

Mining as a tool for reclamation of a Degraded Area *Mineração como ferramenta para Recuperação de uma Área Degradada*

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Abstract

Any human activity causes environmental degradation, resulting in a continuous deterioration of environmental quality (water, air or soil). While mining is also an activity that causes degradation of the environment, it is essential for the continuity of life as it is known. On the other hand, paradoxically, by keeping life in this way, we are contributing to its cessation. This leads us to look for alternatives to reduce the impact of mining activities. The Reclamation of degraded areas may be an alternative, as it can mitigate the current picture of continuous environmental degradation.

However, Degraded Areas not always follow a mining operation. This article presents a case where mining is the tool used to technically and financially allow the Reclamation of a degraded area.

keywords: Mining, Degradation Areas, Reclamation of Degraded Areas.

Resumo

Qualquer atividade humana provoca degradação ambiental, resultando em contínua deterioração da qualidade ambiental (da água, do ar ou do solo). A mineração é, também, uma atividade que provoca a degradação do meio ambiente, no entanto, é essencial para a continuidade da vida como a conhecemos. Por outro lado, paradoxalmente, mantendo a vida dessa forma, estamos colaborando para que ela deixe de existir, o que nos leva a buscar alternativas para diminuir os impactos das atividades de mineração. A recuperação de áreas degradadas pode ser uma alternativa, pois pode atenuar o quadro atual de contínua degradação ambiental.

Áreas degradadas nem sempre vêm depois da mineração. O presente artigo apresenta um caso em que a mineração é a ferramenta que tornou possível técnica e financeiramente a recuperação de uma área degradada.

Palavras-chave: mineração, áreas degradadas, recuperação de áreas degradadas.

1. Introduction

Mining has an intrinsic relationship with the reclamation of areas, not only because the areas degraded by mining must be reclaimed as determined by law, but also because this is a basic principle in the mining activities for reuse and preservation of (future) land use.

Recovery of degraded areas is planned according to the National Environmental Policy (Law 6.938/1981) and its amendments. Furthermore, Article 225 of the Federal Constitution makes clear that "the conduct and activities

deemed harmful to the environment will subject violators, individuals or entities, to penal and administrative sanctions, independent of the obligation to repair the damage." Therefore, the mining activity has as an explicit requisite, the recovery of degraded areas, which should comply with a technical solution approved by the environmental agency. Considering the aspects approached, the reclamation of degraded areas should be thought of as a mining phase. However, in principle, the line of reasoning would be closer to

the one developed by Oliveira (2001) and Sánchez (1994). They considered the reclamation of areas degraded by mining as a phase embedded throughout the procedure, instead of a phase detached from the other phases. Even if regarded as a detached phase, this must be considered as a phase in the Mine Closure Plan, whose presentation is also required by law: NRM 20, text given in Ordinance DNPM 237/2001 and DNPM 12/2002 (BRASIL, 2014).

The most common relationship

between mining and recovery is that in which miners are only concerned about recovery of degraded areas after finishing mining activities and in most cases by force of the law.

This relationship can be more complex, as we remember that mineral resources are among the most noticeable examples of non-renewable, therefore finite, resources, i.e., with possible exhaustion or burnout. However, it is demonstrated that no modern society can live without these mineral reserves as they are necessary and even essential to a wide range of human activities. In addition, mineral resources represent a decisive value for many economies based on the mining activities, the so-called "mineral

2. Objective

The present study aims to present a case study to prove that it is possible to use mining for the reclamation of degraded areas, promoting the stabili-

3. Materials and methods

From the conceptualization of terms related to recovery, especially in the case of mining and recovery terms, obviously, there can only be recovery following degradation. The general overview of current concepts and the corresponding legislation was studied, especially in mining cases.

4. Reclamation of degraded areas

Care in clarifying the concepts "reclamation" as well as "degradation" and the combination of both is relevant for research related to this study's topic, as these terms are used outside the technical context and there is also some disagreement in literature.

The term "degradation" refers to the thinking of Tostes and Neves (1992, p.20) that define "to degrade" as "to decay, ruin (...) transformation of the environment (...)", and add a sense of loss of "positive features" that can lead "to their extinction" or the "extinction" of the positive features.

