ag.

Table of Contents

List of Tables

List of Figures

Appendices

1 General Information

1.1 Research Purpose

This study was conducted for the Roşia Montană Project. It examines changes of the soil cover following gold ore extraction and processing operations. The assessment included the amount of stripped soil, potential changes undergone by the stockpiled soil, and the contribution of stored soil to the ecological reconstruction of land degraded by open pit extraction and ore processing operations. The necessary conditions for soil cover restoration in the impacted areas during the closure of extraction and processing operations was also assessed.
Special attention was given to soil pollution issues, the forecasting of soil impacts during ore extraction and processing operations, and the impact mitigation measures. Emphasis was placed on issues related to land and its limitations, such as erosion, slides, current land use and types of management.

1.2 Study Area

The investigated site is bordered in the north by the Roşia and Vârtop inter-river; in the east by the inter-river separating the headwaters of the Vârtop, Roşia and Corna streams from the streams flowing to the north-east into the Aries or to the east. In the south, it is bordered by the inter-river of the Corna and Abruzel Valleys, and in the west by a conventional north-west to south-east, and then north-south line connecting the north of Iacobesti Village to the south lying Sălişte Hill, Sălişte Valley, Baiesilor Hill and Corna Valley.
The total study area covers 1646.32ha. Soil studies were not conducted on a 17.57ha area, where water supply and electrical power lines will be developed. This area will be excluded from agricultural and forestry land uses and will be subject to a separate soil study.

1.3 Natural Environment

1.3.1 Relief

The nature of topographical relief is determined by the diversity of the geological formations. Volcanic formations dominate, in a number of massifs, including: Cârnic, Cetate, Rotunda, Curmătura, at elevations over 1000m and up to 1300m.
Most of the area is less than 1,000m high, with the lowest areas lying 550-580m in the Roşia Montană depression.
Sedimentary formations give rise to a hilly relief of gentle slopes. Some steep slopes are present near valleys and streams throughout the area. The river system shaped the land in the form of hills and ridges, separated by deep valleys.

1.3.2 Geology - Lithology

The gold and silver ores at Roşia Montană, of the epithermal type, are associated with volcanic and sub-volcanic bodies of andesite-dacite of Neocene age, intruding into a varied lithology The sub-volcanic dacite bodies at Roşia Montană have primarily intruded into a maar-diatreme complexe hosted within Cretaceous age black shale.

The *Cretaceous sediments*, including pyritic black shale, laminated chalks, clayey sandstone, coarse grained sandstone and conglomerate beds with large rounded casts, cover a large part of the study area.
Dacitic intrusions are characterized by the presence of plagioclase feldspar and quartz phenocrysts, of grainy porphyry texture. The dacite and brecciate is fractured, with mineral depositions along the cracks. In the breccia matrix, mineral depositions include sulphides.
A *magmatic breccia* was identified around the dacite domes within the maar-diatreme complexe. The breccias are interspersed with sandstones, conglomerates, porphyries, mica-

shales and a diversity of micro-crystals. The breccia is of pyroclastic origin, formed when the vapours and gases separated from the groundwater flow. The rock is also known as "micro-conglomerate" or "vent breccia".

Black breccia, or phreatomagmatic breccia, is dark brown, black, with a black clay or sandstone-clay matrix. It is made of quartz crystals, weathered feldspar crystals, muscovite and biotite lamelle and scattered pyrite. This type of rock formed when the ascending magma reached the groundwater table.

Other*, phreatomagmatic breccias*, also occur, termed mixed breccia, similar to black breccia, but lacking the black colour and the high clay mineral content.

Within the dacite bodies the rock is variably brecciated, from *fissure breccia* all the way to *matrix breccias.* These breccias are strongly silicified.

The *andesites* overlay the Cretaceous sediments and vent breccia surrounding the Cetate and Cârnic massifs. Andesite, with hornblende and grey feldspar phenocryss, of slightly orientated texture, occurs on the ridges north of Roşia Montană. In parts, the grey andesite is overlain by a pink-brown andesite, with feldspar phenocryss, some hornblende and no orientated texture.

From a *structural* point of view, the Cretaceous sediments are folded around predominantly east-west axes and were broken by faults. The main directions of these faults are NW-SE, NE-SW and N-S.

The younger Miocene intrusions, the Roşia Montană breccias and the andesites at Roşia Poieni, were interrupted by the same fault lines, however, the phreatomagmatic breccias and the vent breccia were not folded, although they show a variety of orientation due to displacement and rotation in faulting.

The *gold and silver mineralization* is especially related to the dacite and mixed breccia, sometimes hosted within the mixed breccia, and is associated with scattered sulphides and native gold and silver. The mineralization displayed by vent breccia is in the form of mineralized stockwork, veins and weathering bands.

1.3.3 Climate

The climate of the study area is temperate continental. The average multi-annual temperature is 6^{o}C, with seasonal variations. Winter averages are -5.5^{o}C, and summer averages 16-17 ^{o}C. The first frost occurs around October 1st and the thaw occurs around May 1st. The snows cover measures 35-40cm, while snowdrifts may be up to 1.5m deep. The average multi-annual precipitation is about 800mm. The highest rainfall occurs in the spring, and sometimes summer, in the form of foehn.

The dominant winds are westerly, with strong foehnal circulation that melts the snow and raises water levels in the surface water bodies.

1.3.4 Hydrography – Hydrogeology

1.3.4.1 Surface Water

Permanent watercourses include the Roşia and the Corna, the first originating in Tăul Țarina, Tăul Mare and Tăul Brazi, then passing the villages of Roşia Montană, Bălmoşeşti, Ignăţeşti, Iacobeşti to flow into the Abrudel River at Gura Roşiei. The stream collects Acid Rock Drainage (ARD) resulting from the oxidation of sulphide minerals, which gives it a reddish-yellow color, due to the precipitation of iron oxides leached from the volcanic rocks. The name of the stream was based on its color [Roşia = Red]. Its maximum flow rate is 300 l/minute.

The Corna stream, originating from Taul Corna, crosses through the communities of the same name and flows into the Abrudel River in the town of Abrud.

The Saliste stream flows west; draining the area between the Roşia and the Corna Valleys, and also discharges into the Abrud. A decant pond was developed on this stream.

Apart from the permanent watercourses, there are a number of semi-permanent streams, manifest only during heavy rainfall or snowmelt. They are torrential in nature, and have the highest flows in spring.

The **lakes** in the Roşia and Corna catchments were built in order to operate the gold ore stamps mills. There are five lakes of this kind, including: Tăul Mare, Țarina, Brazi, Anghel and Corna. They are located at elevations ranging from 950m (Țarina) to 1,000m (Tăul Mare). The largest is Tăul Mare.

1.3.4.2 Groundwater

The geological composition, of low permeability rocks, makes groundwater in the Roşia Montană area rather scarce. Active springs, often go dry over summer. They are present at the interface between the sedimentary rocks and the massive compact rocks.
Groundwater appears as captive water tables emerging in delluvial deposits, following accumulation of storm waters.

1.3.5 Vegetation

The dominant vegetation of the study area includes a complex of meadows, orchards, and scattered local vegetable plots.
Meadows include a variety of floristic species such as: *Trifolium arvense, Spergula arvensis, Setaria virids, Gypsophila muralis, Gnaphallium uliginosum, Centaurea phrygia, C. scabiosa, Cynosurus cristatus, Plantago lanceolata, P. media, Poa pratensis, Poligonum aviculare, Silene sp., Calamagrostis epigegas, Calluna vulgaris, Poa pratensis, Festuca pratensis, F. rubra, Agrostis stolonifera, A. tenuis, A. capillaries, Alopecurus pratensis, Sieglingia decumbens, Glyceria maxima,* with local patches of *Juncus gerardi, Puccinelia distans, and Deschampsia caepitosa.* The orchards contain species of Malus*, Prunus, Pirus, Rubus,* etc.
Forest vegetation is dominated by species of *Fagus* and *Carpinus*. *Fagus silvatica* is predominant among them. At higher elevations, the dominant species are *Abies* and *Pinus* and along the watercourses other species include: *Betula, Populus* and *Salix*. On the historic mining sites, *Betula pendula, Pinus sylvestris* and *Populus ternula* also make an appearance. *Vaccinum myrtillus* and *Vaccinum vitisidea* my also be encountered.

1.4 Material and methods

In the soil mapping, consideration was given to the principles and criteria included in the “Methodology for the Development of Soil Studies" (INCDPAPM, 1987) for studies conducted in mountain areas (rough terrain area).
The topographic basis was provided by SC Roşia Montană Gold Corporation SA (RMGC) and included a topographical map with a scale of 1:10,000, with elevation (primary and secondary contours, heights), and planimetric elements (communication roads, communities, rivers, lakes, land use categories, including the limits of the study area).
During the site investigation, the soils were mapped and approximately 140 primary and secondary soil profiles and surveys were developed. These profiles and surveys provided an average density of 7-8 observation points per 100ha. According to the applicable norms Profile, the locations were established based on GPS, and each profile was photographed (see Initial Conditions Study of Soil Impacts from Gold ore Extraction and Processing Operations at Roşia Montană – Database, INCDPAPM Report, 2003).
Soil samples were collected from 40 main profiles. Twenty-four plots were located in the purchased area and 16 plots were pre-contracted by RMGC, as indicated by the latter. A total of 157 samples of disturbed structure and 317 samples in metal tubes (in natural sequence) were collected. In addition, 41 samples were collected from the fertile horizon for the purpose of microbiological analysis.
Furthermore, hands-on local information was collected regarding the relief (forms, gradients, etc) lithology, hydrology (including slopes), vegetation, and land use categories on the site.
The desk study included development of: a soil map, a land map, a soil texture, skeletal content map for horizon A, a GIS-based map of the parent materials, a map of soil vulnerability to acidification, land suitability maps for meadows and hay-meadows, apple and potato crops, and maps of estimated soil loss to erosion if covered or not covered with vegetation.
The ESR ArcInfo software for GIS applications was used in generating all the maps. The GIS files are of the ESRI shapefiles type. For the soil loss estimation maps, a method developed for INCDPAPM by Simota (1997), based on the USLE equation, was used.

Surfer 8 was used for calculating soil volumes, 3D modeling of surfaces and ESRI shapefiles.

The analytical data were used in calculating soil vulnerability and its reaction buffering capacity. A report was drafted in the format presented in the following.

In the laboratory, the samples collected from the profiles were subjected to a variety of physical, chemical and microbiological tests.

Physical analyses included 6 indicators (10 fraction granulometric analysis, moisture, bulk density, total porosity, resistance to penetration, hydraulic conductivity), for a total of 1902 determinations. Additionally, the shrinkage index was also calculated.

Chemical analyses included 21 indicators (pH_{H_2O} ,pH_{NaF}, $CaCO_3$, SB, SH, T, V, organic content, total nitrogen, heavy metals - Fe, Mn, Cd, Cu, Cr, Co, Pb, Zn - mobile forms of phosphorus, potassium and aluminum). A total of 1521 chemical determinations were completed.

Soil reaction was established potentiometrically by determining the pH of the aqueous suspension and of the sodium fluoride. The latter was only determined for andic-type soils.

The ***$CaCO_3$ content*** was determined gas-volumetrically by means of a Scheibler device.

The cation exchange capacity indicators were determined by volumetric methods (SB base alkali sum by the Kappen method, exchangeable hydrogen by CH_3COOK 1n percolation to exhaustion and solution titration using NaOH 0.05n), while the total cation exchange capacity (T) and the alkali (B) saturation degree were assessed based on calculation.

Organic matter (Organic C) was determined titrimetrically, by means of the Walkley – Black method, in the Gogoasa modification.

Total nitrogen was determined using the Kjeldahl method.

Heavy metals (Fe, Mn, Cd, Cu, Cr, Co, Pb, Ni, Zn) were determined by means of atomic absorption spectrometry in a hydrochloric solution, obtained after disaggregating the soil sample with a mix of HNO_3 and $HClO_4$.

Mobile forms of phosphor and potassium were determined in an ammonium lactate acetate at pH 3.7 (AL), by visible spectrophotometry, and flame photometry, respectively.

Exchangeable aluminum was determined using the Sokolov method.

Microbiological analyses included quantitative and qualitative determinations of bacteria, fungi and soil respiration, for a total of 123 determinations.

The micro flora of the collected samples was analyzed using the serial soil dilution method (Pochon1958). To this end, successive decimal dilutions inseminated on special media were conducted, i.e. the Czapek medium for fungal micro flora and the Topping medium for bacterial flora on Petri dishes. After characteristic incubation periods for each group, the fungal and bacterial colonies developed on the medium out of the breeding elements of spore or hypha type were quantitatively/qualitatively assessed and taxonomically identified, according to the classic microbiological techniques.

The global physiological activity of the micro-organisms of the analyzed soil samples, expressed by the level of potential soil respiration, was determined by assessing the amount of CO_2 released by the total spectrum of the sample micro-organisms after using an accessible source of carbon in a standard precinct, over the unit of time and with maintenance of a constant oxygen concentration within the respirometer (Stefanic method, 1991). Soil respiration, as a parameter for the global assessment of soil biota activity, is a measure of the intensity with which various processes develop in the soil, involving micro-organisms (bacterial and fungal micro flora), as well as soil micro- and meso-fauna, respectively.

2 Soil Cover

Environmental conditions (relief, surface lithology, climate, vegetation) determined the formation of a diverse soil cover. Its diversity is apparent at type and sub-type level, especially in the lower levels, given the soil and terrain characteristics of the respective areas and determining the rules of its distribution.
Based on the data obtained from soil mapping, soil and land maps have been developed.
A review of the soil map (Figure 2) shows that 8 soil units were defined in the study area, by type and sub-type, and 19 units of soil type and sub-type associations in various proportions (see key to the maps, Appendices).
The soil types and sub-types defined as mono-type (pure) or associations include:

- Brown, eu-mesobasic soils with the andic, lithic and andic-lithic sub-types
- Brown, acid soils with the typical, andic, lithic and andic-lithic sub-types ;
- Typical and lithic regosols;
- Typical lithosols
- Typical colluvisols.

Soils were defined according to the principles and criteria of the Romanian Soil Rating System (1980) and further correlated with the World Reference Base for Soil Resources (WRB-SR, 1998).
By processing and summarizing the various soil (thickness, parental material, parental material granulometry, textural class of the soils, skeletal content by soil profile) and land characteristics (relief, main forms of relief, micro-relief, gradient, underlying rock), the land unit map was developed (Figure 4.4.3) using the land formula including the above characteristics.
A review of the land map and of the attached key (Appendices) suggests that 46 land units have been defined in the study area.

2.1 Soil Types and Sub-Types

2.1.1 Typical Bruni Eu-mesobasic Soils (Eutric-Cambisols)

2.1.1.1 General Description

Commonly occurring over the Corna Valley catchment, on the inter-river between the Corna and the Roşia, on a slightly to medium rough terrain (elevation 600-800m), with short or long uniform or non-uniform slopes of moderate (12-25%) gradient. These soils were distinguished on the map as mono-type units, but also as associations with brown eu-mesobasic lithic soils, typical acid brown soils or typical regosols. They developed on clay or clayey-flysh parental material with sandstone sequences. The described and analyzed profiles are located on the map in (Figure 4, Appendices), under numbers 26, 25, 32, 36, 38, 39, 40.

2.1.1.2 Morphological Description

The soil profile is well developed, ranging in thickness between 56–70cm (semi-deep soil), and 110cm (strong deep soil) and of morphological type Ao – AB – Bv – Cn or Cn/R. The thickness of the fertile horizon Ao is 15 – 25cm. They are slightly – strongly skeletal soils, with skeletal content (particulates >2mm, including grit and cobbles) accounting for 6–75% of the volume; high skeletal content (51–75%) is encountered in the deep horizons.

2.1.1.3 Description of the Physical Characteristics

The texture of the Ao horizon (Figure 5, Appendices) ranges from sandy loam (dusty sandy loam) to medium loam (dusty loam) with a clay <0.002mm content of 13.5 – 31.3% and is maintained along the profile (18.2 – 30.3% clay < 0.002mm).
Bulk density is extremely low to low (0.76-1.33g/cm^3) in the fertile horizon and very low to medium (1.21 - 1.46g/cm^3) along the profile. Total porosity is high to extremely high (50 - 62% of the volume) in the Ao and medium to very high (47 - 55% of the volume^3) along the

profile. The values of saturated hydraulic conductivity (17 – 68mm/h) indicate high to very high permeability for water in the soil.

2.1.1.4 Description of the Chemical Characteristics

The reaction of the typical eu-mesobasic brown soils ranges form medium to slightly acid (pH_{H_2O} 5.1 - 6.8) in the Ao horizon and medium acid to neutral (pH_{H_2O} 5.2 - 7) along the profile. The total cation exchange capacity is low to medium (13.2-29.1 me/100 g soil) in the Ao and low (11.65 -17,70 me/100 g soil) along the profile. Based on alkali saturation, the soils are meso-eubasic (V 55 – 83%). The humus content of the fertile horizon is appreciated as low to medium (2.4 - 6.2%) in relation to texture, and the supply of total N (0.159 - 0.343%) is low to high.

