REHABILITATION, GREENING AND STABILIZING WORKS IN BODOŞ MINING AREA, COVASNA COUNTY

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Surface mining is one of the most efficient methods of mining, but it is also the most destructive of other natural resources. Land disturbances associated with the surface mining of coal resources have attracted a great public concern in the last decades.

To minimize environmental impact, it is necessary to minimize the areal extent, intensity, and duration of the environmental disequilibria produced by the extraction process.

The phenomenon of land disturbance is not new on the face of the earth. Humans have always disturbed the land. Accelerated erosion caused by human overuse of the land was confined to parts of Eurasia and was of limited areal extent and duration until about the sixteenth century (Butzer, 1974).

In study of surface mining of coal we must do a complete geomorphic investigation (Toy, Hadley, 1987), which can be divided into three time periods. During the predisturbance period, the landforms and geomorphic processes of an area are taken to represent natural if human did not disturbed the land. There exists an approximate balance between the environmentally controlled geomorphic processes and surface form. Geomorphic data collected during this period provides a goal for eventual reclamation programs. The active disturbance period is a time of maximum disequilibrium between surface form and geomorphic processes. Process rates may be vastly different from those measured during the predisturbance period as the systems operate to reestablish a balance between prevailing forces and resistances. It is necessary an effective management, on-site and off-site to avoid the damaging of adjacent undisturbed lands during this period. The postdisturbance period follows the application of reclamation practices. Restoration of an entirely balanced condition between surface form and geomorphic processes is impossible. Process rates can approach the predisturbance period conditions but a state of disequilibrum will remain.

The geomorphic processes operating on mining areas usually differ significantly in magnitude, frequency and work performed, when compared to

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adjacent, undisturbed areas (Costa, Fleisher, 1984). It is necessary the examination of environmental conditions on local scale, like informations about the geological, climatic, soil and vegetation conditions. Factors influencing the processes include soil, rainfall characteristics, vegetation and slope factors. Mass movements can occur anywhere on the earth's surface, but usually occurs in specific locations. Mass movement will occur at positions dependent upon the hillslope characteristics of aspect, angle and shape, together with geologic features, such as zones of weak and/or closely jointed rock (Toy, Hadley, 1987).

The great variety of slope movements reflects the diversity of factors that may disturb the slope stability. The change in the slope gradient may be caused by natural or artificial interference, by undermining of the foot of a slope by stream erosion or by excavations. The surplus loading by enbankments, fills and spoil heaps produces an increase in shear stress and in the pore-water pressure in clayey soils, which decreases their shear strength. The more rapid the loading, the more dangerous it is (Zaruba, Mencl, 1976).

The degradation process of the soil affects more than half of the land in Romania, including the surface of reclaimed waste dumps too, and the strongest degraded soils (sheet erosion, gully erosion, landslides, wind erosion) represents about 7.262 million ha (30.6 %).

Artificial slopes derived from reclaimed mining areas show some hydrological differences with respect to natural ones. Soil compaction, crusting, texture, chemical composition, mainly control the hydrological processes, usually leading to rill system formation or intensive sheet erosion. Under such conditions soil moisture content, that is, water availability for plants is reduced and, on the other hand, soil removal by rill and sheet erosion is very intense. As a consequence, plant colonisation and growth results very difficult (Nicolau, 2005).

Location in the region

The Bodos Mining Field is positioned in the eastern part of the Baraolt mining basin, on the Bodos rivulet valley (tributary to the Baraolt rivulet). Subterranean mining activities have determined the apparition of an area of submerging and slope breaking in the southern part of the precinct (on 5780 m^2) and in the vicinity of the open-pit mine and its corresponding spoil heap (it occupies 21.550 m^2). The location of the spoil heap (in the northern part, on a surface of 10.000 m^2) and the location of the buildings (on a surface of 1.190 m^2) are the cause of important landscape changes. The extraction of important amounts of rock by the subterranean exploitation has caused the apparition of cavities, filled in time by the collapsing of the upper layers of rock. These phenomena have created more or less circular depressions, which accumulate temporary water from precipitation and from aquifer layers. In the north-eastern

extremity of the mining area, near the exploitation road, ramming phenomena has occurred (on a NW-SW direction), with falls of 2-5 m.