Degradation can also be defined as the "adverse modification of soil characteristics in relation to its various possible uses, both established in planning and those considered as potential" as per NBR 10703 (ABNT, 1989). Even more directly, it "refers

economies". Thus, whether demanding or offering, any economy that aims to develop and grow sustainably depends on minerals. It is almost impossible to consider maintenance, expansion of quality of human life, production and consumption without the exploitation of mineral resources. The discussion on this topic indicates that mining will increasingly be placed within the context of another discussion: sustainable development. Here, the level of socio-economic well-being will have to be expanded, minimizing environmental damage for current generations and providing alternative wealth for future generations, thus yielding compensation for the depleted resources (ISHISAKI, LEINFELDER and LEMOS, 2008).

zation of the medium, integrating the landscape back to the natural environment. Therefore, mining can also be considered as an alternative to promote

The context of mining activities regarding sustainability required to address human activities from the parallel drawn to this type of development was also considered. We took into consideration that despite finite resources and the inevitable degradation that mining can cause, its activities are necessary for

to damage or total loss of the ability of soils for future use" as described in the paper by FAO (1980), which relates the environmental degradation to the degradation of soil properties.

The term environmental degradation suggests an adverse change, or even suggests some loss. According to Sánchez (1992), this loss can be seen from four perspectives: loss of capital or natural heritage, loss of environmental functions, loss of man's either health or safety, and even loss of landscape quality.

The Guide for Reclamation of Degraded Areas by SABESP (2003) defines environmental degradation as "changes imposed by society to natural ecosystems by changing (degrading) the physical, chemical and biological characteristics, thus compromising the quality of life of human beings". On

For Eggert (2000), it is theoretically simple to think about sustainability regarding renewable resources, but it is more complex for the case of resources that exist in fixed amounts. Thus, the concept of sustainable development apparently is conflicting with mining activity that, by definition, is based on non-renewable resources. In order to achieve a sustainable development, Tilton (1996) states that the current pattern of exhaustible resource consumption cannot impose reduction of standard of living on future generations. However, not all relationships between mining and reclamation fall into this category. This study presents another relationship between mining and the reclamation of the degraded area.

reclamation of a damaged area, particularly when there is a great need for removing soil or rock.

human development and maintenance of life as it is known.

An experiment where the author was involved is presented as a case study to illustrate that there are other ways to think about the relationship of mining to society, in particular the relationship between mining and degradation.

the other hand, the Manual for Reclamation of Degraded Areas of IBAMA brings a sense of degradation related to "changing the soil equilibrium" or a "reduction (...) of soil quality in performing its basic functions."

Specifically regarding mining activities, Williams et al. (1990) say that environmental degradation "occurs when there is loss of adaptation to physical, chemical and biological characteristics and makes unfeasible the socioeconomic development."

In particular, mining areas will turn into degraded areas at a given time after the mining activities. Inevitably, mining will cause environmental degradation, and miners must promote the Reclamation of degraded mining areas, in many cases mandated by force of the law.

The use of the term "reclama-

tion" of area already denotes that this area was previously degraded, and this degradation can be understood in several ways, depending on the focus of the study.

The environmental reclamation of a certain area will result from a series of measures yielding a solution for each potentially impacting or polluting mining activity. Griffith (1995) lays down a few principles for this reclamation (ideal) to be successful. The first principle is related to the Reclamation plan, the second one is related to the fact that practice is synergistic in an interdisciplinary effort and the third one is related to the planning of systematic changes.

If we could borrow the term "ecological footprint" and use it in the cases of degradation areas, we would understand the recovered area as an attempt to "erase" the marks left in the mined area. Evidently, while "footprints" left by man cannot be simply erased, they can be minimized or mitigated.

Thus, reclamation of degraded areas is understood as an "application of management techniques in order to make an environment (land) degraded fit a new one, provided there is sustainable productive use" (Sánchez, 2006).

From the conceptual differences presented above, it can be implied that

5. Case study

The study area occupies 5.0 hectares of hillside located in Morro da Glória, which is part of the Serra do Mar, near downtown Guarujá, on the coast of São Paulo.

The hill of Morro da Glória suffered a landslide in mid-January 2001. This landslide occurred due to copious summer rains. This natural phenomenon is the most common cause of outbreaks of geotechnical instability on isolated hills slopes of Coastal Plain and the Serra do Mar, acting as natural modulators of regional geomorphology.

In the case, this natural phenomenon was potentiated by human activities in past decades. The top of Morro da Glória had been the target of deforestation (there is no record of this deforestation's goal, although the use as a borrow pit and / or military facilities is speculated). It was then abandoned and exposed to intense natural processes which persisted until landsliding occurred. To assess the situation of the

techniques to minimize the "footprint" left in a terrestrial environment are designated as "Reclamation of area". This would be one of the types of environmental remediation, particularly when related to the land environment (ISHISAKI, LEINFELDER e LEMOS, 2008).

Sánchez (2006) summarizes the various results of reclamation in seven objectives, with increasing disturbance degree, namely: Reclamation overcoming the initial condition, restoration, rehabilitation, remediation, natural attenuation, spontaneous Reclamation and continuity of degradation. The first four objectives result from corrective action on the current environment.