Analysis of the microbiological characteristics in grouping the profiles by type of soil shows that there is a medium to scarce micro-organism population in the superficial horizon, with a commensurate level of physiological activity, with variations depending on the specifics of the existing situations in every type of soil, and on the particulars of the soil profiles classified under the respective type.

2.1.1.5 Microbiological Description

Typical eu-mesobasic brown soils and lithic eu-mesobasic brown soils in the analyzed profiles display more favorable conditions for bacteria development (88.5 x 10^6 of viable cells/g of dry soil) (Figure 4.4.1) than for fungi (46.4 x 10^3ufc/g dry soil) (Figure 4.4.2) with the former group richer in species, and the latter less diversified, and the respective communities frequently displaying potentially plant-pathogen genera (*Fusarium, Alternaria, Phytophthora*).

Figure 4.4.1. Average level of bacterial micro-flora by type of soil

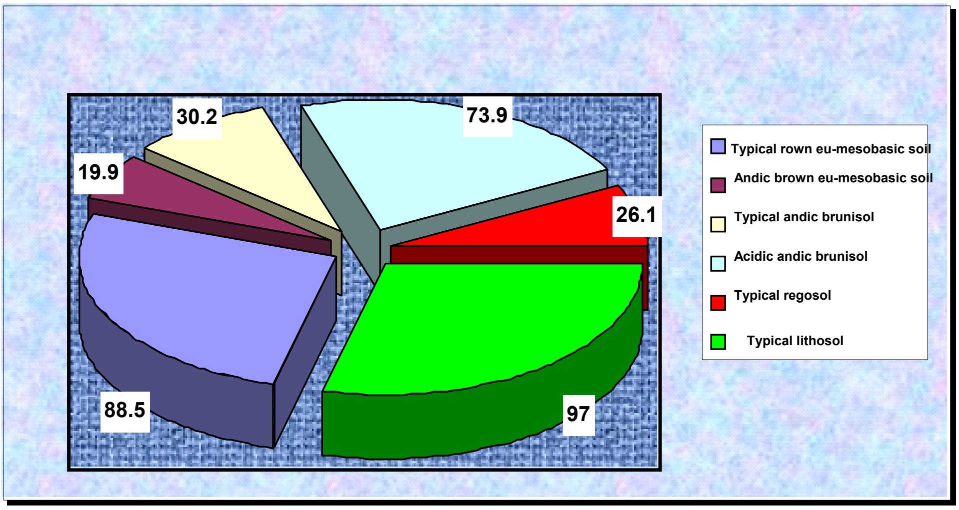
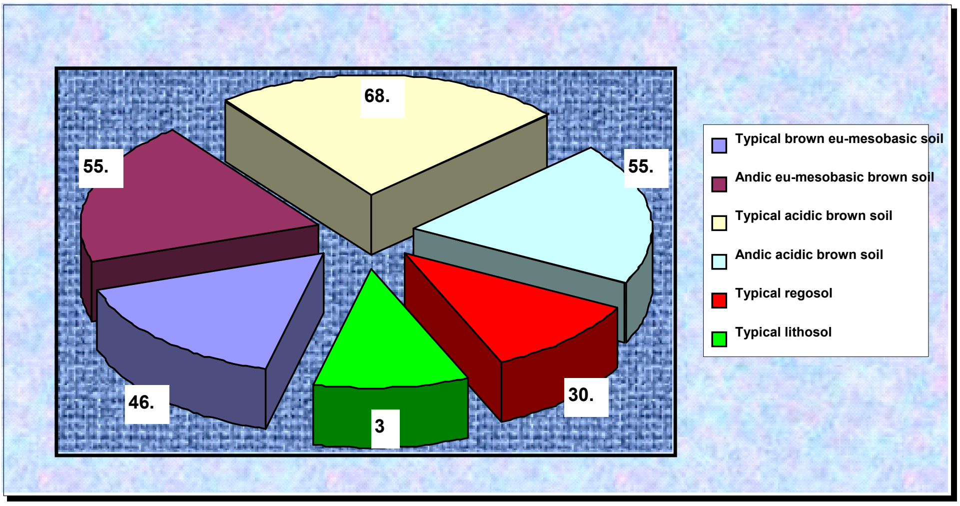
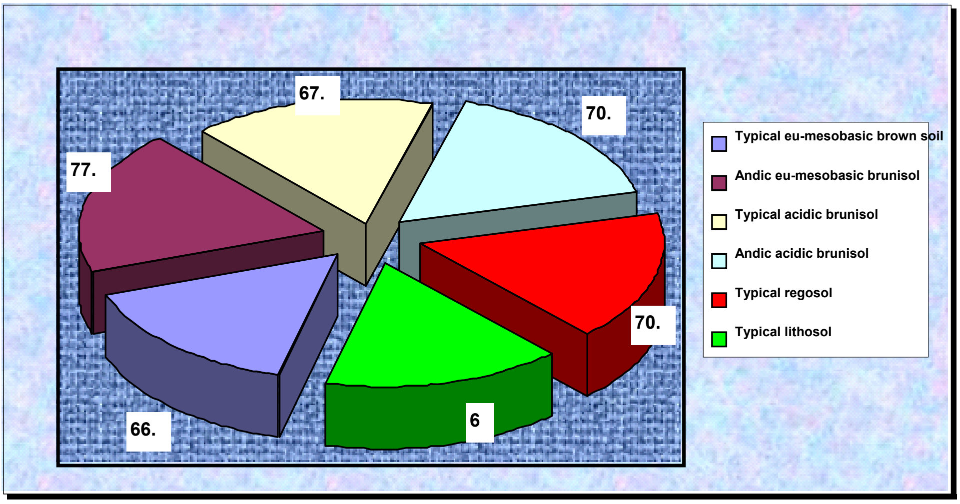


Figure 4.4.2. Average level of fungi micro-flora by type of soil



The average respiration level is 66.7mg CO_2/100g soil, the values indicating a moderately intense microbiological activity (Figure 4.4.3).

Figure 4.4.3. Average level of respiration by type of soil



2.1.2 Lithic Bruni Eu-Mesobasic Soils (Lepti Eutric Cambisols)

2.1.2.1 General Description

These soils are characteristic of various forms of relief, on dominantly short slopes, unevenly and strongly inclined (10.1-50% gradient) or narrow valleys with no flood plain (Corna, Roşia, and some of their tributaries). They occur in association with typical bruni eu-mesobasic soils, lithic acid brown soils, and typical lithosols, locally also as mono-type units. They developed mainly on clayey-flysh with sandstone or andesite intrusions.

2.1.2.2 Morphological Description

The lithic eu-mesobasic brown soils differ form typical sub-types in the occurrence of a lithic contact (hard rock, gravel, cobbles in more than 90% of the volume), between 21 – 50cm in depth.

The soil profile is of the Ao – Bv – R or Cn/R type, and the fertile horizon Ao is 10 - 15cm thick. The depth of soil above the hard rock frequently ranges from 25 – 40 (45) cm (moderately shallow soil). They are loamy texture soils, medium to strongly skeletal (26 - 75%), with higher values encountered on the lower side of the Bv horizon.

These soils were not reviewed, as their physical-chemical characteristics are within the range of the typical sub-type.

2.1.3 Andic, Eu-Mesobasic Brown Soils (Andi-Eutric Cambisols) and Andic Lithic Eu-Mesobasic Brown Soils (Andi Lepti-Eutric Cambisols)

2.1.3.1 General Description

These soils spread in areas of volcanic sedimentary formations, with an important andesite component, determining the andic character of these soils.
The relief is varied, generally broad hilltops (30–100m wide), or slightly to strongly inclined slopes (2.1–50% gradients).
Andic, eu-mesobasic brown soils, commonly occur together with two associated sub-types (andic - lithic), locally separated into associations with typical lithosols.
The parental rock (Figure 4, Appendices) of medium-moderately fine, skeletal, texture, is weathered andesite.
The described and analyzed profiles are located on the map under numbers 6 and 34.

2.1.3.2 Morphological Description

The soil profile is of the Ao – AB – Bv – Cn – R type (for the andic sub-type) and Ao – Bv/R–R (andic-lithic sub-types). The Ao horizon is 15 – 27cm thick. Soil layer thickness ranges between 80 - 85cm, for the andic sub-types (moderately deep soil) and 35 - 50cm for the andic-lithic soils (moderately shallow soil). They are slightly to excessively skeletal.

2.1.3.3 Description of the Physical Characteristics

The texture of the Ao horizon ranges (Figure 5, Appendices) from medium sandy loam to medium clayey loam (12.7– 33.2% clay $<$ 0.002mm) and is maintained within a similar range along the profile (18.3 – 37.7% clay $<$ 0.002mm). Bulk density varies in relation to texture, and was characterised as extremely low to medium (1.04 -1.32g/cm^3) in the A horizon and very low to medium (1.18 - 1.35g/cm^3) along the profile. Total porosity is medium to very high (50 - 61% of the volume) in the fertile horizon high (49 - 56%) to depth. In relation to saturated hydraulic conductivity values (10 - 130 mm/h), permeability for water in the soil is medium to very high, with higher values typical of the andic soils of loamy sandy texture.

2.1.3.4 Description of the Chemical Characteristics

Soil reaction is moderately acid to slightly alkaline (pH_{H_2O} 5.3–7.4), in the A horizon and moderately acid to neutral along the profile (pH_{H_2O} 5.1–7.1). Reaction in NaF (Na fluoride) is very strongly alkaline (pH_{NaF} 9.5–9.9) in both the Ao horizon and in depth, which is an indication of the presence of amorphous materials in the adsorptive complex of the soils.
The total cation exchange capacity is medium (22.5-30.6me/100g soil) with higher values in the Bv or Bv/R horizons.
Based on alkali saturation, they are meso-basic to alkali saturated soils (V 59.5–95.6%). The humus content of the fertile horizon is characterised as medium to very high (5.7-8,6%) in relation to texture, and the supply of total N (0.311-0.369%) is high.
Land use is predominantly secondary meadows (hay meadows and pasture) with small patches of forest.

2.1.3.5 Microbiological Description

The andic eu-mesobasic brown soils and andic-lithic eu-mesobasic brown soils group (P6 and P34) is slightly populated with bacteria (19.9 x 10^6 viable cells/g of dry soil), (Figure 4.4.1), while fungi reach a moderate development, of average values ranging between 55.9 x 10^3ufc/g dry soil, similar to andic acid brown soils (Figure 4.4.2). Soil respiration is maintained at a moderate level, however, the 77.3 mg CO_2/100g soil ranks this type of soil first in point of intensity of physiological processes in the micro-flora (Figure 4.4.3).

2.1.4 Typical Acid Brown Soils (Dystric Cambisol) and Lithic Acid Brown Soils (Lepti – Dystric Cambisols)

2.1.4.1 General Description

These soils are the most wide-spread soils in the area, typically occurring at elevations above 700-800m, in the Corna and Roşia Valley catchments, moderately rough terrain of

predominantly narrow ridges (< 30m wide) and uniform to non-uniform short slopes; locally occurring on narrow valleys with no flood plain. These soils are distinguished on the map as mono-type units, but also as associations with brown eu-mesobasic lithic soils, typical acid brown soils, or typical regosols.
The parental rock is (Figure 4, Appendices) alluvio-delluvial deposits of medium to coarse, texture, with skeletal content originating in weathered sandstone flysh.
The analysed profiles are located on the map under numbers 1, 2, 3, 4, 17, 18, 19, 24, 25, 27, 31, 33, 35, and 37.

2.1.4.2 Morphological Description

The soil profile is of the Ao – AB – Bv – Cn or Cn/R type (for the typical sub-type) and Ao – AB – Bv/R or Ao – Bv/R – R (for the lithic sub-type). The Ao horizon is 15–23cm thick. The typical sub-type of the acid brown soils ranges in depth between 55-110cm, semi-deep to deep soils, while the lithic sub-type is 40-45cm thick, a moderately shallow soil. They are slightly to strongly skeletal soils (10-75%), with higher amounts of skeleton encountered on the lower side of the soil profile.

2.1.4.3 Description of the Physical Characteristics

The texture of the A horizon (Figure 5, Appendices) is sandy loam to medium loam (dusty loam) (13.3 – 31.9% clay below 0.002mm) and is maintained along the profile (16.7– 30.8%) while bulk density ranges between extremely low to low (0.73 – 1.34g/cm^3) in the Ao, and extremely low to medium (0.92 – 1.51g/cm^3) along the profile. Total porosity is high to extremely high (50 - 62%) in the Ao and medium to extremely high (46 - 59%) in the AB and Bv horizons. At the base of the soil profile (Cn horizon), total porosity was appreciated as very low to medium (35 - 43%).
Based on the values of saturated hydraulic conductivity (5.2 – 106.2 mm/h), permeability for water in the acid brown soils is medium to very high.

2.1.4.4 Description of the Chemical Characteristics

Reaction in the typical acid brown soils is highly to moderately acid (pH_{H_2O} 4.6 – 5.8). The total cation exchange capacity is low-medium (19.2 - 26.9me/100g soil) in the Ao and very low-medium (19.2 - 26.9me/100g soil) along the entire profile, for the typical sub-types and medium (21.4 – 28.5 me/100g soil) along the profile in the lithic sub-types. As a result, acid brown soils are de-alkalised, the alkali saturation degree (V) being within the oligo-meso-basic range (19.6-51.1%) in the Ao and 16.7 - 42.6% along the profile.
The humus content of the fertile horizon is low-high (2.4 - 9,6%) and the total N is very low–very high (0.048 - 0.586%) , typically low–medium (0.116 - 0.209%).
Land use is predominantly meadows (hay meadows, pasture), operated in the traditional manner; locally, on small areas, woodland patches may be encountered.

2.1.4.5 Microbiological Description

Typical acid brown soils and lithic acid brown soils are characterized by the presence of moderate levels of bacterial groups. On average 30.2x10^6 viable cells /g dry soil (Figure 4.4.1), and more favorable conditions for fungal development, with an average 68.4 9 x 10^3 ufc/g dry soil (Figure 4.4.2), given by the relatively scattered numerical values, ranging from very low to medium fungal community development, with a low variety of species (1-4) compared to the bacterial group, which is more evenly distributed among the profiles in numbers, but less even in point of specific diversity (2 to 9 species). Global physiological activities of the micro-flora display a medium level (67.6mg CO_2/100g soil), (Figure 4.4.3).

2.1.5 Andic Acid Brown Soils (Andic Dystric Cambisols) and Lithic Acid Brown Soils (Andi – Lepti – Dystric Cambisols)

2.1.5.1 General Description

The distribution of these soils is related to the parental deposits generated by the weathering of intermediate, eruptive, predominantly andesitic rocks, in the sedimentary volcanic formations. They occur around the Cetate and Cârnic volcanic massifs, on broad hilltops and

non-uniform short or long, very slightly to strongly inclined slopes (2.1–50% gradients). In this context, the soils were separated on the map into mono-type (pure) units or in associations with lithosols and typical regosols. Locally, on small areas, andic acid brown soils are associated with cambic andisols (dark, grey-brown soils developing on andesite, soil morphology of the Au (Aou) – AB – Bv – CR – R type).
The analyzed profiles are located on the map under numbers 12, 14, 15, 21, 22, 23, 29 and 30.

2.1.5.2 Morphological Description

The soil profile is of the Ao – AB – Bv – Cn – R type (for the andic sub-type) and Ao – Bv/R–R (andic-lithic sub-types). The Ao horizon is 15–28cm thick.
The depth of soil above the hard rock (R) ranges from 70–105cm (andic sub-type) and 40-45cm (andic-lithic sub-type). In relation to thickness, they are moderately shallow to strongly deep soils.
Based on the skeletal content, they are slightly to highly skeletal soils (V 10 – 60%).

2.1.5.3 Description of the Physical Characteristics

The soil texture (Figure 5, Appendices) is medium sandy loam (dusty sandy loam) or medium loamy (dusty loamy) with a variable clay content (below 0.002mm) of 18.9 – 30.5%. Bulk density is extremely low to very low (0.71 - 1.17g/cm^3) and the total porosity high to extremely high (51 - 62% of the volume). Permeability for water is high to very high (23 - 91mm/h) for the andic sub-type and very high (104 - 112mm/h) for the andic-lithic sub-type.