Morphology of the surface

From the morphologic point of view, the region has a hilly relief, specific to the subcarpathian areas. Before the stripping work, the area of the Bodos pit was hilly, with mild slopes.

The geologic structure of the coal deposit

From the geologic point of view, the Bodos mine perimeter is made of a foundation of Cretacic deposits covered by Pliocene molasses deposits and a quaternary cover. The productive horizon aged lower pontian-dacian (Pliocene) consists of the I-VII lignite seams comprised between marls, clays and sands. Only seam III is of economic importance for exploitation. The seam has considerable thickness and coverage of 2 m to 8.6 m and it is located at depths of 8-130 m. The rocks of the bed and roof of coal seam III are sands and grey clays.

Hydrogeologic conditions

Besides the high degree of tectonization, the lignite seam III has many thickness and quality variations. Due to the sands and the volcanic agglomerates contained, the pliocen and quaternary deposits represent a good subterranean water collector and form aquiferous horizons both above and at the local erosion level.

Water sources, their quality and the flow before the mouth

Water sources are phreatic waters from the quaternary stored in the alluvial deposits of the Bodos and Baraolt, rain waters infiltrated in the floor and sand outcrop areas, subterranean waters from the pliocen deposits located in the sands seams within the sandy aquiferous complex, waters with a captive nature, under pressure, generating aquiferous horizons with ascending level, supplied by rainfalls or by the hydrographic network through the outcrop areas of the sands or through seepages at the seam ends and subterranean waters from the cretacic deposits, located in the fissuration area with free level in the outcrop areas and under pressure in the areas covered by impermeable pliocen deposits. The quality of these waters was determined mainly by the chemistry of the

rocks they have been located in. The chemical analysis of these waters made by different laboratories from Bucharest and Ploieşti indicated exceedances of the main physiochemical indicators. The main pollutant of the evacuated water was represented by the sand-clay slurry. The water flows evacuated daily varied between 400-500 mc. The water flows resulted from the mine were 450 mc/day or 164,250 mc/year. The above mentioned flows were registered during productive activity. After the activities ceased, in April 2004, the waters have not been evacuated and the accumulated as lakes in the mine hearth (Cordonaşu, 2006).

The beginnings of the mining activity

Bodos pit is a surface lignite exploitation unit set up in 1987. It is extended on a surface of 106,64 hectares including mine curtilages, waste tips and ancillary activities. For the activity of this pit, by the documentation „Works for maintaining the production capacity at E. M. Capeni between 1986-1990" no investment funds were allocated; the development and procurement of specific equipments were made from production funds. The economic inefficiency due mainly to the low quality of the extracted coal determined a cease of the productive activities al the end of April 2004. The total volume of overburden from removed from the pit from the start of works reaches over 16 million mc and the extracted production amount approximately 2,000,000 tone lignite, mineral substance used for electricity generation in thermal power station and for heating.

The Bodos pit mine closure

The productive activity of the pit ceased at the end of April 2004 due to economic inefficiency, the main factor being the low quality of the extracted coal. When the productive activity ended all specific equipments and plants were removed and transferred to the Racoş-Sud pit, which belongs to the same exploitation, E.M. Capeni. Electrical pumps used for draining the waters from the pit hearth were also removed and this led to accumulations of rain and seepage waters in quantities of over 150,000 mc.

For the closure of the preparation and opening works it was necessary the adaption of all surfaces affected by the productive activity. This adaptation involved filling all the voids within the pit area so that the newly created surfaces will have maximum inclinations of 15º thus ensuring mechanized works when the surface is used for agricultural purposes again. For carrying out this land adaptation a rocks supply was necessary and the source was the external waste tip whose surface was also adapted for environmental rehabilitation. The degraded surfaces of the

pit and of the waste tip was adapted and rehabilitated simultaneously, starting from the waste tip to the centre of the void created by the pit.

