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# Study of certain technical aspects of the rehabilitation of bauxite mining sites operated at the Sangarédi mine (Parawi deposit, Compagnie des Bauxites de Guinée mining concession; CBG)

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## Abstract

The fatal consequences of open-cast mining are first and foremost the considerable degradation of the earth's surface. Soil disturbed during mining operations must be rehabilitated in line with the progress of the extraction work, to promote environmental protection. Restored areas contribute to the oxygen balance, rainfall and soil regeneration. The aim of this work is to highlight the development techniques used in areas affected by mining operations. To carry out this research work, we used technical restoration, which consists of rehabilitating disturbed soils with a view to their subsequent use for the needs of the population, and biological restoration, which consists of implementing appropriate measures to protect the environment and allow flora and fauna to flourish. This includes creating a fertile layer after logging, developing nurseries and seedlings, transplanting and protecting wooded areas. For forest and fruit restoration in our study area, we have planned: 395,760 cashew seedlings because of their resistance to unfavorable climatic conditions and 168,375 acacia seedlings for firewood, charcoal, furniture and construction. Mine rehabilitation is a more complex discipline, involving the use of native plants to mimic the natural ecosystem, rather than simple revegetation actions. In general, complete reclamation is impossible, but careful restoration and rehabilitation can create a favorable ecosystem.

**Keywords:** Rehabilitation; Vacuums of exploitation; Protection; Environment; Regeneration

## 1 Introduction

The mining industry is one of the most important economic sectors in the world. The mining phase is the result of a long process of developing a mining project. The purpose of mining exploration is to identify deposits of various minerals and useful substances. The development of this sector is the basis for the development of other industries such as iron and steel, the processing industry and the chemical industry, which contributes to the development of the national economy and the creation of job opportunities **(1).** The consequences of this exploitation on the mining environment are not always positive, but seriously affect the ecosystem of the natural environment.

The increase in the harmful effects of human activity on natural environments worldwide has led to a global awareness that is now reflected in unanimous recognition of the need to redevelop and restore natural environments.

Because of the diversity of situations (ecological conditions, nature and relative extent of degradation and its effects on surrounding ecosystems, as well as on people's activities and lifestyles), there are a variety of methods for achieving this **(2).**

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The worldwide increase in the destructive effects of human activity on natural environments has given rise to an international awareness that is now reflected in unanimous recognition of the need to redevelop and restore degraded environments. The means to achieve this are varied because of the diversity of situations (ecological conditions, nature and relative importance of the degradation and its effects on surrounding ecosystems, as well as on people's activities and lifestyles).

At a time when the mining industry is playing an increasingly important role in the harmonious development of nations, useful minerals appear to have undeniable economic potential. In addition to its immense agricultural and energy potential, Guinea's subsoil harbours many significant mineral resources that have yet to be exploited. But exploiting these immense resources requires the creation of new ecological systems. From an ecological point of view, man's industrial activity on the earth's surface leads to the creation of man-made landscapes. Geological prospecting, ore extraction and processing all contribute to the degradation of ecosystems, with changes to the surface occurring throughout the exploitation process. The areas most sensitive to surface change are the layers of topsoil, which develop slowly and are thin in places. Now more than ever, it's time to think about restoring the voids left by quarrying to ensure ecological balance. This publication will outline the methods and techniques for rehabilitating the voids left by quarrying operations, but will also serve as an example for integrated land-use progress agreements for the remaining unmined deposits in the Republic of Guinea.

The main objective of this renovation is to integrate the sites of former open-cast mining operations into their natural environment and landscape, while preserving biodiversity.

Taking into account the needs of new visitors to the sites also means that the design of the green space can be adapted to future uses such as leisure, sports and educational activities.

The structuring elements of the site's environment are defined by the landscape study, which derive from both the natural environment (substrate, climate, vegetation) and human activity (impact of operations, reshaping actions). The framework of the revegetation project is then defined according to the advantages of the local landscape (biological richness, socio-cultural heritage, aesthetics, etc.).

The project must take into account the specific constraints of the site, which are not conducive to the establishment of vegetation:

- low biogenic capacity of substrates;
- Mediterranean mountain climate: harsh with a long dry period;
- sometimes difficult to access and therefore limited maintenance.