2.1.5.4 Description of the Chemical Characteristics

These soils have a strong to moderate acid reaction (pH_{H_2O} 4.6–5.8). Reaction in NaF is very strongly alkaline (pH_{NaF} 9.5 – 9.9) which justifies their andic nature. The total cation exchange capacity is low to medium (19.1 - 28.3me/100g soil) in the Ao and very low to medium (9.9 - 26.3me/100g soil) along the profile. These are de-alkalised soils (oligo-basic-oligo-meso-basic) of alkali saturation (V)14.3 – 48.0%).
The humus (5.1 - 8.5%) and total N (0.259 - 0.327%) supply of the Ao horizon was medium to high.
Land use is predominantly hay meadows and pasture, some of these areas being impacted by tailings landfills.

2.1.5.5 Microbiological Description

The andic acid brown soils and andic-lithic acid brown soils are characterised as favourable to the development of high levels of bacteria (Figure 4.4.1)(on average 73.9 x 10^6 viable cells/g of dry soil), with a maximum at P 23 and moderate numbers of fungi (Figure 4.4.2) (on average 55.5x 10^6ufc/g dry soil). Soil respiration averages 70.8 mg CO_2/100g soil (Figure 4.4.3), with evenly distributed values between profiles and at the same time comparable to those reflecting the intensity of micro-flora activity in typical regosol.

2.1.6 Lithic brown Eu-Mesobasic Soils (Lepti Eutric Cambisols)

2.1.6.1 General Description

These soils are poorly developed mineral soils formed on non-consolidated parental materials (Figure 4, Appendices) of medium to coarse texture, and skeleton of different origins: clay, sandstone flysh, clayey marls, or andesitic detritus.
They occur over limited areas, predominantly in associations with brown eu-mesobasic soils, typical acid brown soils, andic acid brown soils, typical lithosols, as mono-type (pure) units. They are distributed on uneven long or short moderately to strongly inclined slopes (12–50% gradients).
The analyzed profiles are located on the map under number 7.

2.1.6.2 Morphological Description
The soil profile is poorly developed, of the Ao – Cn or Ao – Cn – R type (for lithic regosols). The Ao horizon has variable thicknesses of 5(10) – 25cm.
The parental rock is maintained close to the surface, by geological erosion, with the soil in dynamic equilibrium with the environmental media in which it existed.
The depth of soil above the hard rock (R) ranges from 51–120cm (semi deep to very deep soil). The skeletal content in the soil profile is 10–45% (slightly to moderately skeletal).

2.1.6.3 Description of the Physical Characteristics
Analytical data related to profile 7 (Figure 5, Appendices) suggest the following: the Ao horizon texture is medium sandy loam to medium loam (16.7 - 28.2% clay, less than 0.002mm) developing into medium clayey loam (41.55 – 43.3% clay, less than 0.002mm) in the Cn horizon. Bulk density is extremely low to medium (1.03-1.41g/cm^3) in the Ao and high to very high (1.51 - 1.61g/cm^3) in depth. Accordingly, total porosity is high to extremely high (47 - 62% of the volume) in the Ao and very low to low (40 - 44% of the $volume^3$) in the Cn horizon. Permeability for water is very high to medium (55.4 - 4.4 mm/h) in the Ao and very low (0.3mm/h) in depth.

2.1.6.4 Description of the Chemical Characteristics
Soil reaction is slightly acid (pH_{H_2O} 6.1–6.2), in the Ao horizon and neutral to slightly alkaline (pH_{H_2O} 7.0–8.2) in depth. The total cation exchange capacity is low to medium (24.6-29.8me/100g soil) in the Ao and low to medium (14.0-17.2me/100g soil) in the Cn horizon. Based on alkali saturation (86–96%), these soils are alkali-saturated eubasic soils.
The humus (4.4-7.4%) and total N (0.239-0.570%) content was medium to high.

2.1.6.5 Microbiological Description
In typical regosols bacteria develop in numbers of 26.1 x 10^6 of viable cells/g of dry soil (Figure 4.4.1), and fungi at a comparable level to that of lithosols (Figure 4.4.2). However, the global physiological activities of the micro-flora are slightly more intense (70.9 mg CO_2/100g soil), (Figure 4.4.3).

2.1.7 Typical Colluvisols (Fluvisols)
2.1.7.1 General Description
Like regosols, these soils are poorly developed and form on non-consolidated parental materials (Figure 5, Appendices) of medium to medium fine texture generated by the weathering of clays and skeleton clayey materials.
These soils occur on limited areas towards the north-eastern end of the site, at the foot of non-uniform, short, moderately inclined slopes (10–40% gradients), surrounding some of the local reservoirs.

2.1.7.2 Morphological Description
The soil profile morphology is of the Ao – Cn type.
The fallow Ao horizon, of loamy texture and more than 50 cm (frequently 60–80cm) thick developed on colluvial materials accumulated at the foot of the slopes.
A Cn horizon of loamy to clayey texture is encountered below these depths. The soils are slightly to moderately skeletal (10-35%) with higher amounts in the Cn horizon.
The *physical and chemical characteristics* of these soils depend on both the nature of the colluvial materials transported and deposited at the bottom of the slopes, and by the nature of the parental rocks.

2.1.8 Typical Lithosols (Eutri lithic Leptosols)
2.1.8.1 General Description
These soils are distributed on narrow ridges, uneven long or short, slightly to moderately inclined slopes (10–90%). They occur as the second element in association with andic brown soils, typical acid brown soils, lithic, andic, lithic regosols and rock outcrops (cliffs).

They developed over various deposits: andesite detritus, sandstone flysh, clayey flysh, and tailings of various textural, physical, and chemical characteristics.
The analyzed profiles are located on the map Figure 2 under numbers 5, 8, 9, 10 and 11.

2.1.8.2 Morphological Description

The soil profile is of the Ao – R or Ao – A/R – R type. Hard rock (R) occurs in the first 20cm of depth, which limits the thickness of the Ao horizon to 5-15 (18)cm. The depth above the compact rock (physiologically useful depth) indicates very shallow soils. Based on the skeletal content along the soil profile, the soils are slightly to highly (10–70%) skeletal.

2.1.8.3 Description of the Physical Characteristics

The texture of the Ao horizon (Figure 5, Appendices) ranges from medium sandy loam to medium loam (14.5–31.4% clay less than 0.002mm). Bulk density is extremely low to medium (1.04g/cm^3) and the total porosity is extremely high (61.2% of the volume). Permeability to water of these soils is very high (K 134mm/h).

2.1.8.4 Description of the Chemical Characteristics

Developing under meadow vegetation, lithosols contain medium to high (3.8–7.2%) levels of humus and medium total N (0.195-0.261%).
Soil reaction is strongly to slightly acid (pH_{H_2O} 4.9–6.5). Lithosols developing on intermediary eruptive rocks display an andic character (pH_{NaF} 9.7–10.0). The total cation exchange capacity is predominantly medium (18.4-33.9me/100g soil) and based on alkali saturation (56.0-83.2%), the lithosols range from meso-basic to eu-basic.

2.1.8.5 Microbiological Description

Typical lithsols are generally poorly populated with bacteria (Figure 4.4.1) at an average of 97 x 10^6 viable cells/g of dry soil and is strongly influenced by the very high numbers of representatives of this group, estimated in P5. Fungi are also numerically poorly represented (31 x 10^{3}ufc/g dry soil) as well as diversity of species (1–3), (Figure 4.4.2).
Physiological activities of moderate intensity range and general trend are described for the other types of soil (66mg CO_2/100g soil), (Figure 4.4.3).
A record of areas by monotype or associations is shown in Table 4.4-1, and the areas by type or types and sub-types of soil are shown in Table 4.4-2. As can be seen, they are dominated by the acid brunisols of the andic, andic-lithic and lithic sub-types. They cover 47.7% of the total area.

Table 4.4-1. Areas covered by soil monotypes and associations (us) - ROŞIA MONTANĂ area

No. US	DOMINANT SOIL				ASSOCIATED SOILS				Surface Area US	
	Type	Sub-type	Surface Area		Type	Sub-type	Surface Area			
			ha	%			ha	%	ha	%
1	BM	ti	60.66	3.69	-	-	-	-	60.66	3.69
2	BM	ls	0.0073	0.0004	-	-	-	-	0.0073	0.004
3	BO	ti	114.94	6.98	-	-	-	-	114.94	6.98
4	BO	an	3.71	0.22	-	-	-	-	3.71	0.22
5	BO	ls	7.94	0.48	-	-	-	-	7.94	0.48
6	BO	an – ls	36.39	2.21	-	-	-	-	36.39	2.21
7	RS	ti	4.57	0.28	-	-	-	-	4.57	0.28
8	CO	ti	1.73	0.11	-	-	-	-	1.73	0.11
9	BM	ti	135.72	8.25	BM	Ls	58.17	3.54	193.89	11.79
10	BM	ti	47.57	2.89	RS	Ti	25.61	1.56	73.18	4.45
11	BM	an	14.07	0.85	BM	an – ls	6.03	0.37	20.10	1.22
12	BM	an	1.67	0.10	LS	Ti	1.14	0.07	2.81	0.17
13	BM	ls	98.04	5.96	LS	Ti	65.36	3.97	163.40	9.93
14	BO	ti	47.09	8.87	BO	Ls	62.60	3.81	208.52	12.68
15	BO	ti	5.86	0.36	BM	Ti	3.16	0.19	9.02	0.55
16	BO	ti	44.36	2.70	LS	Ti	19.0	1.15	63.36	3.85
17	BO	ti	110.14	6.70	RS	Ti	36.71	2.23	146.85	8.93
18	BO	an	26.13	1.59	BO	an – ls	17.42	1.06	43.55	2.65
19	BO	an	41.07	2.50	AN	Ca	4.56	0.27	45.63	2.77
20	BO	an	10.67	0.65	LS	Ti	4.57	0.28	15.24	0.93
21	BO	an – ls	72.63	4.42	LS	Ti	31.12	1.89	103.75	6.31
22	BO	an – ls	32.10	1.95	LS, Z	Ti	13.37; 8.03	0.81; 0.49	53.50	3.25
23	BO	an	28.81	1.75	RS	Ti	12.35	0.75	41.16	2.50
24	BO	ls	8.24	0.50	BM	Ls	4.43	0.27	12.67	0.77
25	BO	ls	15.97	0.97	LS	Ti	10.64	0.65	26.61	1.62
26	RS	ls	21.56	1.31	LS	Ti	17.63	1.07	39.19	2.38
27	LS	ti	19.7	1.20	Z	-	8.49	0.51	28.19	1.71
TOTAL SOILS			*1111.34*	*67.49*	-	-	*410.39*	*24.94*	*1521.73*	*92.43*
99	Pit		-	-	-	-	-	-	122.38	7.44
100	Lakes		-	-	-	-	-	-	2.21	0.13
TOTAL									*1646.32*	*100.00*

Table 4.4-2. Surface Areas by Soil Type and Sub-Type - ROŞIA MONTANĂ area

No.	Soil Name (Type and Sub-Type)	Symbol	Surface Area	
			ha	%
1	Typical bruni eu-mesobasic soil	BM ti	247.11	15.02
2	Bruni andi-eu-mesobasic soil	BM an	15.74	0.96
3	Bruni lithic eu-mesobasic soil	BM ls	160.64	9.76
4	Bruni andi-lithic eu-mesobasic soil	BM an-ls	6.03	0.37
5	Typical acid Bruni Soil	BO ti	422.39	25.60
6	Acid andi-bruni soil	Bo an	110.39	6.71
7	Acid lithic bruni soil	Bo ls	94.75	5.76
8	Acid andi-lithic bruni soil	BO an-ls	158.54	9.63
9	Cambic andosol	AN ca	4.56	0.28
10	Typical lithosols	LS ti	182.53	11.10
11	Typical regosols	RS ti	79.24	4.82
12	Lithic regosols	RS ls	21.56	1.31
13	Typical colluvisols.	CO ti	1.73	0.11
14	Rock outcrops associated with lithosols and acid brunisols	Z	16.52	1.00
TOTAL SOILS			*1521.73*	*92.43*
99	Pit		122.38	7.44
100	Lakes		2.21	0.13
GRAND TOTAL			*1646.32*	*100.00*

3 Land Use

3.1 Limitations

Land use limitations are determined by natural causes related to geological composition, surface physiography and morphology that associates them with various levels of vulnerability including erosion, slides and caving degradation processes. In certain areas, the natural cause may be compounded by anthropogenic impacts caused by human economic-industrial activities that result in enhanced intensity and extent of degradation. All this causes limitations in the main land uses, including: agricultural, forestry, and constructions of all kinds that require differentiated, but suitable management practices.

3.1.1 Soil Erosion

Fast erosion of the surface or in depth, was encountered in narrow valleys such as Corna Valley, and Roşia Valley, being frequently associated with bank collapse. The slopes of the stockpile complex in the Cârnic –Cetatuia and Orlea, Oarta area, is associated with rock fall or slides of unconsolidated material, where protective vegetation could not develop naturally. Fast erosion is also encountered in areas adjacent to the connecting roads and the lakes on the site.

The most wide-spread form, however, is geological erosion, which was identified on the site in areas of regosols and lithosols, in association with other soils, or on lithic sub-type soils. The causes that lead to the occurrence of this phenomenon in certain areas relate to the terrain characteristics (steep slopes), poor cohesiveness of materials (in general delluvial detritus), the absence of a vegetative cover (either destroyed or unable to develop naturally), anthropogenic activities including intensive grazing, change of land use, and/or industrial activities

Most of the site is protected by a well developed vegetative cover (meadows, shrub meadows and woodlands) which result in preservation of the specific environment in each area.

Potential soil loss by erosion in the Roşia Montană area was estimated by modeling, using a method developed by INCDPAPM, based on the USLE (Universal Soil Loss Equation). The results are shown in Figures 6 and 7, as soil covered or not covered by vegetation.

3.1.2 Landslides

This process is as strongly localized as erosion, and relates to the presence of fine grained materials (clays) which, for high precipitation levels and in the absence of a vegetation cover able to regulate the hydrological regime of the slope, become loose and start sliding (slide bed).

Landslides identified on the site include active (recent) and stabilized or semi-stabilized (older) slides.

Active landslides involve a higher risk of occurrence or extension, depending on the trend of the precipitation regime and anthropogenic activity, in the absence of mandatory, suitable management practices.

Stabilized and semi-stabilized (older) landslides involve a latent reactivation potential for changes in the precipitation regime (usually intensification) in the land use pattern, or for an increased impact of anthropogenic activities.

Other types of slides also occurred in the same areas of the site, including north and east of Roşia Montană and on the upper Corna Valley, as also mentioned on the "Natural Risk Map" developed by S.C. Proiect Alba – 2001.

The presence of the lakes on the site is another risk source for landslide generation. Suffusion may also occur in such areas.

3.2 Types of Land Use and Occupation

The types of land use are harmonized with the environmental media characteristics in the study area. The main types of land use in the area include:

a. **agricultural**: 1004.65ha (61.02%), of which:

- arable: 16.90ha (1.02%);
- hay meadows: 987.75ha (59.99%).

Apart from these, some smaller areas (a few hundred m^2) were identified as vegetable and herb gardens or maize and potato crops for individual households. Moreover, tree growing is also practised in small holdings, as climate, soil and terrain conditions are not suitable for intensive fruit crops.

b. forestry: 289.22ha (17.56%),including deciduous and conifer forests (especially Norway spruce plantations);

c. waters: rivers, lakes (ponds): 14.20ha (0.86%);

d. **non-productive**, including rock outcrops, torrents, scree and landfills, and tailings heaps 82.37ha (5.003%);

e. **roads and other communication**: county, commune and site roads: 48.76ha (2.96%);

f. **development land:** backyards, mining operations, village hubs: 198.25ha (12.04%);

g. **cemeteries:** 8.87ha (0.54%).

The above-mentioned data were communicated by RMGC.

3.3 Soils (Land) Suitability for Various Crops

Suitability was determined by the method of land rating for groups of crops. The crops were established based on site observations of traditional land use in the area. It was found that the most frequent land use is pasture and hay meadows, followed by fruit trees (apple, plum) growing in small holdings, and potato crops. No cereal crops were identified in the area.
The rating was based on natural conditions. Suitability was expressed by rating scores (1 to 100), grouped into 10 suitability classes, with each class being awarded a set of 10.
Calculation of the rating scores and land classification by suitability for hay-meadows and apple and potato crops led to the following findings (Table 4.4-3):

- **For pasture** (Figure 8, Appendices), good land suitability only accounts for 157.56 ha (9.58%) in Roşia Montană and on the inter-river on the right of Corna Valley;
  - class IV is dominant with 314.60 ha (19.12%), mostly in the northern part of the site;
  - class V and VI of land suitability totals 751.38 ha (45.61%), and dominates the study area; such land is encountered in both Corna Valley and west and north of the Cârnic-Cetate area;
  - the rest of the territory is distributed into lower suitability classes (VII-X) totaling 298.19 ha (18.12%), scattered all over the site.
- **For hay meadows** (Figure 9, Appendices), land suitability classifies as V-VIII totaling 1213.84 ha (73.71%), scattered all over the site.
  - classes V - VIII are dominant south of the Cârnic-Cetate area and the NW portion of the site, while class VIII is encountered west and north of the Cârnic-Cetate area;
  - classes III and IV, covering 166.91 ha (10.15%) are mainly encountered in the northern part of the site and on the inter-river right of the Corna Valley;
  - land of class IX and X, covering 140.98 ha (8.57%) is frequently encountered in the northern part of the study area;
- **For potato** (Figure 10, Appendices), land suitability is very low, with classes IX and X accounting for 1183.11 ha, i.e. 71.85%; other lands classify as VI-VIII suitability, and

cover 338.62 ha (20.58%) in the north, in the Roşia Montană area and on the inter-rivers of Corna Valley.