Before starting the activities at the Bodoş pit, Bodoş II curtilage was organised at the bottom of the eastern slope, near the Bodoş brook, in order to research the lignite seam III with underground mining works. The adits has been closed, they have a goose-neckpipe for evacuating the waters that might have accumulated or might accumulate and a gas control pipe.

As a result of exploitation through the pit of lignite layer III, in the initial mining perimeter surface of Bodoş pit, an area in the hill slope and hill top, a hole was created by uncovering and exploiting lignite layer III, the initial level of land being an average of + 600 m, and the existing level at the pit heart in some areas, below + 554 m. The height of the Northern hill slope was increased, with rock resulted by uncovering lignite layer III, the volume of land located in this area meant for dumping exceeding 16 million m^3.

Also, in areas occupied by the pit, special constructions were executed for the supply and distribution of electricity to different voltages, lightweight demountable buildings, concrete platforms, high capacity reservoir for fuels and others, which were relieved of duties and were subject to rehabilitation and greening tasks when the pit closed. The initial surface, degraded directly or collaterally by the activity of the pit, was a natural meadow, agricultural lands and forest. To eliminate the effects of coal exploitation by the pit and prevent water accumulations and landslides, the protection of modeling done in the pit and dump affected areas is executed under a plan described in the specification.

Evacuation of waters accumulated on the pit hearth

Uncovering and exploiting the pit inevitably created a gap limited by the pit hearth. In these conditions infiltration waters and especially pluvial waters fallen on the newly created slopes gathered on the pit heart in areas with the lowest level. To work safely and in conditions of security during the activity of the pit, waters were drained from the pit hearth with electro-pumps. The pit activity stoppage (April, 2004) coincides with the cessation of water evacuation from the pit hearth. In these conditions the volume of accumulated water in the form of two lakes was estimated at 150,000 m^3. Reconstruction of degraded areas because of the pit could not be started because of accumulated waters, the work area starting from the very lowest levels of the pit heart, so an anthropogenic lake was built in the middle of the pit, which will collect pluvial waters from the pit area, the pit hearth needing to be heightened up to the rate of + 570 m.

Restoration of areas occupied by the enclosures

The area occupied by the two enclosures is of 1.1318 ha. In view of the rehabilitation and greening of these areas the following are required: scarifying and removal from the scarified land mass of the concrete refuse, branches, herbs and other materials incompatible in the land mass, surface discing, leveling and fertilization, overgrowing with specific hayfield perennial herb seeds.

Modeling and greening areas occupied by the outdoor pit dump and by the pit

Rendering to the agricultural and forest circuit the area occupied by the outdoor pit dump and by the pit is the main object of all the targets in terms of volume and complexity of works. Modeling requires the achievement of the angle of slope of the modeled surfaces of 12^o and a maximum of 15^o in the Eastern slope of the pit, the height of steps in areas where the surfaces are shaped in steps, will be a maximum of 5 m and the width of the berms of 20 m at least, so the overall slope angle will be of 7^o.

Prevention of continued landslides in areas where these events took place is done by changing the slopes upstream slipped lands, gentle surface modeling of the slipped areas, unsilting and reshaping pluvial water channels from the slipped lands, fertilizing and equal afforesting of slipped lands with beech and oak, afforesting of areas that were built in the mound, areas located in the Eastern slope of the pit.

The excavations required for modeling surfaces to the imposed limit take place in the existing area of sterile dump, as well as the area occupied by the pit and the mounds required for modeling surfaces occur in the existing pit area as well as in the dump covered area. The excavation within the pit area and the mounds within the dump area are works that are summed up to leveling unleveled areas in view of obtaining continuous slopes. After excavations are achieved and new horizontal or steeped surfaces are created, there is also need for leveling and compacting new surfaces, settling and compacting vegetable soil, fertilizing the new surfaces, afforesting and overgrowing with grass the rebuilt surfaces. The mounds of the surfaces require soil distribution in a layer no thicker that 30 cm on the surface to be rebuilt, compacting this layer with a “sheep foot” compactor to a compaction degree close to that of the rocks in adjacent and non-degraded surfaces.