Hardy, vigorous plants adapted to local ecological conditions and requiring little maintenance are necessary because of these constraints. The list of species to be planted is drawn up after a detailed survey of local plant groups, as the most suitable plants are those that grow spontaneously in the vicinity of the site (3).

## 2 Material and Methods

All the players in the mining sector are concerned about optimising the various operations described above. Much remains to be done to further improve the effectiveness and completeness of site rehabilitation.

Areas for improvement in ecological restoration include various aspects, including differentiated treatment of surfaces to take greater account of what nature can contribute spontaneously. It is important to integrate the notion of ecological continuity into revegetation projects and to optimise land use, as this has a positive impact on both the environment and the economy. Various studies have emphasised the importance of preserving or recreating areas of biodiversity (scrubland or forest) on farmland, because the distance between revegetated areas and natural vegetation is an important factor in the diversification of species in a developing ecosystem (4).

There are two (2) stages to restoring the voids left by mining operations:

- Technical Restoration;
- Biological Restoration.

#### *2.1.1 Technical restoration*

It consists of rehabilitating disturbed land with a view to its subsequent use for public purposes. The technical operations to be carried out are

- Stripping The Topsoil And Stockpiling It;
- Smoothing The Edges;
- Levelling The Excavated Areas And Adding Topsoil;
- Staking;
- Digging.

The equipment used for this work includes bulldozers, lorries, loaders, GPS, topographical equipment, decameters, ropes, etc.

When renovating a specific mine, it is important to take several aspects into account, such as the safety of the mine site, particularly if the area is accessible to the public; the rehabilitation of the land surface; water quality and waste disposal areas to avoid long-term water contamination; soil erosion; dust production or vegetation problems. Monitoring is the final stage of reclamation. All reclaimed areas are monitored during this process to assess, among other things, vegetation growth (5).

#### *2.1.2 Biological restoration*

It consists of taking appropriate measures to protect the environment, allowing fauna and flora to flourish. The creation of a fertile layer after quarrying, the development of nurseries and seedlings, the transplanting and protection of wooded areas.

The choice of plant types for reforesting quarries depends on:

- Relief;
- The Thickness Of The Planted Soil
- Climatic Factors
- The Needs of the community affected.

However, revegetation procedures remain complex and require a number of factors to be taken into account, on which the results obtained largely depend: the geographical origin of the seeds used to respect genetic diversity, which can vary from one mining massif to another, the choice of species to be planted according to the characteristics of the environment, the choice of techniques to be used according to morphology and accessibility (6).

The world's major industrial and mining companies, grouped together in the International Council on Mining & Metals (ICMM), strongly support the application of the principles of ecological restoration of degraded sites, and have published Good Practice Guidance for Mining and Biodiversity. It is widely recognised that the revegetation of areas denuded or damaged by mining or industrial activity must have the clear objective of eventually establishing a vegetation cover that can protect slopes from erosion, regulate water flows, ensure the reconstitution and protection of biological diversity and reintegrate impacted sites into the landscape.

### 2.2 Presentation of the CBG mining concession

#### *2.2.1 Situation*

The HALCO concession is located in the western part of Guinea, in the administrative province of Boké (Fig.1) - in the prefecture of Boké, sub-prefecture of Sangarédi, and in the prefecture of Télimélé, sub-prefectures of Missoura and Daramagniaki. The total surface area of the HALCO concession is 1,715 km$^2$ (54.6 km x 31.4 km). It is bounded by the following geographical coordinates: 10°55'-11°12' North latitude and 13°40'-14°10' West longitude. In the international coordinate system (WGS-84), the concession is bounded by the coordinates Y: 0 591 000-0 645 700 and X: 1 206 850-1 238 200.