- **For apple** (Figure 11, Appendices), land of suitability classes IX and X dominate, accounting for 1038.74 ha, i.e. 63.07%; suitability classes VI-VIII cover about one third of the site, on an area of 482.99 ha (29.36%); land of these classes is scattered all over the study area.

Table 4.4-3. Distribution of surface areas by suitability class for the main crops in Roşia Montană Area

Class	PS		HM		AP		PT	
Rating score	ha	%	ha	%	Ha	%	ha	%
I 91-100	-	-	-	-	-	-	-	-
II 81-90	78.07	4.75	-	-	-	-	-	-
III 71-80	79.49	4.83	78.43	4.77	-	-	-	-
IV 61-70	314.60	19.12	88.48	5.38	-	-	-	-
V 51-60	381.67	23.21	248.00	15.07	-	-	-	-
VI 41-50	369.71	22.40	448.61	27.27	48.86	2.97	54.40	3.31
VII 31-40	95.30	5.79	289.98	17.63	180.63	10.98	139.56	8.48
VIII 21-30	95.80	5.82	227.25	13.74	253.50	15.41	144.66	8.79
IX 11-20	102.25	6.22	75.58	4.60	587.94	35.74	214.82	13.06
X 1-10	4.84	0.29	65.40	3.97	450.80	27.33	968.29	58.79
TOTAL	1521.73	92.43	1521.73	92.43	1521.73	92.43	1521.73	92.43
Pit	122.38	7.44	122.38	7.44	122.38	7.44	122.38	7.44
Lakes	2.21	0.13	2.21	0.13	2.21	0.13	2.21	0.13
TOTAL	*1646.32*	*100.0*	*1646.32*	*100.0*	*1646.32*	*100.0*	*1646.32*	*100.0*

Note that appreciation of land suitability for the investigated crops was conducted for the whole site area. There are less areas covered by pits and lakes (124.59ha). At the time of the study, the consultant did not have a land survey map (plan), but rather a topographical map made available by RMGC, therefore, village hubs, cemeteries, forests, etc, have been included in the total 1521.73ha.

3.4 Types of Soil Management

Given the natural conditions (climate, relief, geology, soils) the dominant land use categories are natural meadows (pasture and hay meadow) and forestry. This is complemented by areas of ancient mining operations including landfills, tailings dams, and rock accumulation on or at the foot of the slopes.

In such circumstances, land and soil management involved use of natural resources (pasture and hay meadow) for domestic purposes by the land owners, including grazing, feed and fodder hay meadow, and animal breeding.

On these lands, the soil cover is well preserved, with the vegetation cover largely intact. Low input small holding management types were used for such areas.

Forest land size areas varied over time, due to deforestation.

However, many years ago, afforestation measures were implemented for soil cover preservation and hydrological regime regulation on the slopes. This helped mitigate surface and/or deep degradation processes.

Moreover, erosion and landslide impacted areas of farmland should be integrated into the forestry land use so as to undergo reforestation with suitable species.

A particular situation relates to tailings impacted areas. Some of these have been included in reforested areas (especially spruce plantations), but most were left as open, un-reclaimed land. Natural vegetation could not develop on these areas because of unfavorable conditions (mostly chemical) of the materials and because of continued landfilling.

Therefore, these areas have remained the most vulnerable, due to degradation processes, and a potential pollution source, for the adjacent areas.

4 Soil Pollution

4.1 Current Pollution

In the area designed for the open pit, extraction of gold and silver ore and for the processing plant plus the stockpiles of rock waste from stripping and ore processing, there are no current major soil pollution sources, either mobile or stationary.
The only *stationary potential sources* of pollution are the current Cetate and Cârnic pits (including Napoleon area and 18 waste rock stockpiles), operated by SC MINVEST SA, which during blasting, cause the release of airborne particulate matter. However, due to their large size, these particles largely resettle in the pit area. Moreover, the heavy metal content, the only potential contaminant of the sterile and even ore bearing rock, is not very high. Furthermore, the heavy metal content determined in the upper soil horizon in the vicinity of the current Cetate Pit, ranges up to: 1.4mg/kg Cd, 23mg/kg Cu, 34mg/kg Co, 21mg/kg Cr, 39mg/kg Ni, 1040mg/kg Mn, 36mg/kg Pb and 130mg/kg Zn. These levels range within the geochemical soil background and their abundance is not caused by anthropogenic activities in the area.
In effect, the area currently contains no mobile source of soil pollution. Ongoing road traffic levels are low.
However, in order to track potential pollutant loads, especially of heavy metals, throughout ore extraction and processing, the current pollutant loads and heavy metal levels in the soil should be characterized and also how this relates to the current interpretation limits provided in Ministerial Order 756 of the Ministry of Waters, Forests, and Environmental protection of 1997.

4.1.1 Heavy Metal Pollution

Table 4.4-4 shows the (x_{min} şi x_{max}) content intervals for heavy metals and the values of the grouping centre: arithmetic mean ($\overline{x}$), geometric mean (xg), median (Me), and module (Mo). To these, the standard deviation must be added.
A review of these data shows that the content intervals are relatively broad, with a maximum value of up to 27 times larger than the minimum (Mn). For the other chemical elements, exept Cd (20 times), the maximum value is up to 10 times larger than the minimum. However, the values of the group centre parameters lie around normal values (Cd), below NVs (Cr, Cu, Mn, Zn) or slightly above NVs (Co, Ni, Pb).
If we follow the percentage distribution of the soil samples based on abundance of heavy metals, in accordance with Alert (AT) and Intervention (IT) Thresholds (Table 4.4-4), we find that most samples range within normal values and the value class of up to the Alert Threshold (AT).

Table 4.4-4. Statistical parameters of the heavy metal content (mg/kg) of the soils in the RMGC area, compared to normal values (NV) and alert (AT) and intervention (IT) thresholds for sensitive uses (MO 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
VN	*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*

These two groups include: 97% of the values for Cd and Mn, 100% of the values for Cr, Cu, and Zn, 84% for Pb, 83% for Ni and 34% for Co.
The high contents ranging between the Alert and the Intervention Thresholds are approximately the difference between the two classes of up to 100%. Only 2% of the Cd values and 13% of the Co values, that might be considered accidental, range within the intervention interval.
A graphic representation of the sample frequency by abundance intervals is given by the histograms in Figure 4.4.4.
The percentage distribution of the soil loading or pollution with heavy metals is shown in Table 4.4-5.

Table 4.4-5. Percentage distribution of soil samples (n=153) in the Roşia Montană area, by class of heavy metal abundance, based on the Alert (AT) and Intervention (IT) Thresholds according to MO 756/1997

Chemical element	Value classes			
	normal	up to Alert Threshold (AT)	high, between the Alert (AT) and Intervention (IT) Thresholds	above the Intervention Threshold (IT)
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		

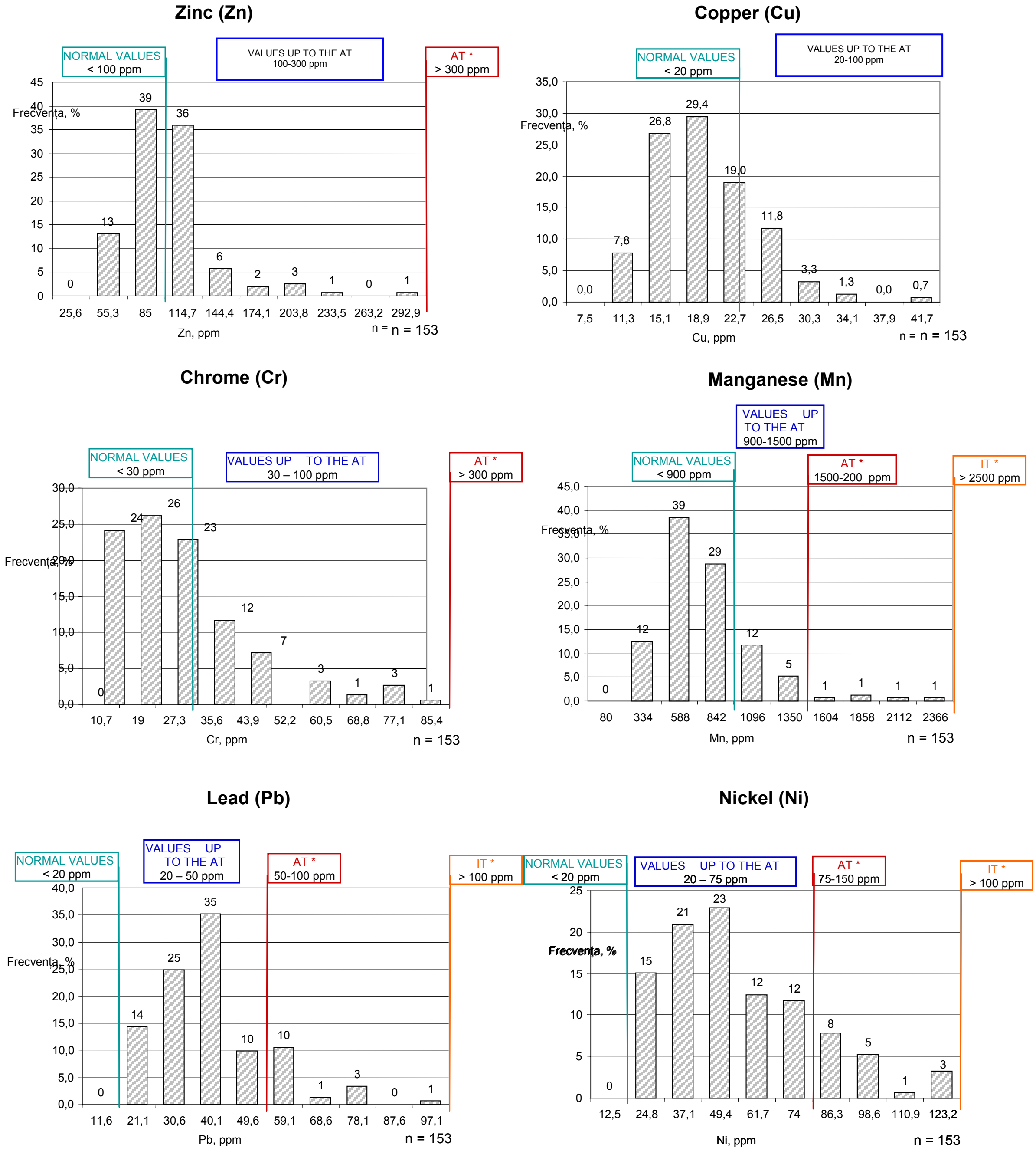
Loading refers to the enrichment of the soil content of chemicals that does not translate into negative effects on plant growth or development, or on the other environmental media. Conversely, pollution in the sense of this approach (Lăcătuşu, 1995), means a level of chemical content that might generate direct or indirect negative impacts on plants and on the other environmental media, respectively. Note that the assessment method relies upon the calculation of the relationship between the analytical value of the sample and a reference value which considers the clay and organic matter content. The reference value is in fact the value of the A parameter in the Dutch system of interpreting analytical data related to the heavy metal content of soils (1988, given in Ewers, 1991).

Table 4.4-6. Percentage distribution by class of heavy metal loading/pollution in the soils (A Horizon) of the Roşia Montană area

	Cd	Co	Cr	Cu	Ni	Pb	Zn
Loading : low			38.5			5.1	
medium		5.1	56.4	46.1	7.7	51.3	25.6
high	2.6	10.3	5.1	43.8	15.4	33.3	51.3
very high	7.7				15.4	7.7	1.8
Pollution : low	76.9	66.7		2.6	53.8	2.6	10.3
medium	12.8	17.9			7.7		

A review of the data in Table 4.4-6 shows that considerable percentages of all the analyzed samples (77% for Cd, 67% for Co, and 54% for Ni) range within a low pollution values, while for the other chemical elements (Cr, Cu, Pb and Zn), most samples range within low to strong load categories.

Figure 4.4.4. Content levels and distribution frequency of heavy metals in the soils of Roşia Montană area, compared to the limits provided in MWFEP Order no. 756 of 1997



The conclusion of the above is that the soil cover is currently slightly polluted by Cd, Co and Ni of geogene origin. Most of the soil heavy metal loads are within the regional soil geochemical background levels.

4.1.2 Current Level of Soil Acidification

Assessment of the current level of vulnerability to acidification (Figure 12, Appendices) shows that of the total 1646,32ha, an area of 497.18ha, i.e. 30.20% is covered by soils of low vulnerability to acidification; 256.75ha (15.60%) of low-medium vulnerability; and 767,80ha (46.67%) by soils of medium vulnerability. The surface area differential (7.57%) up to 1646.32ha is occupied by lakes and the Cetate pit.
The native acidic reaction of the soils impacted by the low cation exchange capacity may lead to effects such as loss of exchangeable alkali, increased content of soluble Al in the soil solution, both generating restrictive edaphic conditions for plant growth. Considering the pH

values and the cationic exchange capacity of the soils, the current vulnerability to alkali loss, acidification, aluminum solubilisation, and the general vulnerability of the soils was assessed based on Halowaychuk & Fessenden (1999) (Table 4.4-7).

General soil vulnerability is medium for acidic brown soils and lithosols. In some cases (5 out of 28), the general vulnerability of these types of soils is low. Conversely, in regosols, andisols and eu-mesobasic brown soils, general vulnerability is low. A map of soil vulnerability to acidification is given in Figure 12, with the key provided in Appendices).

Another chemical characteristic of soil resistance to acid impacts generated by acid rain or from other sources is their reaction buffering capacity. The values of this characteristic, grouped by soil types and sub-types (Table 4.4-8), show a relatively broad range for a certain type of soil. Thus, for acid brown soil with all its sub-types and for typical lithosol, the intensity of the reaction buffering capacity ranges between very low to medium and even high, while for eu-mesobasic soils the intensity of the reaction buffering capacity ranges along a broader spectrum from low to very high.