The SOBRADE (Sociedade Brasileira de Recuperação de Áreas Degradadas) chose the terms restore and recover as the best form to identify and conceptualize the issue of reclamation of degraded areas, and they use the term "restore" as synonymous of recover. For Roberts & Gandolfi (2001), on the other hand, restoration would be "recreating" an ecosystem in order to obtain the condition before degradation.

According to Balensiefer (1998), recover means returning the degraded area to its usage form, through a definite plan for land use. This concept is similar to that proposed by Williams *et al* (1990)

landsliding in Morro da Glória, the municipality of Guarujá promoted a study of slope stability in November 2001, which concluded (as expected) that stabilization work was required. Meeting the request of the municipality and the owners of the soil, Lordello Brothers Ltd. has developed a reclamation project, proposing the use of the material (gravel soil, which is used in construction to landfill) that would be removed as a way to fund this reclamation of the area. Due to this use with financial value the material was considered a mineral asset.

As Brazilian legislation required people interested in extracting mineral resources to obtain a Mining Concession through the National Department of Mineral Production - DNPM of Ministry Energy and Mining, Lordello promoted the necessary steps to license its mining venture, obtaining the Mining Concession issued by DNPM and Environmental License issued by Cetesb.

for recovering mining degraded areas.

However, "rehabilitation (...) is the most frequent mode of reclamation." And, "in the case of mining activities", it is the "mode (...) required by the regulator" (Sánchez, 2006). As defined by law, in Article 3 of the Federal Decree 97.632/1989, the concept of Reclamation is the "return of degraded land to a usage form, according to a pre-determined plan for land use in order to obtain a stable environment."

The most particular case of reclamation of area is the recuperation that improves the initial condition. Here, the initial condition is understood as a previous condition. For example, degraded mining areas where the present condition would be post-ore of interest mining condition, or after degradation of the mining area, and the initial condition would be that before the current condition. This brings us to the condition of no human interference, making it quite difficult to obtain such reclamation, especially in areas degraded by mining.

Taking into consideration the definitions of reclamation of degraded areas, ultimately the reclamation will be the recovery of soil. Given the very nature of mining activity, the recovery of areas degraded by mining is an attempt to provide a new use (sustainable) to the area after ceasing the mining activities.

This reclamation project is actually a project of geotechnical stability. The first step in this project is to understand the dynamic process, including the specific reasons for the landslide and its encumbrances, such as intense and concentrated rainfall in summer and geological and geomorphologic typology of the area studied. The resulting project included:

- Formation of stable slopes, with complete removal of unconsolidated material to promote geotechnical stability;
- Construction of an access ramp to start the excavation of unconsolidated material and stabilization of the slope;
- Implementation of a drainage system of surface water, to drain the water with flow channels, settling ponds and the outlet box;
- Replacement of organic matter (where necessary) as soon as the embankments take their final shape;
- Planting of grasses in areas of exposed soil;

- Revegetation of area with native plants, always seeking the implementation of the local vegetation, using trees, seedlings and seeds from the spot;
- Reclamation the area of the construction site for urban use

After completing the study, another side of the hill suffered a smaller landslide. Considering the proximity to the rainy season, summer of 2004, the reclamation work assumed an emergency nature.

At the time, the company started its activities in the area with an unstable situation, and several emergency measures were taken to not worsen the situation. Despite the urgency, the environmental agency had not issued authorization for removal of vegetation to build the access ramp.

Given the pressing legal matter, the decision to build the ramp on the slipped material was taken (including the use of this material as part of the ramp).

While geotechnical issues occurred, the construction was viable and the ramp is still in operation. Moreover, removing the vegetation unaffected by the landslide was not necessary in order to build the ramp. The ramp remained in position and a monitoring system for topographic landmarks with routine inspection was installed. No instability has ever occurred in the ramp.

The formation of stable slopes (and consequent extraction of gravel soil) started upstream of the landslide face (Figure 1a), at the top of Morro da Gloria. Additionally, channel drainage and

revegetation with formation of counter-tops and slopes were developed aiming at stability of the slope. The activities were performed in descending order, i.e., from the highest to the lowest area, gradually eliminating the need for using the accesses by machines and vehicles.

The countertops and slopes in the final configuration (Figure 1b) were revegetated and the final drainage system was installed (Figure 2a), consisting of channels and hydraulic energy dissipator stairs. Ultimately, this was precisely the motivation for the start of work on site: promoting the stabilization of Morro da Gloria, through stable countertops and stable slopes in the landslide face, taking into consideration the marketing of gravel soil extracted.