#### *2.2.2 Climate*

The HALCO concession is part of the humid savannah and woodland climatic zone. The climate of the zone is tropical, intermittently wet, with two alternating seasons: rainy (June - October) and dry (November - May). Average rainfall during the observation period varied between 1684.6 mm (1995) and 3334.7 mm (2003), with an average value of

2159.5 mm. However, it is worth noting the predominance of periods with values below the annual average. These periods account for 18 of the 30 target years. Ten of these years fall between 1980 and 1990. At present, we seem to be witnessing a period of sudden variations with an interval of 1-2 years. Maximum monthly variations were observed in July and August, with values ranging respectively from 238.7 mm (1995) to 711.2 mm (1975) and from 283.8 (1977) to 1204.6 mm (2003). In annual cycles, most of the precipitation falls between June and October, accounting for 79.5% (1984) to 98.5% (1985 and 1991) of annual precipitation, with an annual average of 90.4%. The maximum value is observed in August, with an average of 490.9 mm. The average annual temperature in the area varies between 24 and 30°C.

### *2.2.3 Vegetation*

The HALCO concession is mainly located on the lower slope of the western side of the Fouta Djalon plateau, with elevations ranging from 177 to 372 metres. However, on the right bank of the Kogon, the concession occupies part of the slope formed by higher terraces. Here, heights reach 400 - 426 m. The relief of the target area represents a plateau dissected into isolated flat-topped massifs (bowé) by the valleys of the major rivers - Kogon and Tinguilinta and their tributaries. The gradients in relation to the main rivers - Kogon, with a bed of 116÷100 m, and Tinguilinta, with a bed of 65÷39 m - reach 380 m. The slopes of the valleys separating the bowé are generally steep, and often impassable.