As a rule, carbonate containing soils, starting with the upper horizon, have high reaction buffering capacity. *As these types of soil are encountered on limited areas of land, it may be stated that on the whole, the soils in the RMGC area have low to medium reaction buffering capacity. It follows that their vulnerability to acidifying impacts is medium to low.*

Table 4.4-7. General soil vulnerability in the RMGC area and vulnerability to alkali loss, acidification, and aluminum solubilisation

No. profile	Soil Type	pH	T me/100 g soil	Vulnerability to			General Vulnerability
				alkali loss	acidification	Al solubilisation	
P1	Acidic brown soil	5.25	16.69	M	L	M	M
P2	Acidic brown soil	4.87	22.33	M	L	H	M
P3	Acidic brown soil	4.97	21.58	M	L	H	M
P17	Acidic brown soil	5.45	24.11	M	L	M	M
P24	Acidic brown soil	4.93	22.89	M	L	H	M
P25	Acidic brown soil	4.87	23.21	M	L	H	M
P27	Acidic brown soil	5.36	23.86	M	L	M	M
P19	Typical acidic brown soil	4.69	20.02	M	L	H	M
P31	Typical acidic brown soil	5.58	19.22	L	L – M	L – M	L
P33	Typical acidic brown soil	4.89	15.15	M	L	H	M
P35	Typical acidic brown soil	5.26	22.12	M	L	M	M
P37	Typical acidic brown soil	4.74	20.94	M	L	H	M
P4	Lithic acidic brown soil	4.95	22.35	M	L	H	M
P18	Lithic acidic brown soil	6.17	26.97	L	L	L	L
P15	Andic acidic brown soil	4.86	20.36	M	L	H	M
P16	Andic acidic brown soil	5.42	20.54	M	L	M	M
P20	Andic acidic brown soil	4.67	22.89	M	L	H	M
P22	Andic acidic brown soil	4.84	27.30	M	L	H	M
P29	Andic acidic brown soil	4.70	15.2	M	L	H	M
P30	Andic acidic brown soil	4.87	22.42	M	L	H	M
P14	Andic lithic acidic brown soil	5.66	35.09	L	L – M	L – M	L
P21	Andic lithic acidic brown soil	4.94	21.13	M	L	H	M
P12	Andic lithic acidic brown soil	5.38	19.12	M	L	M	M
P5	Typical lithosol	6.47	23.80	L	L	L	L
P8	Typical lithosol	5.38	39.00	M	L	M	M
P9	Typical lithosol	5.63	23.54	L	L – M	L – M	L
P10	Typical lithosol	5.53	26.01	M	L	M	M
P11	Typical lithosol	4.90	33.94	M	L	H	M
P7	Typical regosol	6.16	25.47	L	L	L	L
P23	Cambic andisol	5.71	24.95	L	L – M	L – M	L
P13	Typical eu/mesobasic brown soil	5.77	24.15	L	L – M	L – M	L
P26	Typical eu/mesobasic brown soil	5.21	20.67	M	L	M	M
P28	Typical eu/mesobasic brown soil	6.02	23.32	L	L	L	L
P32	Typical eu/mesobasic brown soil	6.14	17.42	L	L	L	L
P36	Typical eu/mesobasic brown soil	6.48	18.12	L	L	L	L
P38	Typical eu/mesobasic brown soil	6.84	27.24	L	L	L	L
P39	Typical eu/mesobasic brown soil	7.76		L	L	L	L
P40	Typical eu/mesobasic brown soil	5.89	24.5	L	L – M	L – M	L
P6	Typical eu/mesobasic lithic brown soil	5.29	22.48	M	L	M	M
P34	Typical eu/mesobasic andic brown soil	7.16	CO_3	L	L	L	L

L – low; M – medium; H – high

Table 4.4-8. Classification of the reaction buffering capacity in soils ($ICTR^{SB}$) based on soil type

Soil Type	No. of profiles	$ICTR^{SB}$ Interval	Significance of buffering capacity intensity*
Acidic brown soil	P1, P2, P3, P17, P24, P25, P27	3.1 – 4.2	low reduced
Typical acidic brown soil	P19, P31, P33, P35, P37	2.9 – 4.2	very low low reduced
Lithic acidic brown soil	P4, P18	3.4 – 5.2	low medium high
Andic acidic brown soil	P15, P16, P20, P22, P29, P30	2.8-4.1	very low low reduced
Andic lithic acidic brown soil	P12, P14, P21	3.0 – 4.7	very low low reduced medium
Typical lithosol	P5, P8, P9, P10, P11	3.8 – 5.3	low reduced medium high
Typical eu-mesobasic brown soil	P13, P26, P28, P32, P36, P38, P39, P40	3.8 – 5.8	low reduced medium high very high
Andic eu-mesobasic brown soil	P34	carbonate soil	very high
Andic lithic eu-mesobasic brown soil	P6	4.0	reduced
Typical regosol	P7	5.1 – 5.2	high
Cambic andisol	P23	4.4 – 4.6	reduced medium

*Value ranges of $ICTR^{SB}$:	Intensity of reaction buffering capacity *
≥5.6	very high
5.1 – 5.6	high
4.5 – 5.1	medium
3.9 – 4.5	reduced
3.1 – 3.9	low
<3.1	very low

4.2 Soil Pollution During the Construction and Operation Phases of the Roşia Montană Project

4.2.1 General Considerations

The proposed construction period for development of the Project will be 24 to 36 months. Activities will commence with the establishment of site offices, site construction facilities, and the mobilization of principal contractors. Important Project activities conducted during this time will include:

- Preparation of existing and future mine areas;
- Development of quarries for construction materials (La Pârâul Porcului Sandstone Quarry; Şulei Andesite Quarry);
- HV power line diversion;
- Construction of water supply pipeline from Aries River;
- Construction of the access road to the process plant and ancillary facilities;
- Construction of the process plant and ancillary facilities;
- Construction of a new access road to Roşia Poieni;
- Construction of TMF, including main dam and secondary containment system;
- Renovation of existent apartments in Roşia Valley for the accommodation of construction workers;
- Construction of the necessary infrastructure;
- Construction of other water control containment structures and channels.

During the *construction phase*, an area of soil and sub-soil will be carved out for the construction of the TMF.

During the *operations phase*, the mining areas will be prepared based on the local situation in every extraction pit, and rehabilitation programs will be initiated for the areas where extraction activities have ceased.

Final closure of the site will involve rehabilitation of the remaining un-reclaimed areas after the operations phase. The material used for closure will be taken from lower and upper soil horizons stockpiled on the site, close to the reclamation areas.

These phases will be scheduled as shown in Table 4.4-9.

Table 4.4-9. Schedule of the Industrial activity in Roşia Montană area

Task		Year 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	PC
Mining Pits	Cetate		■	■	■	■					■	■	■	■	■	■												
	Cirnic	■	■	■	■	■	■	■	■	■	■																	
	Orlea								■	■	■	■	■	■														
	Jig										■	■	■															
Low Grade Ore	Low Grade Ore Filling	■	■	■	■	■	■	■																				
	Low Grade Ore Removal															■	■	■										
Waste Rock Stockpiles	Cirnic	■	■	■	■	■	■	■	■	■	■																	
	Cetate		■	■	■	■																						
Pit Backfill	Cetate										■						flooding ■	■	■	■	■	■	■	■	■	■	■	▶
	Cirnic										■	■	■	■														
	Orlea													■	■	■												
	Jig													■														
TMF Dam Construction	Dam Raises with Mine Waste		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■										
Reclamation	Low Grade Ore Stockpile																		■	■								
	Cirnic WR											■	■	■														
	Cetate WR						■	■																				
	TMF Dam																■	■	■									
	TMF Basin																			■	■	■	■	■	■	■	■	▶
	Cetate Pit WR											■ southern rim						■ secure slopes										
	Cirnic Pit WR														■	■												
	Orlea Pit WR																■	■	■									
	Jig Pit WR														■	■	■											
	Plant Site																			■	■							
	Roads																			■								
	Cetate Dam																				■							
	SCD																				■							
	Aggregate pits (Sulei, La Pirioul Porcului)																				■							
Possible Final Landuse Turn Over	Low Grade Ore Stockpile																					■						
	Cirnic WR																					■						
	Cetate WR (overlap with LGO stockpile)																					■						
	TMF Dam																				■							
	TMF Basin																										■	
	Cetate Pit WR																			■								
	Cirnic Pit WR																	■										
	Orlea Pit WR																				■							
	Jig Pit WR																		■									
	Plant Site																						■					
	Roads																						■					
	Cetate Dam																						■					
	SCD																						■					
	Aggregate pits (Sulei, La Pirioul Porcului)																					■						

The first soil impacting operation during the construction phase will be topsoil *stripping* on an area of 973.63ha and stockpiling in 5 heaps covering a total area of 39.74ha. On the whole, an area of 1013.37ha will be impacted, including the stripped area plus the area taken by the topsoil heaps.
Therefore, of the total 1646.32ha, an area of about 632.95ha will remain, that is not programmed to be directly impacted.
Potential soil pollution by heavy metals, considering the large mass of waste and mineral bearing rock handled, may result from the elemental content of such rocks.
The analytical data for the heavy metal content of the ore (Table 4.4-10), shows values slightly higher than clarke (the concentration of an element in mineral or rock relative to its crustal abundance). Thus, the values of the enrichment coefficient, representing the ratio between the average analytical data values and clarke values, show that the analyzed rocks contain 3.4 times more Cd, 1.75 times more Hg, 2.8 times more Pb, and 1.64 times more Zn than the value for clarke.

Table 4.4-10. The average heavy metal content (mg/kg) of the mineralization bearing rocks at Roşia Montană vs. clark values*

(based on the analytical data provided by RMGC)

Location	No. 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	*1108*	*0.47*	*9.13*	*714*	*0.10*	*1108*	*43*	*135*
clarke* after Fiedler & Rösler (1988)		*0.13*	*18*		*0.05*		*16*	*83*

In the waste rocks (Table 4.4-11), the average values of the heavy metal content are lower for Cd, Pb and Zn, and higher for Co, compared to the concentrations of the same chemical elements in the mineralization bearing rocks. Therefore, the enrichment factors in their turn will be: 2.08 (Cd); 1.81 (Pb); 1.40 (Zn); and 0.78 (Co).

Table 4.4-11. Statistical parameters of the heavy metal content (mg/kg) of the waste rocks in the Roşia Montană area, vs. clark values*

(processed from analytical data provided by the RMGC Geochemical characterization Report)

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

After Fiedler & Rösler (1988)

Migration of these elements from the rocks into the soils occurred in the weathering process, when the soil horizons were formed, under the influence of soil-generating factors. Due to the higher mobility of some of these heavy metals (Cd) or some others' affinity for the organic component of the soil (Co, Ni), a concentration of such elements in the soil was produced, as observed, so that on the average, the content is higher than in the rocks (Table

4.4-6). Thus, the average value for Cd is 1.1mg/kg, Co is 28mg/kg, and Ni is 44mg/kg. If the average elemental content of the soil is related to the average values in both rock categories (waste and mineralization bearing) it appears that the soil is 3.1 times richer in Cd, 2.3 times richer in Co, and 1.8 times richer in Ni. The other elements (Cr, Cu, Mn, Pb and Zn) centered less in the soil, so that the rocks contain 1.3 times more Cr, 2.9 times more Mn, 1.1 times more Pb and 1.2 times more Zn.

Considering the abundance of these chemical elements in the mineral bearing and waste rocks, and the fact that the applied technology, there is a low probability for the soil in the non-stripped areas to become so highly polluted during the construction and operation phases as to attain Alert or Intervention Thresholds.

Nevertheless, soil monitoring will be required during both construction and operation.

Other sources of pollution during construction include emissions from vehicles, dust released from traffic and exhaust fumes. There will be heavy traffic both within the pit areas and on the construction site for the processing plant, the dams, and the water catchment pond embankments. Since the area is mostly covered with grass and wood vegetation, the latter will collect the suspended particles from traffic, so that the vegetation will protect the soil against the impacts of this category of air emissions.

Another potential, but low intensity source, will relate to cement handling.

Other potential pollution events include hazardous waste accumulation and storage, and general garbage and municipal waste storage, both pending offsite disposal. Vehicle parking and the fuel storage area might be impacted by local soil pollution by oil hydrocarbons.

As no process chemicals will be used during the construction phase, there will be no other potential soil impacting pollution sources

During *operation*, the traffic related emission sources will continue, including dust from traffic and exhaust fumes. There may also be areas of soil polluted by oil hydrocarbons in the fuel storage or refueling sites. Moreover, there will be new sources of dust due to the blasting activities on sterile and mineralization bearing rocks.

Soil contamination may also be caused by accidental spills of chemicals used in the cyanide leaching ore processing technology or from wastewater treatment. Besides sodium cyanide, granulated carbon, lime, copper sulphate, sodium metabisulphite, sodium hydroxide and hydrochloric acid will also be used in the Project. These may come into contact with the soil in spills of solutions, process water, effluent, and leaks from the tailings pipe carrying detoxificated slurry into the TMF.

Other potential soil pollution sources relate to the wastewater discharges into the Corna tailings pond and then into the anaerobic, aerobic, an mixed treatment cells used for the treatment of pit ARD and waste rock runoff at Cetate, which will be collected into a dedicated pond, followed by a lagoon system, with an anaerobic, aerobic and mixed treatment systems.

4.3 Soil Pollution during the Closure / Post-Closure Phase

During closure and post-closure, there is some likelihood of soil pollution around the industrial facilities, due to spills occurring in the decommissioning of processing equipment, chemical storage structures or fuel storage facilities. Dust released from decommissioning and grading activities, from vehicles and exhaust fumes, will continue to represent potential pollution sources for the environment, mainly of vegetation, but also of the soil.

5 Forecasted Soil Impacts

5.1.1 Soil Stripping for Construction and Extraction Works

Much of the soil cover, about 973.63ha, i.e. 59.1% of the RMGC concession site area will be stripped for the development of pits, processing plant, access roads, topsoil and waste rock stockpiles, and low grade ore storage area. More soil will be stripped from water collection and diversion channels. This will also include the soil on the TMF pond and dam site and that of the seepage treatment cells downstream of the TMF and the Cetate water catchment pond and dam. Further sites include the construction camp and the explosives storage facility.

The maximum areas of disturbed land, broken down by type of soil, and the topsoil area and depth and volumes of stripped soil, are shown in Table 4.4-12.

Table 4.4-12. Soil stripping on different objectives determine by soil type

Facility	Total impacted area	Principal soil type (m²)							
		Dystric Cambisol BO	Lithosol LS	Regosol RS	Eutric Cambisol BM	Andosol AN	Rocks Z	Pits	Lakes
Processing	51.37	448231.65	16196.13	19795.28	22918.98	4068.83			2541.39
Construction camp	1.18	11800							
Low grade ore	26.97	157061.13	14738.98	18014.31	22249.71			57674.30	
Cetate dam	16.84	73365.96	8806.53	8998.01	77215.47				
TMF Corna Vally	363.13	1198546.61	493379.3	411771.06	1486070.21		4262.02	36828.14	451.00
Cetate waste rock stockpile	38.21	150009.45	41387.73	50585.01	140137.26				
Cârnic waste rock stockpile	139.17	935135.97	116208.3	201639.02	94756.16		9375.82	34579.10	
Plant access road	11.77	20344.45	416.99	51.05	96893.94				
Diversion of road 742	44.88	320064.86	9075.11	32592.74	87036.61				
Construction and demolition waste storage area	0.59							5883.74	
Explosive storage	0.2	1800				200.00			
Şulei andesite quarry	11.33	100190.78	12874.54			200.00			
La Pârâul Porcului sandstone quarry	4.55	40940.29	4529.37						
Orlea Pit	45.04	25461.9	101186.3		285357.26		38427.45		
Jig Pit	18.5	129495.61	55483.83						
Cetate Pit	69.09	199332.67	42549.58	695.83	5840.93		22676.57	419803.57	
Cârnic pit	72.84	193803.86	71430.25				33468.49	429744.56	
Water collectors and diversions channels	22.25	105228.83	26847.18	15250.18	71574.40	163.85	1414.54	2067.13	
Exploitation and technologic roads	35.81	195905.899	20379.75	12336.56	65420.40	90.09	2410.46	61539.25	
Total	973.63	4306719.919	1035490	771729.05	2455471.33	4722.77	112035.35	1048119.79	2992.39

5.1.2 Current State of the Land that Needs Stripping for the Development of Industrial Facilities

The general state of the lands that will be disturbed by current land use types and by projected industrial facility is given in Table 4.4-13.

Cetate pit and waste rock stockpile sites – the current land-use of this area is a mix consisting of the existing mining operations, including the open pits and waste disposal areas, outcrops, woodland consisting primarily of conifers, and areas of urban and urban fringe development. A large part of the site consists of current or historic mining areas. The use of these areas is not to be altered by the development, and as such, there is no identified land use impact.

The soil resource associated with the old mining areas is significantly depleted, leaving either bare rock or raw, shallow soils resulting from the weathering of the *in situ* materials that have not yet developed a biologically active horizon. These are therefore not capable of supporting productive use.

Most of those soils are covered by coniferous woodland with a very low land-use potential and due to the thin soils and very steep slopes, are categorized as Class VI for pasture land (with category I representing the best conditions and category X the worst). The quality grade assessment of traditional land uses within the Project area (pasture, hay production, orchards, and potato crops), indicates that the land use pasture has the highest suitability grade or class (Class VI for pasture) of the four land uses assessed.

Table 4.4-13. Land areas that will be disturbed (m^2) by type of use and projected facilities

Objective/Category of use	Agriculture	Constructions	Cemetery	Road	Waters	Non-productive	Forest	Meadow	Total
Processing Plant	2049	123037		11698			86114	290879,66	513777,66
Stockpile 3							12087,75	59376,14	71463,89
Stockpile 2	706,2	4080,73		1479,58			16955,29	99058,89	122280,69
Stockpile 1	357,44			1549,75			0,937	86622,99	88531,117
Stockpile 4		2306,93		1232,6			9582,35	102049,06	115170,94
Overburden stockpiled from plant site area						11305,47	10436,45	19338,72	41080,64
Site mobilisation								11756	11756
Low grade ore deposit				9348,35		10120,6	6868,97	243406,01	269743,93
Cetate ARD pond and dam	172,521	64098,429		15652,7	14715,56		27,4	73653,45	168320,06
Corna TMF	9061	482654	11253	106275,93	51724	2782,72	887285,353	2080339	3631375
Cetate Dam	929	58788		13485			32690	276226,58	382118,58
Cirnic Dam	9821	120721		51673	13411,53	234	264573	931172	1391605,53
Access road to the processing plant	490	9499		14300			46584	46926,54	117799,54
Decomissioning of the overhead power line	2700	2057		0	26		0	76219,68	81002,68
Deviation of the overhead power line	328	99722		2904	570		17199	145487,72	266210,72
Diversion of DJ 742	4230	39806		7122			115077	282575,28	448810,28
Inert waste dump						5879			5879
Powder magazine								2000	2000
Sulei Quarry	1082			333				111862,64	113277,64
Paraul Porcului Sandstone Pit		24879		130				20455,73	45464,73
Orlea Pit	868	70378	14726,3	17157	3939		102694	240662,98	450425,28
Jig Pit	685	15917		8521				159832,71	184955,71
Cetate Pit		6992		6942	927	327765	7773	340437,01	690836,01
Cirnic Pit				9617		351174	244205	123447,46	728443,46
Drains \ water diversion	999	30394		4338	3220	1041	46253	136336,82	222581,82
Decommissioning of DJ 742				7852,46					7852,46
Private roads	25	20431		11446	654	352	7292	74914,36	115114,36
Industrial water pipeline	1747,98	15391		2399,99	859,25	3873,89	5123,25	30966,66	58419,91
Access road to protected area		5380		3560				18017,67	26957,67
Industrial roads	1108,489	18056,241		6802,193	538	14534,71	52415	149451,787	242906,42
Total	**37359,63**	**1214588,33**	**25979,3**	**315819,55**	**90584,34**	**729062,39**	**1971236,75**	**6233473,55**	**10616161,7**

Processing plant – The plant site occupies land on the relatively gentle upper slopes of the ridge to the south east of the Roşia Valley. The plant site will be constructed using cut and fill techniques to create level ground for development platforms. The area is currently under mixed agricultural and forestry land use. There are no inhabited dwellings or farm buildings within the site boundary.