Construction of the new area to the projected quota is done by repeating the cycle '”distribution – compaction” the final phase being the soil settlement and its compaction followed by fertilization-grass overgrowing or afforesting.

It is stated that when pit activity started, the plant soil (fertile) was not pickled from the pit areas or from the area covered by the dump before depositing the sterile resulted from uncovering. The source for the plant soil to be deposited on the newly formed surfaces is the vegetable soil formed on the surface of sterile dump and on the Western pit areas. There is no other source for the necessary vegetable soil in the area.

Pickling formed plant soil is done little by little, with temporary dumping, and, as there come out modeled surfaces, the vegetable soil formed in the same way, little by little, is deposited on them. The completely modeled areas bear fertilization and afforesting works imposed by the environment that existed before pit activity started, where certain surfaces were covered by forest. The modeled and fertilized areas meant for agricultural purposes are overgrown with specific hayfield perennial herb seeds, after rehabilitation and greening the owners being free to change plant cultures on these areas, not also on afforested areas. External pit and dump affected areas that were touched by the pit activity are also worked upon and afforested. In the area adjoining the 0.44 ha western pit the whole forest was destroyed, either by cutting trees or by entering this area with heavy machinery specific for pit works.

Rehabilitation and greening areas that do not require modeling

Areas covered by the mining operation perimeter, as well as the adjacent ones, bearing the "fingerprints" of pit activity and not requiring modeling, are also subject to rehabilitation and greening from the very first year, so that they should yield agricultural crops at the same level as before being affected. The total above mentioned areas amount to 22.3899 hectares.

Construction of the cut-off trench for pluvial waters

Rehabilitation of pit covered areas requires increasing the pit heart at a maximum rate of + 570 m. By increasing the pit heart level and by piercing the slope hill between the pit and the water drainage canal into the Bodoş brook, the only safe and stable possibility is created for evacuating pluvial waters from the modeled and greened areas of the pit.

The trench is built by excavation and, to the inside of the pit fitted areas and to the exit of the hill slope, by mounding. Trench construction by mounding in the pit areas is done at the same time as rebuilding the pit heart in the trench area. The newly built slopes of the trench will tilt up to 12^{o} and will be overgrown with grass, and trench work will be of 2 m/1000 m on its entire length.

Canal construction for collecting and draining pluvial waters on the berm + 595 m from the modeled and greened surface of the dump

The purpose of constructing the canal is to retrieve excessive pluvial waters upstream berm + 595 m in order to reduce the quantity of pluvial waters on the Eastern dump slope that is situated in the downstream of berm + 595 m and in the Western town and pretty close to this one. The built canal involves achieving the section needed to pick waters from the beginning of the canal and at the discharge mouth, slope of 2m/1000 m, waters discharge in the North-Western area of remodeled and greened surfaces of the dump in the working guard canals before works started at the pit. For raising the degree of stability of the canal walls they will become overgrown with grass.

Unsilting and reshaping the connection canal between the cut-off trench for pluvial waters and Bodoş brook

The existing canal requires unsilting and reshaping on certain sections. Also, this canal has to be connected to the cut-off trench for pluvial waters, by excavation, and, by reshaping, it has to be connected to the ditch through which the Bodoş brook waters are flowing. All excavation constructions, earth works, are compacted and become overgrown with grass. The connection canal will discharge waters in Bodoş brook the course of which is a newly built concrete ditch belonging to the communal road that is being reconstructed.