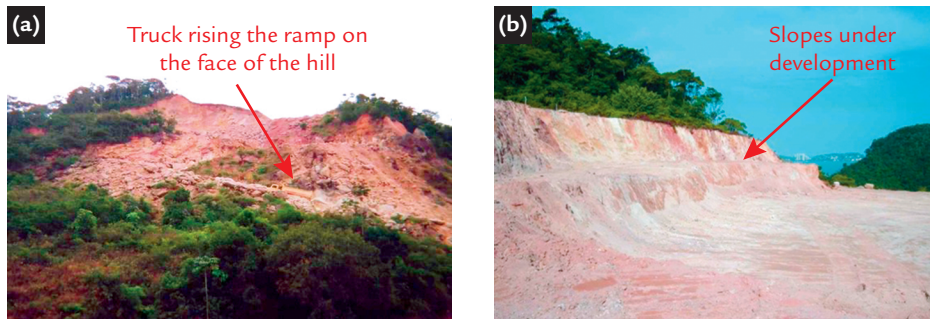


Figure 1
(a) Face of the hill where the ramp was built in 2004
(b) View of countertops in formation in the year 2005.

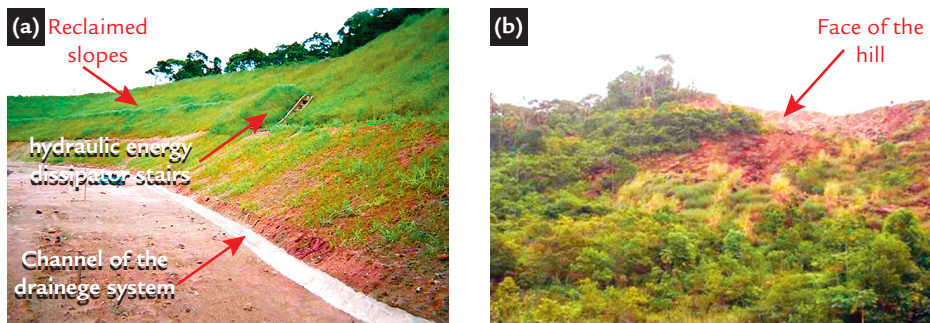


Figure 2
(a) View of countertops in formation in the year 2006.
(b) Face of the hill where the ramp was built in 2007.

The stable countertop designed for the area plans the top, which at the time was at elevation 95 meters, to reach 57.5 meters in the final quota situation. It is noteworthy that in addition to all the aspects already presented above, Guarujá economics is based on tourism, and

therefore there is a natural concern for the comfort of attending tourists. Thus, the aesthetic viewing of the landscape is as important as the landscape's stability. The landscape ecology is a matter already in evidence in academic texts that is becoming more important in the

licensing process. Therefore, the activity is important not only from the point of view of geotechnical stability, but also from an aesthetic one, and the work was performed accordingly, as shown in photos from years 2004, 2007 and 2014 (Figures 1a, 2b and 3).



Figure 3
Reclaimed face of the hill in 2014.

6. Results and discussions

This case can be considered as peculiar, of rare application. There are not many opportunities of using the mining as a way of promoting the recovery of an area, especially because in the past, the area was not degraded by mining activities. Even so, we must consider that it is a very relevant case, due to geotechnical instability of the area, the bureaucracy from the regulatory authorities and the urgency of the case.

Perhaps the greatest feature of this case is the geotechnical stability as well as the apparent geotechnical stability, for the layman (represented by the sur-

rounding population and tourists), he or she conceives an "idea of stability" when the visual aspect of the project depicts a wooded area or one with lush vegetation. Due to the proximity to the urban area, this aspect becomes quite relevant.

The "idea of stability" of the laity might have prevented the mobilization of the municipality regarding slope stability, i.e., despite the uninviting aspect of the area, it was still preserving some "green" before the landslide.

The most relevant part of the case can be considered as a requirement to begin the operation, reflected by the

entrepreneurial initiative in seeking an economical alternative in order to enable the venture.

The implementation of the project of slope reclamation provided Lordello the financial returns by exploitation of mineral gravel soil. It is impossible to imagine the case without the use of the slipped material, and additionally, the cost of building the stable countertops (representing a large removal of slipped material) where planning a site to put all removed material resulting from the work of slope stabilization would be required.

7. Conclusions

The relationship between mining and reclamation is the main focus of the article. As background, it is a peculiar case where mining was the tool that allowed the recovery of the degraded area.

The reclamation is one of the practical steps that can result in resource conservation and/or soil recovery, which is a fragile and important resource for

sustaining life on Earth. This relationship among preservation, recovery and human activities is even clearer regarding mining. Inevitably the dependence of mining activities by mankind and the relationship among these activities and the concepts of sustainability lead us to study the matter.

Thus, reclamation is understood

as one of mining phases, becoming an important tool when seeking to minimize the "footprint" left in the environment, especially in the terrestrial one. At the same time, after knowledge of this case, we can say that mining can also be thought of as a tool for the recovery of degraded areas, especially where recovery involves a huge volume of soil.

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