Agricultural use is restricted to pasture or forage production. Woodland areas are small with cut wood being used for fuel and building materials.

Cârnic waste rock stockpile and the TMF – Both facilities are proposed to be located in Corna Valley. The TMF will be the largest single structure of the Project. The final TMF area will cover 363.13 ha.

The land use of the Corna Valley is primarily agricultural, with a series of farmsteads established along the valley floor. Agricultural activity includes grazing of cattle and sheep, with pasture land mowed for hay as preserved winterfeed. Small areas of land along the narrow valley floor, and in more gently sloping areas of the valley, sides have been cultivated to grow root and vegetable crops and fruit trees. These areas represent a very small proportion of the total agricultural land. Overall, this section of the valley is generally of restricted agricultural use (generally Class V for pasture and hay production), though there are areas that support Class II for pasture land. Crops (orchards and potatoes) are limited to Class IX or lower.

Loss of existing land and land uses in Corna Valley is assessed as being of moderate significance on a local scale. However, on a regional scale, the loss of such an area of low-class agricultural land is not significant.

The topsoil stockpiles – The locations proposed for the five stockpiles are as follows: south of the plant site, west of Şulei quarry, at the north-western en of the TMF, north-west of the Corna catchment, near the pond and at the foot of Corna dam. The topsoil stockpiles are expected to cover some 40 ha of the land. Land use at the stockpile locations is primarily agricultural with cattle and sheep pastures and forage fields and woodland patches.

Occupation of the soil resource under the topsoil piles will be temporary, lasting until the closure/post-closure phase. Following removal of the topsoil stockpiles, the soils are expected to return to their original use supporting fodder crops for forage and grazing.

Cetate low grade ore stockpile – The low-grade stockpile is a temporary structure that is designed to exist during the years of the most intensive mining only. The proposed location for the stockpile is on a gentle to steep slope, with the main current land use being hay meadows interspersed with isolated patches of woodland. The soil will be stripped on an equivalent depth of topsoil, plus 20-30cm of overburden. Following removal of the low-grade ore stockpiles, the soils are expected to gradually return to their original use. If the stockpiles are kept in place and should they contain acidic material, the areas will be covered with a 30cm thick layer of compacted clay followed by 80cm of over horizon material and topped by a topsoil cover of about 20cm.

Cetate water catchment pond and dam – The construction of the Cetate water collection dam will result in the creation of a pond for ARD collection from historic and current mine workings. The dam and resulting pond are expected to cover an area of about 10ha.

This land is currently supporting the Roşia Montană road and its ribbon development. The infrastructure and assets will have to be permanently relocated from this site. This area is not expected to be returned to its current use for an extended period of time, as the pumping and treatment of the collected waters is likely to continue into the post-closure phase. When there is no longer a functional requirement for impoundment and treatment of acid drainage at this site, an option will be to breach the dam and create a wetland area, subject to obtaining the relevant agreement from the regulatory authorities.

La Pârâul Porcului and Şulei quarries – Combined, these quarries will impact an area of 15.87 ha. Extensive rock outcrops exist at the proposed Şulei quarry area.

Land use at the quarry locations is primarily agricultural, with pasture for cattle and sheep grazing, feed fields and woodland patches. A forest curtain will be planted at the base of the quarry, which will minimize further soil degradation.

5.1.3 Loss of Fertile Soil Cover

Soils of the Project area have a very thin fertile top layer. The largest part of the proposed industrial area is covered with fertile soil either less than 10 cm or between 10 – 20 cm thick, followed by 24.4% of soil with fertile layer 20 – 30 cm thick, 12.2% with a 10-30 cm thick fertile layer, and only 2% with fertile layers 30-40 cm thick. Topsoil depth, by land unit, is summarized in Table 4.4-14.

Stripped soil volumes from both the top (fertile) layers and lower (mineral) horizons are given in Table 4.4-15.

As a general conclusion, all the industrial facilities (pits, TMF and rock stockpiles) will be located on areas of topsoil either less than 10 cm deep, or thickness ranging from 10 to 20 cm. On the other hand, all the areas covered with more than 20 -30 cm or 30-40 cm of topsoil will be temporarily covered by transitory structures only (processing plant, low grade ore and topsoil stockpiles). The volume of excavated soil will be proportional to the depth of the excavation.

Table 4.4-14. Depth of the Fertile Layer - Roşia Montană Area

No. of land unit	< 10 cm	10-20 cm local < 10 cm (10-15%)	10-30 cm local < 10 cm (10-15%)	20-30 cm local < 10 cm (10-15%)	30-40 cm local < 10 cm (10-15%)	30 cm	40 cm
1				X			
2						x	
3							x
4		x	x				
5			x				
6		x		X			
7		x	x				
8			x				
9		x					
10			x				
11			x				
12		x					
13			x				
14				x			
15			x	x			
16		x		x			
17		x					
18		x	x				
19				x			
20			x				
21		x					
22	x						
23	x						
24	x						
25			x				
26				x			
27		x					
28		x	x				
29		x					
30	x	x					
31		x	x				
32				x			
33					X		
34	x	x					
35	x						
36		x	x				
37	x	x					
38		x					
39		x					
40		x					
41	x						

No. of land unit	< 10 cm	10-20 cm local < 10 cm (10-15%)	10-30 cm local < 10 cm (10-15%)	20-30 cm local < 10 cm (10-15%)	30-40 cm local < 10 cm (10-15%)	30 cm	40 cm
42			**x**				
43	**x**						
44		**x**					
45	**x**						
46	**x**	**x**					

*) see land unit map (Figure 3, Appendices)

Table 4.4-15. Volumes of stripped soil by industrial facility type

Facility	Upper horizons m^3	Lower horizons m^3
Plant	102239.13	1034747.67
Construction site facilities	1190.01	17850.08
Cetate water impoundment and dam	24093.04	57160.45
Tailings Management Facility Corna	541048.02	1865442.32
Cetate waste rock pile		
Cârnic waste rock pile	302777.77	391165.23
Low-grade ore stockpile		
Plant access road	17107.79	23492.12
Road DJ 742 diversion	68202.10	259631.98
Inert waste dumps	0.00	0.00
Explosives storage	679.14	1584.66
Sulei Andesite Quarry	45157.91	74344.59
La Paraul Porcului Sandstone Quarry		
Orlea Pit	179520.20	441341.49
Jig Pit		
Cetate Pit		
Cârnic Pit		
Collecting ditches \ water diversion	36138.08	53107.28
Haul roads and site roads	43245.07	53026.72
TOTAL	**1361398.26**	**4272894.59**

5.1.4 Storage of Stripped Materials

The stripped soil will be stored in *five* locations, each receiving soil from the upper humifer horizon and the lower mineral horizons.

The storage facility area will be developed by the construction of a storage platform, involving grading and the building of a basic structure made of consolidated rock. This will create a base horizon, allowing free circulation of water and air and preventing the formation of stagnant water horizons that might induce a reductive environment, with impacts on the physical, chemical and biological balance of the soil.

The storage platform will also be surrounded by a cement berm that will prevent loss of soil through water or mechanical erosion of the slopes. To further prevent erosion, it is proposed that the stockpiles should be planted with grass. Storm water will be collected and directed toward the drains.

It is estimated that the stockpiles will be up to 10 m high, at a breadth and length proportionate to the land area involved. As a rule, these might mean up to 100 and 300 m, respectively.

In order to prevent inter-mixing over time of the stockpiled soil with materials from organic horizons and materials from mineral horizons, respectively, the distance between the two types of stockpiles will be at least 10-20m.

However, due to the specifics of the stored materials, a number of events might impact on the physical state of the soil, including compaction, reduced porosity and therefore aeration, increased density on its chemical state by slight changes over different periods of reaction, the potential redox or macro- and micro-element mobility, and even on its biological state.

5.2 Impacts on Soil Quality in the Stockpiles

Stockpiling may cause physical, mechanical (erosion and soil compaction, settlement, strata mixing and density change) or chemical and biological impacts.

5.2.1 Physical and Mechanical Impacts

Erosion –The overburden will be stripped and stored specifically to protect it from erosion as well as possible contamination. The stockpiles will be maintained so as to minimize potential erosion while they develop a new vegetative cover to prevent any longer-term possibilities of erosion. A berm or other soil erosion control system will be put in place around the stockpiles to prevent any erodable material from draining into watercourses.

Soil compaction and sedimentation, strata mixing and density change – mixing between upper and lower horizons of various genetic soil types, will occur as soil is moved to the stockpiles during construction of the various facilities. This will determine a combination of natural characteristics that will not significantly impact the use of this material for reclamation during closure. Characteristics such as structure, texture and skeleton content will be permanently modified.

5.2.2 Chemical Impacts – Impacts on Soil Nutrients

Changes in the organic matter content will occur due to soil type mixing, and anaerobic conditions will disturb the mineralization process. This is unavoidable at depth in the stockpiles, though nearer the surface of the piles, normal aerobic conditions will cause continuous raw organic matter breakdown and humus mineralization at a rate that is normal for the climate of the area.

The reductive conditions within the stockpile may cause significant changes in the soil nitrogen regime, in the sense of enhancing the de-nitrification process, with the formation of lower nitrogen compounds and elementary nitrogen. This may cause loss of nitrogen.

The phosphorus and potassium from the top layer will be maintained to a great extent during the time in which it is to be stockpiled. While they may breakdown to more mobile forms, they will remain *in situ* if leaching is prevented.

Losses would also occur for the masses of other nutritive elements included in the chemical composition of the soil, such as Ca, Mg, S, Fe or micro-elements such as Mn, Cu, Cd, Cr, Co, Ni, Pb, and Zn.

5.2.3 Biological Impacts

Microbiological analyses of the soil samples taken in the study area showed heterotrophic bacteria populations ranging from small to medium size limits, i.e. from $2x10^7$ viable cells/g dry soil to $1x10^8$ viable cells /g dry soil. Variation of the total number of bacteria is determined by the types of soil they colonize, the specific soil characteristics defining the size of the colonies. The average total number of heterotrophic bacteria for the entire site is $6x10^7$ viable cells/g dry soil. Also, qualitative determinations of bacterial populations in certain soil profiles (especially in the typical acid cambisol and lithic acid cambisol groups) revealed a remarkable diversity, with up to 9 species of bacteria identified.

In general, both the diversity and the size of heterotrophic bacteria communities determined for the site reflect sufficiently favorable conditions for the development of this group of micro-organisms in the soil (nutrient medium, reaction medium, etc.).

The second group of investigated micro-organisms, filament fungi, shows more restricted variation ranges, of $31x10^3$ufc*/g dry soil to $77x10^3$ ufc/g dry soil. As it concerns soils that are generally favourable to the development of this group of organisms, such as acid cambisol, the fungal communities determined in the investigated soil profiles are relatively modest in size, which suggests the presence of limiting factors. The high levels of organic matter and total nitrogen present in some of the analyzed profiles corroborated with the very high nutritional opportunism of the micro-fungi, which clearly shows a low mineralization rate. Although numerous fungal species of intensive cellulolysis activity were identified, they are not very active and organic matter is not decomposed.

All the statements are further supported by the medium intensity of the soil respiration process which ranges around 70mg CO_2/100g soil.

In the short term, the evolution of these micro-organisms once the soils are piled into heaps, will be influenced by the profound disturbance of the architecture and structure of the soil in which they have multiplied and conducted their physiological activity. Soil is a living environment in which subtle equilibrium is achieved between the nutrient content, solution reaction, degree of moisture, oxygen level, etc., all either enhancing or inhibiting micro-organism development and their physiological processes.

After a certain period of time, the length of which is rather difficult to determine, the high metabolic versatility of the micro-organisms, and their ability to survive in unfriendly environments in their sturdy forms (typically as spores) will help create a new equilibrium, reflected in the resumption of physiological functions based on the new environmental conditions.

As the soil is being stockpiled, monitoring of its microbiological activity will also be necessary.

In order to maintain soil functionality in the stockpiles, at least in the superficial layers, it is recommended that mineral fertilizers and possibly soil amendments and grass should be initially added, possibly followed by the planting of bushes, and even tree saplings. This may largely maintain soil functionality before its reuse in closure and post/closure land reclamation works.

* colony forming units

6 Mitigation Measures

6.1 Reusing Stripped and Stockpiled Soil

The stripped soil, stockpiled for a number of years in specially designed storage, will be used in restoring the soil cover on the areas where the rock and overburden were stripped for construction or ore extraction purposes.
The soil will be used in the last reclamation stage, after waste rock has been used to fill the pits and other excavations.
Thus, in the case of the pits, once filled with rock up to a convenient level, and based on the available amount of rock, the soil profile will be rebuilt by the installation of 20-30cm deep lower horizons topped by 10-15cm of fertile soil. Should the waste rock in the stockpile be acidic, a 20-30cm thick layer of compacted clay will be built over it, followed by lower and upper soil horizon materials. The same fertile horizon will be built along the berms, which will be re-sown, first with grass, and, in a year or two, with bushes or trees. In the stone quarries, the berms will be covered with 20cm of material from lower horizons and 10 cm of the upper, humus generating horizon.
For the ecological restoration of the land used in the building of the TMF, a base will be built on top of the discharged tailings. This will be made of a 30cm thick layer of compacted clay, followed by 80cm of predominantly mineral lower soil horizons, topped by 10cm of humus rich soil. This will be sown with various species of common native grass.
On the process plant site, after decommissioning, the land will be graded, covered with a 20-30 cm thick layer of lower soil horizons and topped with 10-15cm of humus-rich soil. This will be sown with various species of grass and bushes.
The lower grade ore stockpiles will be covered with 20cm of material from lower horizons and 10 cm of the upper humus generating horizon, and then seeded with grass.
For the ecological reconstruction of the decommissioned roads, scarification is recommended on a depth of 50-60cm, followed by application of 20cm of lower horizon material and 10cm of humus-rich soil.

6.2 Impact and Pollution Mitigation Measures

The main strategy in reducing the soil pollution impacts of the newly created, reclaimed soil covers, is to prevent contact between the potential pollutants and the soil resources. Two main preventative measures (engineering and management measures) are proposed.
Technical measures – The implementation of the technical measures will start as early as the construction phase. Specifics thereof will depend on the nature of the area and the activities conducted.

- *Vehicle fuelling, maintenance and fuel storage areas* – The mine maintenance workshop, truck washing station, fuelling station and associated infrastructure, will be located adjacent to the main process plant area. The fuel and lubricant storage facility and equipment-refueling bay will be located by the workshop facility. Field fueling and maintenance operations will employ portable drip trays or protective devices, and automatic shutoff valves. The areas will have a concrete foundation and will be fully bermed, with drainage to sumps and oil water separators, as appropriate, to prevent any soil or groundwater impacts in the event of a spillage. Organizing the site in this way ensures that all possible pollution incidents be in one area, minimizing any subsequent impacts. The fuel and lubricant storage facility will include gas, diesel and oil storage tanks, and separate waste oil/grease storage tanks. All tanks stored on the premises will be located in a concrete Secondary Containment System that will have at least 110% primary tank capacity and will therefore be able to contain potential spills resulting from the primary tank breakage or damage. Engine specifications will meet the strictest EU and/or Romanian emission standards for mobile and stationary equipment. A maintenance program will be implemented on all stationary and mobile equipment to ensure continued operation within manufacturer's specifications.