Reshaping the existing guarding canal to the Northern, Western and Southern limits of areas that are being vindicated and that were covered by the dump and the pit

The earth resulted from unsilting and reshaping will be deposited to the left and to the right of the canal, and after the transfer of water and moisture from the ground, it will be re-laid by compaction in the form of prisms, in order to increase the capacity of taking water. The channel will be unsilted and reshaped throughout its length.

Unsilting and reshaping Bodoş brook from the limit of Bodoş locality up to the emissary (Baraolt Brook)

The unsilting and reshaping of the river bed requires a lowered fund rate with 0.4 m maintaining the 2.23 m/100 m declivity on the first 900 m and 0.33 m/100 m on the last 275 m.

The earth resulting from these works will be deposited on the left bank of the river bed, this bank being lower than the right bank, the river length in its majority being located at the root of a hill slope. By rising the left bank, by depositing, geometrizing and compacting the deposited earth, water spill out of its bed is prevented, with such consequences as: flooding lower leveled area between the brook bed and the communal road, forming lakes and marshes leading to the removal of affected areas from agricultural production.

Rehabilitation of access road to the modeled and greened areas of the dump and of the pit

For the rehabilitation of access road works are done to remove humps along the whole area of the road, distribution, leveling and compacting of a 0.2 m ballast layer (river aggregate), clearing up the guarding trench all along the left side of the road (uphill walking way), from the village limit to the entrance into the modeled and greened areas of the dump and of the dip.

Monitoring closing works

Pit closing is paralleled by quality control of works and their monitoring without affecting the pace of work. Control and monitoring consist of visual checks, dimensional control by topo-geodesic methods, quality control of ground works carried out in the branch site laboratories of the constructor, and central laboratories, control of construction response during execution works.

Assessing the global impact created and conclusions

In accordance with the Law on Environment at the cessation of Bodoş pit activity the impact on the environment were identified. We can the total change of land morphology in the excavations done in his pit, the deposition of sterile in the area intended for the sterile dump and in areas covered with its yard. Excessive water accumulation both in the area inside the pit and in the sterile dump engendered landslides inside the pit and in the Western slope of the dump. The communal road in the inhabited area as well as outside of it was affected, circulation being aggravated.

To bridge over Baraolt brook that connects communal road with Baraolt Sfântu Gheorghe inter-county road was damaged. The stream of Bodoş brook was deflected in the area of the bridge crossing over it and the right bank was gnawed, thus putting in danger the line of high voltage power parallel to this brook bank. Gnawing was visible on the length of 500 m. The riverbed of Bodoş brook was clogged, a brook that discharges its waters in Baraolt brook,

the foot-walks to the households of the inhabitants of Bodoş village were more or less degraded, including the guard ditches of the communal way. The sections of the collection channel from the south, west and north of the area occupied by the pit and the sterile dump were changed.

Phenomena predicting a possible sliding of the eastern slope of the dump were noticed; the eastern slope was directed to Bodoş locality. The access road that connects the communal road with areas covered by the pit and the sterile dump was degraded. Vegetation was destroyed, land slopes changed, which were elements that changed the hydrological regime in the area. In the area adjacent vegetation and fauna have been affected in the small extent of dust deposition and sediment and fauna, in anthropogenic stress. Vegetation has undergone no qualitative modifications, but only quantitative.

In the evolution of exploitation no rare or protected species or natural monuments were destroyed. Emergence and development of coal exploitation by the pit led to socio-economic changes in the area.

After closing down the Bodoş pit the results are: the elimination of noise caused by specific equipments used, the elimination of the dust in the atmosphere produced in the pit, in the waste tip and on the access road alignment, the elimination of the solid slurries in the water courses in the areas adjacent to the pit and the waste tip. The scope was the restoration of the natural landscape on the surfaces affected by the pit and the waste tip and improving the surface soil. Restoration of the natural landscape takes into account the forrested areas before building the pit as well as land cultivated mainly with hay. To restore relations between the components of the ecosystem so that they evolve towards a stable equilibrium, the natural restoration by the corresponding integration of anthropic elements appeared in the regional landscape are required.

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