**Table 1** Characteristics of deposits in the CBG mining concession

| **Order number** | **NN° Bowal (Designation)** | **Coordinates (Bowal centre)** | | **Distance to Sangarédi mine, km** | **Distance to Sangarédi-Kamsar railway line** | **Ribs, m** | **Height difference, m** | **Total area of Bowal, km2, (S)** |
|---|---|---|---|---|---|---|---|---|
| | | X | Y | | | | | |
| 1 | N'Dangara | 184 500 | 95 500 | 5 | 2 | 146-231 | 16-100 | 18,5 |
| 2 | Boundou-Waade | 184 500 | 98 000 | 5 | 4 | 150-232 | 18-100 | 14,4 |
| 3 | Parawi | 177 000 | 96 000 | 12 | 8 | 140-245 | 70-175 | 19,8 |
| 4 | Bowal N 1 (Dademouna) | 154 964 | 106 071 | 36 | 10 | 136-176 | 10-118 | 14,0 |
| 5 | Bowal N 2 (Fello Parawi) | 160 250 | 105 750 | 32 | 9 | 120-236 | 56-172 | 25,1 |
| 6 | Bowal N 3 (Lemounehoun) | 162 446 | 101 542 | 26 | 13 | 130-234 | 20-144 | 7,7 |
| 7 | Bowal N 5 (Köniz) | 176 200 | 106 400 | 17 | 10 | 142-296 | 10-196 | 19,3 |
| 8 | Bowal N 6 (Dalagala) | 180 250 | 106 100 | 11 | 10 | 150-299 | 10-125 | 17,2 |
| 9 | Bowal N 7 (Fello Yopedji) | 168 500 | 102 500 | 23 | 7 | 140-272 | 60-796 | 2,3 |
| 10 | Bowal N 8 Sud (Tiapikoure-Sud) | 179 500 | 101 250 | 12 | 9 | 158-282 | 6-130 | 3,3 |
| 11 | Bowal N 8 Nord (tiapikoure-Nord) | 178 000 | 102 800 | 12 | 5 | 168-294 | 10-150 | 7,3 |
| 12 | Bowal N 9 (Fello Maoule) | 184 600 | 103 100 | 5 | 3 | 150-242 | 10-90 | 3,8 |
| 13 | Bowal N 10 (Parawi) | 153 940 | 100 075 | 34 | 7 | 110-204 | 40-164 | 16,4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14 | Bowal N 11(Fello Capeyi) | 165 000 | 97 500 | 27 | 5 | 190-275 | 64-199 | 15,8 |
| 15 | Bowal N 12(Bourore Sud) | 176 500 | 99 000 | 13 | 5 | 150-281 | 76-207 | 3,8 |
| 16 | Bowal N 12-2(kounsiou Madiou) | 182 750 | 100 250 | 7 | 5 | 151-238 | 11-98 | 9,3 |
| 17 | Bowal N 14(tiouladji) | 159 935 | 98 551 | 29 | 5 | 115-222 | 25-172 | 7,0 |
| 18 | Bowal N 15(tionkita) | 169 432 | 98 014 | 19 | 5 | 142-234 | 10-122 | 7,9 |
| 19 | Bowal N 16(Woungourou koura) | 195 500 | 99 500 | 2 | 2 | 120-304 | 5-185 | 6,0 |
| 20 | Bowal N 17(Gangarandyi) | 169 419 | 94 514 | 20 | 2 | 130-230 | 15-152 | 3,3 |
| 21 | Bowal N 19 (Diwe) | 162 425 | 96 042 | 26 | 4 | 130-246 | 35-155 | 21,4 |
| 22 | Bowal N 20(Diarabaka) | 151 909 | 92 083 | 38 | 4 | 98-228 | 15-148 | 7,2 |
| 23 | Bowal N 22(koobi) | 173 000 | 93 500 | 16 | 1 | 148-206 | 84-142 | 4,7 |
| 24 | Bowal N 24 (Vendoubala) | 159 399 | 89 554 | 31 | 3 | 130-224 | 30-194 | 23,8 |
| 25 | Bowal N 25(kaganaka) | 180 250 | 90 600 | 10 | 4 | 126-290 | 5-170 | 18,5 |
| 26 | Bowal N 26(Dkandouka) | 156 380 | 84 565 | 35 | 7 | 140-266 | 15-186 | 8,6 |
| 27 | Bowal N 27(Bouna) | 159 876 | 83 552 | 33 | 7 | 140-266 | 10-186 | 2,6 |
| 28 | Bowal N 28 (Louga) | 182 893 | 87 962 | 12 | 4 | 148-246 | 5-86 | 2,7 |
| 29 | Bowal N 29(Yaladane) | 186 450 | 86 350 | 8 | 8 | 146-390 | 5-130 | 10,7 |
| 30 | Bowal N 30(limbiko) | 192 350 | 88 850 | 6 | 6 | 178-386 | 5-158 | 15,2 |
| 31 | Bowal N 31(tapoli) | 153 862 | 80 075 | 39 | 12 | 140-242 | 5-142 | 4,0 |
| 32 | Bowal N 32 (Deli dima) | 163 886 | 86 036 | 30 | 6 | 150-254 | 10-185 | 20,7 |
| 33 | Bowal N 33 (Wossou) | 170 750 | 89 750 | 20 | 2 | 126-257 | 74-177 | 5,1 |
| 34 | Bowal N 34(Mamanao) | 175 750 | 82 500 | 24 | 10 | 152-211 | 66-125 | 4,2 |
| 35 | Bowal N 36(Danlaido) | 165 368 | 81 530 | 30 | 8 | 140-232 | 40-152 | 6,2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 36 | Bowal N 37 (Bantanbouro) | 172 870 | 82 001 | 23 | 87 | 140-280 | 25-180 | 9,6 |
| 37 | Bowal N 38 (popo badiel) | 182 879 | 84 462 | 16 | 10 | 160-320 | 5-140 | 6 ,1 |
| 38 | Bowal N 39 (hafia) | 189 879 | 84 435 | 14 | 14 | 240-380 | | 7,4 |
| 39 | Bowal N 46 (borou) | 191 969 | 107 426 | 8 | 8 | 35-195 | 10-154 | 8,4 |
| 40 | Bowal N 49(kogonlingue) | 196 000 | 104 000 | 2 | 2 | 120-274 | 10-125 | 13,3 |
| 41 | Bowal N 55 (Pied) | 195 500 | 95 500 | 4 | 4 | 120-333 | 5-213 | 9,9 |