- *Process plant* – Concrete will be used for all the foundations and for berms around facilities. The site will be graded so that any spills will flow towards a dedicated storm water and spill containment pond. Water collected in the pond will then be pumped, depending on its quality, either to the Wastewater Treatment Plant or to the TMF. Pipeline leak detection systems and automatic shutdown systems for the process plant tailings pumps will be installed.
- *Pipe transport* – All piping systems will have their condition regularly checked as part of the Environmental Management System to ensure that any wear/deterioration can be dealt with in advance of any associated impacts. The type of piping system materials used will be chosen based on their suitability for their intended service and on the climatic conditions and the life span of the Project.
- *Temporary hazardous waste storage facility* – A temporary facility will be developed with a roof and separate bays, sumps, and drainage systems to prevent intermixing of incompatible materials and containment of any potential spills. All such waste will be properly containerized while in storage. Used absorbent/other routine spill cleanup waste will be managed as hazardous waste.
- *Municipal waste* – Waste will be accumulated in dedicated skips or bins and shipped offsite on an established schedule to a permitted municipal waste landfill.

Management measures are detailed for the safe handling of chemicals and the prevention of spills are outlined in the Waste Management Plan ((**ESMS Plans, Plan B**), *Cyanide Management Plan* (**ESMS Plans, Plan G**), and *Emergency Preparedness and Spill Contingency Plan* (**ESMS Reports, Report I**), and will be described in detail in specific Standard Operating Procedures as cited therein.

6.3 Physical Impact Mitigation Measures

If the clay content of the base soil materials to be used in the ecological reconstruction of the soil profile is too high, then it will be diluted with sandy material to create an optimum texture for the physical and chemical characteristics in the reconstructed soil. This would allow normal vegetation development.

Compaction prevention, in areas where unfavourable conditions might cause it, may be achieved by scarification at the depth of the compacted clay horizon.

7 Reclamation Management Plan

The areas disturbed by the construction and mining activities will be progressively rehabilitated in order to minimize impact and especially the soil erosion. Starting with Year 9 of the project development, the areas where the mining activities have finished, will be rehabilitated by remaking the topsoil and revegetation. The final rehabilitation will be conducted at the end of the Project, when the mine will be closed down and the facilities will be commissioned.

7.1 Soil Replacement Plan

The goal of the soil replacement plan is to reconstruct soils to an equivalent land suitability that existed prior to disturbance. Reconstructed soil is a mixture capable of sustaining an initial erosion-controlling plant cover, and of supporting vegetation species found in adjacent forest communities. The replacement soil will provide:

- Adequate moisture supply;
- Adequate nutrient supply; and
- Capability to support an erosion-resistant vegetative cover.

Soil salvage and its placement on reclamation areas is designed to follow the methodology and guidelines of the INCDPAPM, of the Ministry of Agriculture, Forests and Rural Development and of the Ministry of Environment and Water Management. Soil capability for arable and forest development is the primary consideration for soil reclamation. This focus is not expected to drastically alter soil salvage criteria, but it will assist in managing the appropriate placement of reclamation amendments.

The stripped soil, stockpiled for a number of years in specially designed storage, will be used in restoring the soil cover on the areas where the rock and overburden were stripped for construction or ore extraction purposes.

The soil will be used in the last reclamation stage, after waste rock has been used to fill the pits and other excavations.

Thus, in the case of the pits, once filled with rock up to a convenient level, and based on the available amount of rock, the soil profile will be rebuilt by the installation of 20-30cm deep lower horizons topped by 10-15cm of fertile soil. Should the waste rock in the stockpile be acidic, a 20-30cm thick layer of compacted clay will be built over it, followed by lower and upper soil horizon materials. The same fertile horizon will be built along the berms, which will be re-sown, first with grass, and, in a year or two, with bushes or trees. In the stone quarries, the berms will be covered with 20cm of material from lower horizons and 10 cm of the upper, humus generating horizon.

For the ecological restoration of the land used in the building of the TMF, a base will be built on top of the discharged tailings. This will be made of a 30cm thick layer of compacted clay, followed by 80 cm of predominantly mineral lower soil horizons, topped by 10cm of humus rich soil. This will be sown with various species of common native grass.

On the process plant site, after decommissioning, the land will be graded, covered with a 20-30 cm thick layer of lower soil horizons and topped with 10-15cm of humus-rich soil. This will be sown with various species of grass and bushes.

The lower grade ore stockpiles will be covered with 20cm of material from lower horizons and 10 cm of the upper humus generating horizon, and then seeded with grass.

For the ecological reconstruction of the decommissioned roads, scarification is recommended on a depth of 50-60cm, followed by application of 20cm of lower horizon material and 10cm of humus-rich soil.

Over some of the operational areas to be stripped of soils, the soil cover is thin and in some cases missing. It is therefore likely that there will be a shortfall in natural soil material for rehabilitation. In this case, the deficit will be made up using soil-forming materials. One option for this is the use of finely crushed non-mineralized rock, with addition of organic matter and nutrients appropriate to the vegetation cover being established. Such methods would be trialled prior to closure.

Details of closure strategy for Roşia Montană Project are describe in Mine Closure and Rehabilitation Management Plan **(ESMS Plans, Plan J)** together with rehabilitation strategy for that areas which will create permanent modifications of land use.

7.2 Revegetation Plan

The primary objective of RMGC's re-vegetation program is to establish a permanent, viable plant community which will be capable of developing into a self-sustaining cover of forest species suitable for commercial forestry, traditional land uses, wildlife use and with possibilities for recreation and other end uses.

The re-vegetation plan is intended to follow an ecosystem approach for establishment of a suitable cover type on each of the following developments:

- Roşia Montană Project central facilities;
- Pits (disposal areas);
- Roads; and
- Utility and pipeline corridors.

These developments will be re-vegetated according to the appropriate ecosite phases following soil replacement, re-contouring and site preparation. The re-vegetation plans will be specific for each development area based on pre-disturbance vegetation, surrounding vegetation and the type of disturbance.

Plant species representative of the final reclamation ecosite phases will be planted at appropriate densities. An annual grass (shrubs or trees later one where area permit so) or an Ministry of Agriculture, Forests and Rural Development approved seed mix will be used in areas that require erosion control.

7.2.1 Revegetation Practices

Re-vegetation of reclaimed landform surfaces is dictated by the nature of landform morphology, slope, aspect, soil type, nutrient and moisture regime, and soil drainage conditions. The types of vegetation communities which will successfully establish and develop under various combinations of these factors will be the subject of research and monitoring programs conducted over the next 20 years.

Establishment of woody plants in reclamation areas will be implemented in consultation with ICAS. Selection of species and the proportion of each species in the supplemental planting mix are based on:

- Woody-stemmed species common to the targeted ecosite phases;
- Existing field conditions;
- Vegetation type or types desired for development on the site, based on end land use objectives and terrain features;
- Expected growth of woody-stemmed species from seeds and root fragments in the soil amendment layer; and
- Success of establishing desired species in previous re-vegetation programs to target ecosite phases.

Development areas will be re-vegetated to ecosite phases following soil replacement, re-contouring and site preparation. The re-vegetation plans will be specific for each development area based on pre-disturbance vegetation, surrounding vegetation and the type of development. The availability of plant materials for re-vegetation will be reviewed by RMGC well in advance of revegetation.

7.2.2 Biodiversity Potential

Some of the areas that are disturbed due to Roşia Montană Project development will be reclaimed to a target ecosite phase of forestry community or arable community. Other areas, such as pits or TMF, may be reclaimed to a target of grassland. Other target ecosite phases are planned for the reclamation landscape and will be established on the basis of site-specific reclamation objectives and conditions. These reclamation vegetation types have high to moderate biodiversity potential and will mimic vegetation types that currently exist in the region. Because these areas will be interspersed throughout the landscape and will be actively reclaimed, it is expected that native plants and animals will use and colonize these areas soon after the reclaimed areas are established.

7.2.3 Re-vegetation Procedures

The re-vegetation of long-term disturbed areas will occur following reclamation material replacement as follows:

- An initial cover of native grass or another suitable annual grass will be established the first year for erosion control;
- Tree and shrub species will be planted during the first year whenever possible; and
- Weed control will be undertaken as required.

Re-vegetation of disturbances will be phased to coincide with construction activities to limit the area of soil exposed at any one time. Temporary re-vegetation will be undertaken for road cuts, ditches and berms surrounding the pits. These sites will be re-vegetated using a grass/shrubs cover. Seed will be applied either with a truck/quad-mounted seeder or hydro-seeder. Seeding of these areas will be undertaken upon completion of construction to limit erosion.

The process for establishing vegetation (ecosites) for different land use objectives will be used as a guide for determining the planting prescription. Where possible, when a roadway or cutline crosses an ecosite phase, effectively cutting through an ecosite phase polygon, the disturbance will be re-vegetated to a similar ecosite phase as that which was disturbed. This will be implemented in an attempt to restore the continuity of the remaining undisturbed ecosystem.

In the early years of operation, RMGC will commence a programme to develop best practices and procedures for site reclamation construction. The primary focus will be on re-vegetation to accelerate forest and grassland capability after disturbance.

7.3 Erosion Control Procedures

Where necessary, ditches will be constructed at crest and toe cuts to control erosion. Cut and fill slopes, portions of the reclamation material stockpile or any other disturbed land surface that will remain exposed during operations and will not be immediately utilized for reclamation, will be seeded to a barley cover or grass, to provide a vegetated surface that will help minimize erosion. (ESMS Plans, Plan C, Water Management and Erosion Control Plan)

Where plant access and related infrastructure has been constructed, the potential exists for erosion until sufficient vegetation cover has been established to stabilize the soil. Even though these features will be used for several years, RMGC proposes implementing an erosion-control programme using a number of techniques:

- Where the slopes are gentle (<30%) and short in length (<30m), seeding to an annual crop (such as barley or grass) will be undertaken to provide erosion protection. The area will be fertilized and harrowed to encourage rapid germination of the cover crop; and
- On steeper slopes, or slopes longer than 30 meters in length, seeding of a cover crop and the use of fertilizer will still be implemented. In addition, erosion blankets with an application of a Ministry of Agriculture, Forests and Rural Development approved native grass mixture at 20 kg/ha will be applied on areas where the greatest erosion potential is evident.

The intent is to stabilize the land as rapidly as possible while encouraging the invasion of native plants from the adjacent undisturbed sites, thus grass seed will be used sparingly and species selection will be made in consultation with the Ministry of Agriculture, Forests and

Rural Development or with the Ministry of Environment and Water Management. Seed and fertilizer will be applied by hydro-seeder or cyclone spreader in most areas, but helicopter application may also be used over more extensive areas (e.g., main access roads). When applying seed and/or fertilizer aerially, application rates will be increased appropriately (e.g., doubled) to ensure adequate ground coverage.

7.3.1 Fertilization

Fertilizer is to be applied to the reclaimed areas to encourage the rapid growth of the cover crop (barley) and enhance the invasion of native plant species. On areas where maintenance and repair work is required, a maintenance fertilizer will be included as part of the prescription.

On reclamation areas and soil stockpiles, fertilizer is to be applied and incorporated into the surface followed by maintenance applications where soil and vegetation monitoring indicates nutrient deficiencies exist. Annual fertilization is not intended to be part of the standard re-vegetation program to prevent herbaceous species from becoming overly competitive with invading tree and shrub species, and to discourage rapid establishment by weed species. Where maintenance fertilizer is needed, application rates will be determined through annual monitoring of cover performance and cover objectives. Typical maintenance periods, which depend on the rate of ground cover establishment, are expected to be limited to one to three years after reclamation.

Details of the closure strategy for the proposed mine development are described in the ***Mine Closure and Rehabilitation Management Plan*** **(ESMS Plans, Plan J)**. A more detailed reclamation plan will be developed in the future to cover rehabilitation and re-vegetation activities.

8 Soil Monitoring Program

8.1 Soil Monitoring During Construction, Operation, Closure and Post Closure

All soil-related operations from stripping through to the ecological reconstruction of the soil profiles will be conducted under the guidance of a soil specialist. A soil specialist will provide stripping depth of both topsoil and lower horizons, and will also supervise the building of the overburden stockpiles, in separate compartments for fertile topsoil and mineral soil. The soil scientist will also monitor, through analyses conducted by a certified company, the developments in the stockpiled soil and recommend the necessary measures.

Also based on analyses, the soil specialist will monitor the developments in the non-stripped soil, in regard to acidification and heavy metal loading. This activity is to be performed on an annual basis, starting with the first year of operation and until the site is closed.

In the event of accidental spills of chemicals or fuels, the soil scientist will collect samples and have them analyzed by a permitted laboratory, and will indicate measures based on the type and intensity of the pollution.

During the closure/post-closure period, the soil specialist will supervise the dismantling of the soil stockpiles, soil transport to the reclamation sites and the buildup of the soil horizons. The soil scientist will ensure that the base horizons are built with an adequate texture. If not, the soil specialist will indicate the texture mix to be achieved. The soil scientist will supervise the installation of the fertile horizon.

8.2 Reclamation Monitoring

Development of the Roşia Montană Project will progress in a phased manner, allowing for sequential and progressive reclamation of pits, roads and facilities over the operating period of the project. The development schedule reduces the extent of disturbance area within the project area at any one time and will allow for consistency in the reclamation measures to be used in each phase of the Roşia Montană Project. Reclamation and monitoring activities will also be incorporated into an annual report to be used to document the success of reclamation efforts, and over time, refine measures according to site-specific conditions.

The objectives of the reclamation monitoring program are to evaluate the success of reclamation measures and to adjust or modify those measures where necessary to ensure the following:

- Erosion control and slope stability;
- Re-vegetation and sustainability of disturbed areas;
- Noxious weed control;
- Achieving desired reclamation targets (e.g., ecosite phase); and
- Reclamation certification.

The objectives will be met through regular site inspection of the project area, additional reclamation measures (if necessary), through evaluation of the results of monitoring programs on reclaimed areas. When reclamation is completed according to the progressive reclamation schedule, an interim Conservation and Reclamation report will be prepared.

8.2.1 Monitoring Schedule

Reclamation monitoring will be consistent with the reclamation schedule to ensure that reclaimed sites are fully documented according to the types of reclamation measures employed. Information on each reclamation site will include:

- Description of the reclamation specifications (e.g., reclamation material depths, seed mix);
- The date when reclamation activities took place; and
- The target ecosite phases and the end land use objectives that were established for each site.

Each reclaimed area will be inspected after the first growing season following re-vegetation. The inspection will be used to gauge the success of reclamation and to evaluate the initial establishment of the target ecosite phases. Subsequent inspections will be undertaken to monitor the establishment of the vegetative cover and to identify requirements for follow-up remedial and/or maintenance activities.

Once active reclamation is complete and vegetation has been re-established, progress towards maturation of ecosystems will be monitored to allow evaluation of the reclamation program, and to provide the basis for future submissions for reclamation certification. The timing of monitoring activities is described in the following section. The pre-development vegetation mapping and field sampling programs conducted within the Roşia Montană Project area will be used as a reference to compare reclamation success and to assess reclamation progress towards the agreed upon end land use for the area.

8.2.2 Reclamation Database

The monitoring program will consist of site inspections of reclaimed areas to assess soil properties, soil stability and erosion controls, vegetation types and vegetative establishment. All the data will be kept in a reclamation soil and vegetation database to observe the success of the rehabilitation and closure programmes.

8.2.3 Reclamation Criteria

The basis for the reclamation monitoring programme is that:

- Success of land reclamation is measured against the original (pre-construction) or representative (adjacent) site conditions with due consideration for construction norms at the time of the development.
- The certification criteria describe the allowable changes in site conditions from the pre-disturbance conditions and typically require an assessment of terrain, soil and vegetation conditions. RMGC will conduct additional monitoring to address the full extent of the Roşia Montană Project and incremental disturbances that will occur over the life of the project.

8.2.4 Approach

Reclaimed areas will be monitored to assess soil stability, soil quality and the status of herbaceous vegetation growth, including dominant species composition.

Monitoring of soil and vegetation will be accomplished by means of permanent plots established on reclaimed areas in the year of reclamation. The location of the plots will represent the reclaimed area. This will be determined through site inspection of each reclaimed area and by review of aerial photographs and site maps. At each location, permanent 10mx40m plots (based on a Modified-Whittaker plot arrangement with nested subplots) will be established to cover the range of variability within the reclaimed site. These plots will be inspected to collect data for input into the reclamation database and evaluation of reclamation effectiveness within the reclaimed areas.

Monitoring of “short-term” reclaimed areas (e.g., road ditches and corridors, soil stockpiles) will be similar to that implemented for permanently reclaimed areas, but will focus on the stability and productivity of soils, the establishment of a suitable vegetative cover and weed control, rather than the long-term establishment of target ecosite phases for a specific end land use.

8.2.5 Vegetation Monitoring

The reclamation monitoring program will include an annual inspection program to assess re-vegetation success on each of the reclaimed areas within each stage of the Roşia Montană Project. The program will include a routine maintenance component to address, where necessary, site erosion repair and control as well as supplemental seeding and fertilizing of reclaimed sites. Noxious weeds will also be identified and removed during this annual inspection. The monitoring program will include the disturbed lands and margins within the RMGC leases. Annual monitoring would be undertaken for at least the first two years after initial reclamation, until vegetation has fully established (e.g., at least 80% ground cover), soils have stabilized and no further annual maintenance is required.

Data on vegetation establishment, species composition and cover, tree productivity and volume of coarse woody debris will be collected from within each 10mx40m assessment plot and from subplots within the main plot. Species composition and percent cover measurements will be recorded for herbaceous and woody stem species, to estimate vegetation density by species and by strata (i.e., grasses, forbs, low shrubs, tall shrubs and trees). Out-planted trees and shrubs will be tagged and their heights and mortality recorded for calculation of site indices. Photographic records will be taken from fixed photo stations to provide a vegetative succession progress record. This monitoring would be conducted one full growing season following initial reclamation and as required thereafter, likely in conjunction with the soils monitoring activities.

Monitoring sites will be established on all reclamation areas on the Roşia Montană area. The initial focus of monitoring will be the reclaimed pits areas (including around areas) and the reclaimed areas along road ditches and around waste areas.

8.2.6 Terrain and Soils Monitoring

Soil and slope stability monitoring of reclaimed sites will be undertaken in conjunction with the vegetation assessment, using a combination of site observations and systematic monitoring plots. Monitoring will include early annual assessments of soil stability to identify erosional issues, in conjunction with annual vegetation assessments.

The performance of reconstructed soils is a key element of erosion control and ecosystem sustainability. RMGC will monitor the sustainability of reclaimed soils to support vegetation growth by comparing soil physical and chemical parameters against reference soils (pre-disturbance conditions). In addition to terrain parameters (i.e., drainage, erosion, contour, stability, gravel, rocks and debris, vegetation and bare areas), soils will be sampled to monitor their physical and chemical characteristics. Composite samples of the surface soil and subsoil will be collected after the first growing season within each plot and assessed for parameters to allow for calculation of the soil's suitability rating. Parameters may include:

- Texture;
- Structure;
- Bulk density;
- Saturation percentage;
- pH;
- Salinity (as indicated by electrical conductivity and sodium adsorption ratio);
- Cation exchange capacity;
- Macronutrient levels;
- Humus;
- Heavy metals.

Follow-up soils sampling and assessment will be undertaken as required.

This monitoring information will be used for evaluating the reclamation techniques and measures used for various sites and moisture conditions to achieve target ecosite phases.

After the soil profile has been achieved mechanically and chemically, the soil specialist will collect samples for an agro-chemical analysis and potential pollution levels. The analytical data will help determine the potential doses of mineral or organic fertilizer required in order to enhance topsoil fertility.

In the post-reclamation phase, the soil specialist will monitor the evolution of fertility and pollution level for a number of years.

9 Conclusions

- The soil types and sub-types defined as mono-type or associations include: a) brown eu-mesobasic soils, andic, lithic and andi-lithic sub-types; b) acid typical cambisols soils, andi, lithic, andi-lithic sub-types; c) typical regosols; d) typical lithosols; e) typical colluvisols.
- Limitations of land use for the main uses (agricultural and forestry) are determined by soil erosion and landslides. Both are currently low intensity.
- Land use types include: primarily agricultural and forestry, followed by road, river, lake and non-productive (rock, landfills, detritus, etc.).
- Soil suitability for various crops, expressed by rating scores, ranges around 45-55 for hay and grazing meadows and 12 – 17 for apple, plum and potato crops.
- Land management and soil management consist of natural resource capitalization (hay meadows, pastures) and animal husbandry.
- Anthropic pollution of the soil cover with Cd, Co and Ni is currently low. Most of the soil heavy metal loads are within the regional soil geochemical background levels.
- In general, the soils are relatively acidic, with low to medium reaction buffering capacity and low to medium vulnerability to acidifying impacts.
- Considering the abundance of heavy metals in the mineralization bearing rocks and overburden and the technology that will be used during construction and operation, there is a slight possibility that the un-stripped soils might become polluted with high levels of heavy metals, so as to attain alert or intervention thresholds.
- Accidental events of local pollution might occur during the operation, closure and post-closure phases, involving process chemicals or fuels.
- Solid particles released during operation, due to blasting and transport will mainly resettle in the pit areas. The likelihood of heavy metal pollution or acidification of the surrounding soils is low.
- During construction and operation, soil will be stripped on 973.63 ha.
- The stripped soil will be stored into five stockpiles, and topsoil piles will be separated from those of lower horizon materials. The stockpiles will be built according to the technological norms to prevent or reduce physical, chemical or biological impacts on the stored soil.
- The stockpiled soil will be used in the ecological reconstruction of the land in the closure, post-closure phase, based on technological recommendations.
- In order to reduce soil impacts during operation, a number of technical and management measures will be adopted for every one of the industrial facilities.
- To prevent soil pollution, all activities involved in stripping, stockpiling, soil quality control during storage, ecological reconstruction of the soil cover, pollution control on the non-stripped areas of the RMGC site, will be monitored and conducted under the guidance of a soil specialist.
- The impacts on lands around the Project site are anticipated to be low. The local biodiversity will not undergo major changes.
- Land occupied by project activities will be rehabilitated for various types of land uses including: forestry, agricultural and tourism. The dominance of one use or another will be established in consultation with the local community.
- A summary of the issues related to the nature, intensity, sense and duration of soil impacts and of the relevant mitigation measures is given in Tables 9-1 and 9-2.

Table 4.4-16. Soil Impact Summary

Potential Impact	Mitigation Measures	Applicable Management Plans
Construction, Operations, and Decommissioning/Closure Phases		
Potential pollution from spills of reagent chemicals or petroleum products at vehicle loading/unloading and refuelling areas, vehicle maintenance areas, and chemical or fuel storage areas.	Chemical/fuel unloading, fuelling, and vehicle maintenance areas will have concrete foundations and be fully bermed, with drainage to sumps and oily water separators, as appropriate, to capture any spilled material Chemical/fuel storage areas will be covered to the extent practicable, and will have secondary containments with at least 110% primary tank capacity The process plant site will be designed to drain to a lined stormwater runoff and spill contingency pond Used absorbent/other routine spill cleanup waste will be managed as hazardous waste Waste fuel/lubricants recovered from oily water separators will be accumulated in dedicated containers (with secondary containments as previously noted) and recycled To the extent possible, spilled reagent will be captured and returned to the appropriate process circuit Field fuelling and maintenance operations will employ portable drip trays or protective devices, and automatic shutoff valves; operations staff will be trained in proper field fuelling and maintenance procedures	ESMS Plans, Plan B, Waste Management Plan ESMS Plans, Plan C, Water Management and Erosion Control Plan ESMS Plans, Plan G, Cyanide Management Plan ESMS Plans, Plan I, Emergency Preparedness and Spill Contingency Plan
Potential impacts from hazardous waste accumulation and storage, pending offsite disposal	Development of a secure Temporary Hazardous Waste Storage Facility as noted in Section 3.1; facility will be covered with a roof, and include separate bays, sumps, and drainage systems to prevent intermixing of incompatible materials and containment of any potential spills; all such wastes will be properly containerised while in storage	ESMS Plans, Plan B, Waste Management Plan
Potential impacts from general refuse and municipal waste	Municipal waste will be accumulated in dedicated skips or bins on an established schedule, and shipped offsite to a permitted municipal waste landfill Implementation of general site housekeeping procedures to prevent littering/uncontrolled accumulation of waste	ESMS Plans, Plan B, Waste Management Plan RMGC Occupational Health and Safety Plan

Potential Impact	Mitigation Measures	Applicable Management Plans
Settled dust and exhaust particulates (metals) generated from vehicle/mobile equipment operations	Specification of engines meeting strictest emission standards for all mobile and stationary equipment. Implement maintenance program on all stationary and mobile equipment to ensure continued operation within manufacturer's specifications Monitor acidic content of particulates deposited in protected areas, implement additional corrective/preventive action as warranted Monitor potential stakeholder concerns, implement additional corrective/preventive action as warranted The process plant site will be designed to drain to a lined stormwater runoff and spill contingency pond Increase watering of roadways during high potential emission conditions. Apply chemical stabilisers on heavily travelled roadways. Reduce mobile source speeds during high potential emission conditions	ESMS Plans, Plan D, Air Quality Management Plan ESMS Plans, Plan D, Public Consultation and Disclosure Plan
Loss of land use potential due to industrial development (see Table 4.4.3. for a list of mine facilities creating disturbed areas) As above	Periodic review and adjustment of mine rehabilitation and closure schemes to accommodate changing stakeholder interests, preferred post-mining options, socio-economic conditions, and other appropriate factors Location of Project site in area previously impacted by mining operations, in order to minimise impact on undisturbed areas Stockpiling of stripped topsoil and replacement to support revegetation of disturbed areas during site rehabilitation and closure; application of appropriate erosion control measures to topsoil stockpile pending use in rehabilitation Progressive rehabilitation of disturbed areas during the life of mine Creation of large, low-relief meadow in the deposited tailings area via placement of a topsoil cover and revegetation with native species Creation of other rehabilitated/revegetated land areas suitable for other non-mining/non-industrial uses Topsoil and low-grade ore stockpiles will be consumed in site rehabilitation and processing; stockpile areas will be graded, revegetated, and made available for their original or other uses. Retention of pit lakes and minimisation of pit backfilling will	ESMS Plans, Plan J, Mine Rehabilitation and Closure Plan ESMS Plans, Plan M, Social Impact Management Plan ESMS Plans, Plan O, Socio-Economic Development Plan ESMS Plans, Plan C, Water Management and Erosion Control Plan As above

Potential Impact	Mitigation Measures	Applicable Management Plans
	minimise "sterilisation" of remaining mineral resources, should additional mining land use preferences develop in future	
Operations Phase		
Potential impacts from process chemical/water/effluent spills, piping leaks or storage area spills.	Process plant areas will have concrete foundations and be fully bermed, with drainage and sumps to capture any spilled material Reagent storage areas will be covered to the extent practicable, and will have secondary containments with at least 110% primary tank capacity The process plant site will be designed to drain to a lined stormwater runoff and spill contingency pond Process plant piping systems (cyanide and non-cyanide) will be subject to routine inspections and preventive maintenance programs Used absorbent/other routine spill cleanup waste will be managed as hazardous waste	ESMS Plans, Plan B, Waste Management Plan ESMS Plans, Plan C, Water Management and Erosion Control Plan ESMS Plans, Plan G, Cyanide Management Plan ESMS Plans, Plan I, Emergency Preparedness and Spill Contingency Plan
Potential impacts from leakage of detoxified tailings from tailings deposition pipeline	Installation of pipeline leak detection systems and automatic shutdown systems for the process plant tailings pumps Institution of periodic inspection programs to ensure the integrity of the tailings pipeline and associated emergency systems The lined stormwater and spill contingency pond will be designed to accept tailings leakage on the process plant side of the high point in the tailings pipeline Potential tailings pipeline leakage on the TMF side of the pipeline high point will drain to a series of lined catchbasins, from which accumulated tailings can be pumped to the TMF until leaks are repaired	ESMS Plans, Plan I, Emergency Preparedness and Spill Contingency Plan ESMS Plans, Plan F, Tailings Facility Management Plan
Decommissioning/Closure Phase		

Potential Impact	Mitigation Measures	Applicable Management Plans
Potential pollution from spills of residual reagent chemicals or petroleum products during decommissioning of the process plant, vehicle loading/unloading and refuelling areas, vehicle maintenance areas, and other chemical or fuel storage areas.	Phasing of decommissioning activities to retain protective structures and the Temporary Hazardous Waste Storage Facility until all residual chemicals or fuels have been removed from the site and properly recycled or disposed of Chemical/fuel unloading, fuelling, and vehicle maintenance areas will have concrete foundations and be fully bermed, with drainage sumps and oily water separators, as appropriate, to capture any spilled material Chemical/fuel storage areas will be covered to the extent practicable, and will have secondary containments with at least 110% primary tank capacity The process plant site will be designed to drain to a lined stormwater runoff and spill contingency pond Used absorbent/other routine spill cleanup waste will be managed as hazardous waste Waste fuel/lubricants recovered from oily water separators will be accumulated in dedicated containers (with secondary containments as previously noted) and recycled	ESMS Plans, Plan B, Waste Management Plan ESMS Plans, Plan C, Water Management and Erosion Control Plan ESMS Plans, Plan G, Cyanide Management Plan ESMS Plans, Plan I, Emergency Preparedness and Spill Contingency Plan

Table 4.4-17. Cumulated Soil Impacts

Type of impact	Impact Nature				Impact Intensity			Impact Sense				Impact Duration		Impact Mitigation Measures
	direct	indirect	secondary	cumulative	Short	medium	long	positive	negative	reversible	non-reversible	permanent	temporary	
1. Soil stripping	✓					✓			✓		✓	✓		Soil profile reconstruction
2. Erosion during construction / operation	✓				✓				✓		✓		✓	Erosion control work
3. Landslides during construction / operation	✓					✓			✓		✓	✓		Land reinforcement work
4. Stockpiling		✓			✓				✓	✓			✓	Topsoil fertilization and re-vegetation
5. Dust and suspended particulate matter		✓				✓			✓	✓			✓	Maintenance of vegetation cover
6. Heavy metal pollution		✓			✓				✓		✓		✓	Soil monitoring Acidic soil amendment
7. Soil acidification by dust. Suspended particulate matter		✓			✓				✓	✓			✓	Acidic soil amendment
8. Spills of chemicals, process fluids, fuels	✓				✓				✓	✓			✓	Physical and chemical cleanup
9. Soil compaction	✓				✓				✓	✓			✓	Scarification
10. Mix of topsoil and overburden, including mix of different soil types	✓				✓				✓	✓			✓	Fertilization and amendment

10 Legal frame

10.1 National legislation

1.Order No. 756/1997 for endorsing the Regulation for Environmental Pollution Evaluation, published within the Official Bulletin, Chapter I No. 303bis from 06/11/1997;
2.Order No. 863/2002 regarding the approval of methodological guidelines referring to framing procedure for evaluation the environmental impact, published within the Official Bulletin, Chapter I no. 52 from 30/01/2003.

10.2 European legislation

1.Directive on Soil Monitoring.
2.Comunication from the Committee of the European Parliament Council, the Social and Economic Committee and Committee of the Regions – regarding the soil protection strategy.
3.Directive of the Council 86/278/EEC regarding the environmental protection, especially soils, while using processing slurry in agriculture.

11 References

Bridges E. M., Batyes N. H., Nachtergaele F. O., 1998, World Reference Base for Soil Resources, Atlas, Aceo, Leuren, Belgium;

Ewers U., 1991, Standards, guidelines and legislative regulations concerning metals and their compounds, in „Metals and their compounds in the environment” (Ed. E. Merian, VCH, Weinhein, New York, basel, Cambridge,) p. 687 – 711;

Fiedler H. J., Rösler H. J., 1988, Superenelemente in der Umwelt, Ferdinand Enke Verlag, Stuttgart;

Holowaychuk N., Fessenden R. J, 1999, Soil sensitivity to acid deposition and the potential of soil and in Alberta to reduce the acidity and acidic inputs, Earth Science Report 87 – 1, Alberta Research Council;

Lăcătuşu R., 1995, Metodă pentru evaluarea nivelului de încărcare şi de poluare a solurilor cu metale grele (Metod for appraising the level of soil loading and poluution with heavy metals), Ştiinaț Solului (soil Science), vol. XXIX, 2, p. 69 – 80;

***1980, INCDPAPM, Sisitemul Român de Clasificare a Solurilor, Bucureşti;
***1987, INCDPAPM, Metodologia elaborării studiilor pedologice; 3 vol, Red. Red. de Prop. Agrocolă, Bucureşti;

***1988, Harta de soluri, scara 1 : 200.000, foaia Turda, Red. N. Florea, V. Bălăceanu, Elisabeta Marin, Rodica Vespremeanu;

***1997, Ordin pentru aprobarea Reglementării privind evaluarea poluării mediului nr. 756, Monitorul Oficial al României, Partea I, nr. 303 bis/6.XI. 1997;

***2002, Ordin aprobarea Producerii de evaluare a impactului asupra mediului şi de emitere a acordului de mediu, nr. 860/2002;

***2003, Studiu de impact asupra solului, datorat activității de extracție şi prelucrare a minereului aurifer de la Roşia Montană, Arhiva INCDPAPM;
***2003, INCDPAPM, Bază de date la Studiu de impact asupra solului, datorat activității de extracție şi prelucrare a minereului aurifer de la Roşia Montană, Arhiva INCDPAPM;
***1998, FAO – World Reference Base for Soil Resources
***2001, S.C. Proiect Alba - „Natural Risk Map”

12 Appendices