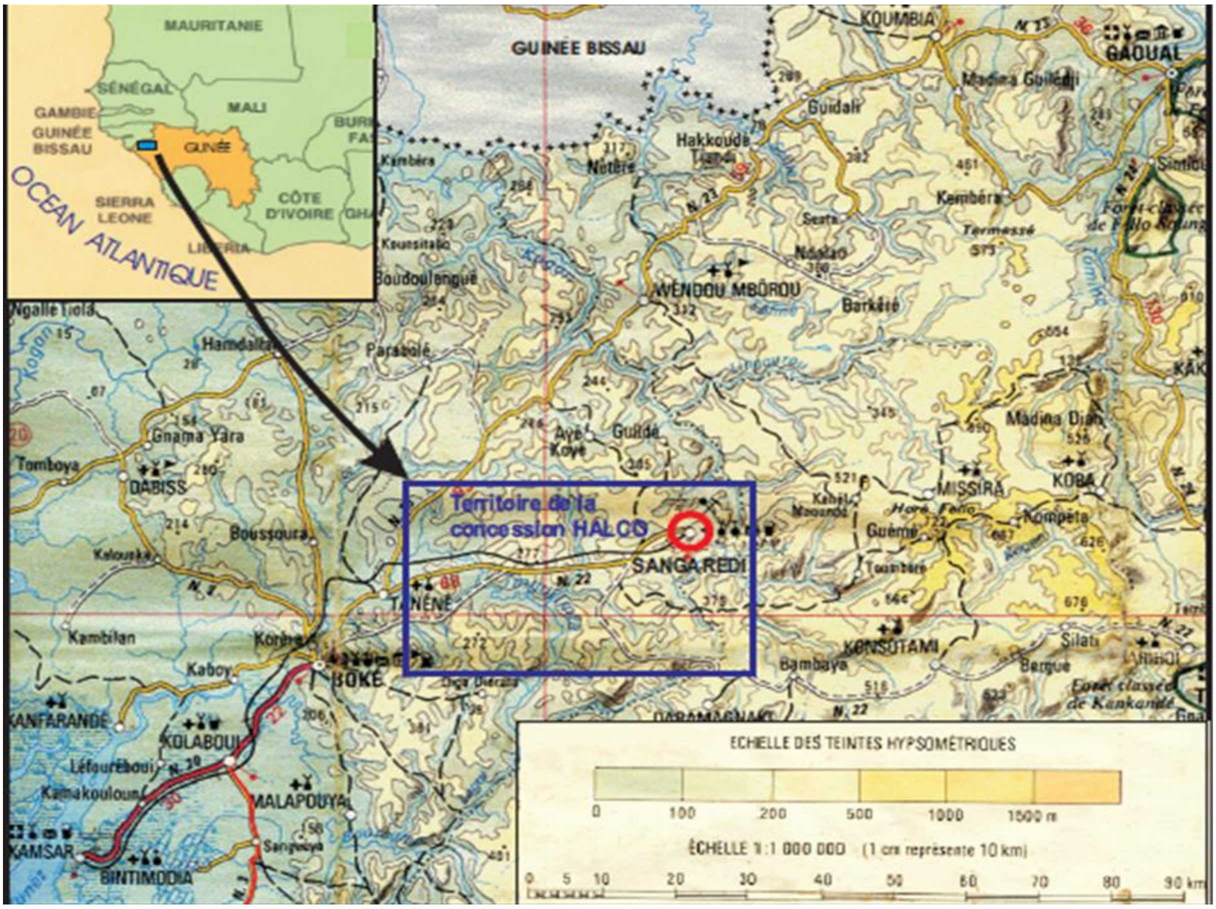


**Figure 1** Map of CBG mining concession

The vegetation in the target area is characterised, on the one hand, by the virtual absence of vegetation cover in the central parts of the bowé and, on the other hand, by the accumulation, up to a depth of a few metres, of grey silts in local depressions. This distribution of vegetation cover determines the character of the vegetation. In areas where there is no continuous vegetation cover (bowé tops, rarely escarpments on slopes), grassy vegetation generally develops. With the presence of even a thin layer of vegetation, the bowal becomes covered with bushy and shrubby vegetation. The vegetation is particularly thick on the slopes of the valleys and at the foot of these slopes. Dense gallery forests generally line watercourses.

In assessing the overall vegetation cover of the HALCO concession, it is necessary to highlight the extensive development of vegetation on the right bank of the Kogon and in the southern sector of the central part of the target area. Southern sector of the central part of the target area. The vegetation is also thick on the bowé located further north of the HALCO concession.

### 2.3 Presentation of the Parawi site

The Parawi deposit is located in the central part of the CBG concession. The Bowal to which the deposit is attached has an elongated shape in the south altitudinal direction with a complex contour due to the burial of numerous watercourses and steep ravines. The bowal hosting the deposit is of average size, extending over 7.5 km, narrowing abruptly from east to west from 4.5 km to 10 km. Its total surface area is 19.8 km2. The exact area of bauxite required is 16.6km2; its length is 6.8km, its width is 2.91km and its average thickness is km.

The Parawi deposit represents a medium-sized source of raw material. The estimated reserve at the $Al_2O_3$ cut-off is 45.53% Megatonnes. The deposit is generally of average quality (total $Al_2O_3$ 45.64%).

**Table 2** Content of components in Parawi bauxite

| **Parameters** | **LO** | **$SiO_2$** | **$TiO_2$** | **$Fe_2O_3$** | **$Al_2O_3$** | **$Al_2O_3$(143)** | **$Al_2O_3$(245)** | **Mono** |
|---|---|---|---|---|---|---|---|---|
| Content, % | 25.80 | 1.59 | 2.69 | 29.09 | 48.09 | 42.44 | 46.28 | 3.86 |

## 3 Results and Discussion

### 3.1 Technical restoration

#### *3.1.1 Levelling work*

For this work, 40% of the rock making up the upper part of the slope to be softened will be blasted downwards. The loose rock remaining on the roof will be pushed by the bulldozer, and the same machine will level the bottom and the edge along the projected plane (at an angle of 18° to the horizontal), see figure 2.

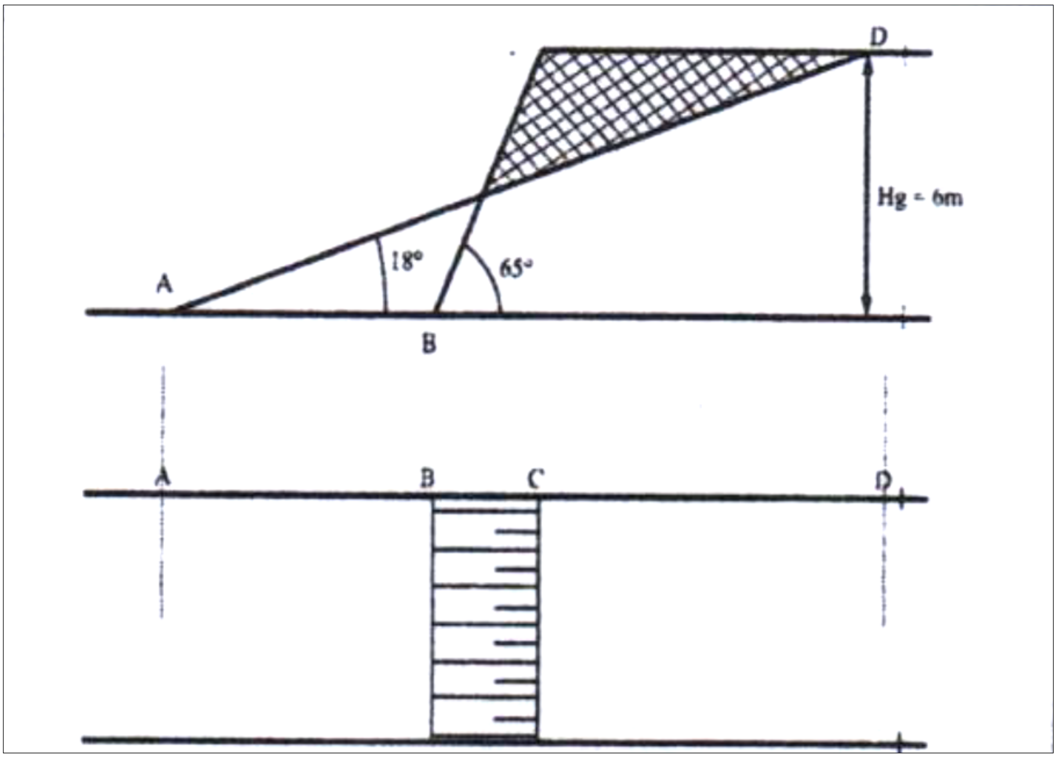


**Figure 2** Schematic diagram of the slope softening at the edge of the step

BC: slope of the step after ore extraction;
AD: embankment after slope softening

NB: To prevent the formation of water spots in the mine, irrigation drains are dug to protect against water ingress.

#### *3.1.2 Levelling the quarry floor*

There are two particularly important aspects to this work:

- The volume of topsoil removed in order to determine the quantity required to restore;
- The type of crop to be grown on the redeveloped area will determine the amount of work required to prepare it.

The topsoil is placed 300 m from the stripped area. The layer of sterile rock is 0.12 m thick. The volume of topsoil to be stripped in the borrow area will therefore be:

$$V = Sc * Rd, m^3$$

Where V is the volume of rock to be stripped in m3;
Sc: Surface area of the quarry to be developed in m2;
Rd: Overburden ratio (0.12 m).

$$V = 19\ 788\ 000 * 0.12 = 2\ 374\ 560\ m^3$$

### 3.2 Biological restoration

#### *3.2.1 Choice of plant type*

The three main revegetation techniques for starting to restore a degraded site are natural regeneration, seeding and planting. Each has modifications to improve effectiveness, advantages and disadvantages, depending on the characteristics of the site to be revegetated. The table opposite sets out the different techniques and the conditions for their implementation.

It is possible to combine these methods, and it has even been suggested that this will improve the success of revegetation. For example, planting on previously fertilised clay soil produces exceptional growth rates and low mortality.

It is also recommended that seeding be supplemented by planting, particularly for:

- ➢ species which have difficulty developing or which are known not to develop from seeding;
- ➢ species with expensive seeds;
- ➢ planting species to create favourable shade and moisture conditions for sowing more quickly.

As recommended by Australian authors (7) .

The best strategy for rapidly restoring a diverse plant cover, both biologically and functionally, is to combine all these techniques in a reasoned way.

The choice of planting material for reforesting a quarry depends on:

- Du relif ;
- Climate;
- The need for community;
- The type of material used.

Based on the above conditions, we have selected the following plants for forest and fruit restoration in our study area:

1. Cashew: resistant to adverse weather conditions such as drought. This plant has the following advantages:

- ✓ Production of popular fruit;
- ✓ Production of exportable seeds;
- ✓ Less favourable soil use.

2. Acacia: after planting, it is used for firewood, charcoal, furniture and construction. Given the predominance of basic clay on the plateaux after exploitation, we recommend the use of a quantity of topsoil on the surfaces intended to receive the young seedlings for their development.

#### 3.2.2 *Planning reforestation*

To better carry out the restoration work and obtain the best results, it is important to divide the year into three (3) work periods:

- Surface preparation period: January, February, March, April and May;
- Reforestation period: June, July and August;
- Monitoring period: September, October, November and December.

Vegetation reappears very slowly, and the soil is generally sloping, fairly compact and bare, lending itself particularly well to superficial washing by surface water. In this case, topsoil has to be transported to fill in the cracks. The furrows dug by the bulldozer rippers will be covered with plant products resulting from the stripping before receiving the seedlings intended for reforestation. The soil must be loosened to a level surface and sufficient depth around each plant, or over the entire surface, in order to

- Allow good penetration of the roots, which will then have to resist tornadoes;
- Aerate the soil;
- Improve water retention on all nurseries.

For reforestation work, the seeds will be sown directly at the end of April and beginning of May, as soon as the first rains start. Transplanting will take place in June and July, when the rains are abundant, and the young plants will have time to grow long roots before the dry season. Surveillance will be carried out to prevent theft and protect the plant species planted.

#### 3.2.3 *Estimated volume of work*

1) Determining the surface area for each type of plant

$$S = \frac{Sc}{Npl}; m^2$$

• Sc: surface area of the quarry; Sc =19788 000 $m^2$
• Npl: the number of plant types; Npl=2

Hence :

$$S = \frac{19788000}{2} = 9894000\, m^2 = 989{,}4\, ha$$

2) Determining the volume of a hole for each type of plant
Cashew tree: Hole size (5m x 5m). Dimensions of the holes in the plane:( 0,35mx0, 35m). Hole depth: 0.35m
Hole volume: Vtr=0.35m x0.35m x0.35m=0.043m3 Vtr=0.043m2

3) Determining the number of plants for the 989.4 ha

Npl=SxNpi/ha

Where S: area to be reforested for each type of plant; S=989.4 ha

Npl/ha: Number of plants per hectare

$$Npl/ha = \frac{10^4}{Spl}; Plants$$

We know that 1ha =10,000 $m^2$

Spl: area occupied by a plant (for cashew Spl = (5mx5m) = 25m $)^2$

Hence:

$$\frac{Npl}{ha} = \frac{10^4}{24} = 400\, Plants$$

**Npl/ha = 400 plants**

So Npl=989,4 x 400=395,760 plants

Npl = 395 760 plants

4) Determining the total volume of holes

VTtr = Npl x Vtr

VTtr = 395 760 X 0.043m3 = 17 017.68 m3

VTtr=17,017.68 m3

Acacia: Surface occupied by a plane; Spl= (4mx4m) =16m2

Determining the number of plants per hectare

$$Npl/ha = \frac{10^4}{16} = 625\ Plants$$

Hence Npl=Sreb x Npl/ha

Or Sreb: area to be reforested, Sreb = 989.4ha

Npl=989,625=618 375

Npl=168 375 plants

Total volume of holes

VTtr = Npl x Vtr

VTtr = 618 375 x 0.043m3 = 265 901.125m$^3$

Reclamation generally simply means returning a mine site to a different use, be it the same as before mining began. This includes environmental issues relating to surface and groundwater, air quality, erosion problems, re-vegetation with appropriate plant species and animal refuges. Mine reclamation is a more complex discipline involving the use of native plants to mimic the natural ecosystem, rather than simple revegetation actions. In general, complete restoration is impossible, but careful restoration and rehabilitation can create a favourable ecosystem (8).

**Table 3** Summary of calculation results

| **Designation** | **Cashew** | **Acacia** |
|---|---|---|
| Area to be reforested, m$^2$ | 9 894 000 | 9 894 000 |
| Mesh, m$^2$ | 5 * 5 | 4 * 4 |
| Area for one plant, m$^2$ | 25 | 16 |
| Number of plants/ha | 395 760 | 618 375 |
| Volume of the hole, m$^3$ | 0.043 | |
| Total volume for holes, m3 | 17 018 | 265 901 |

The purpose of this study is to develop and document a standard rehabilitation procedure for mines operated by CBG in accordance with the legislation in force in the Republic of Guinea. The objective of this study, relating to this development, is to comply with the requirements of the regulations set out in the environmental protection code through a method of responsible exploitation of mineral resources. This study does not take into account the duration and cost of the work. A detailed draft study will set out the various economic options for a proper exploration programme.

Proper planning of a mine for future development will enhance the value of damaged sites and make the mine suitable for positive future use. As a result, former mine sites can be transformed into leisure areas, shopping centres, golf courses, airfields, lakes, underground storage facilities, storage areas for mine and power station waste, museums, sites of special scientific interest and geological sites of regional importance, industrial estates, fishponds and many other economic or ecological uses (9).

## 4 Conclusion

From an ecological point of view, man's industrial activity on the environment leads to the creation of the man-made landscape. Mining brings considerable benefits, but it also has adverse effects on the physical and biological environment and on human health.

The advantages include: improved living conditions for the community through the creation of school, health and sports facilities in the areas concerned; youth employment, which is a major source of revenue for the State. The disadvantages can be summed up as the destruction of the ecosystem, the disappearance of wildlife, the deformation of the original structure of the land and the expropriation of cultivable land from the local population. As a result, if these mining voids are abandoned without being restored, it constitutes a natural disaster. In view of the above, the use of cashew or acacia trees, given their resistance to climatic conditions and their practical importance, will facilitate the regeneration of the wooded area, as will the use of a large quantity of topsoil on the surfaces intended to receive the young seedlings for their rapid development.

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