Multitemporal analysis of environmental restoration of quarries and intervened areas

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Keywords : sustainability, flora, fauna, restoration, topography, landscaping.

SUMMARY

The open pit mineral extraction process affects the natural terrain, the vegetation cover is eliminated and changes are made in the morphology of the area, the last phase of the mining cycle corresponds to the closure and landscape restoration, this rehabilitation process is carried out comprises a series of activities that seek to mitigate the negative impacts of mining so that the legacy left by the project is positive, seeking collective well-being, meeting environmental, social and technical objectives.
This summary will expose the technical methodology used in the closure of 2 mining titles and the gradual restoration of several active partial fronts; by means of topographic and photogrammetric monitoring that has allowed to bring exploitation areas to a state equal to or better than they were before being intervened.
The importance of carrying out these activities parallel to the exploitation project has made it possible to reduce the environmental impact of mining, after the pandemic we have focused on making better use of resources to carry out projects that were established for the long term, obtaining environmentally favorable results.

SUMMARY (optional summary in one other language in addition to English, eg your own language)

El proceso de extracción de minerales a cielo abierto ocasiona una afectación al terreno natural, se elimina la cobertura vegetal y se realizan cambios en la morfología de la zona, la última fase del ciclo minero corresponde al cierre y restauración paisajístico, este proceso de rehabilitación se compone una serie de actividades que buscan mitigar los impactos negativos de la minería de forma que el legado que deje el proyecto sea positivo buscando el bienestar colectivo, cumpliendo los objetivos ambientales, sociales y técnicos.
En este resumen se expondrá la metodología técnica usada en el cierre de 2 títulos mineros y la restauración paulatina de varios frentes parciales activos; mediante el acompañamiento topográfico y fotogramétrico que ha permitido llevar zonas de explotación a un estado igual o mejor del que se encontraban antes de ser intervenidos.
La importancia de realizar estas actividades paralelas al proyecto de explotación ha permitido reducir el impacto ambiental de la minería , después de la pandemia nos hemos enfocado en aprovechar mejor los recursos para adelantar proyectos que se tenían establecidos par largo plazo, obteniendo resultados favorables ambientalmente.

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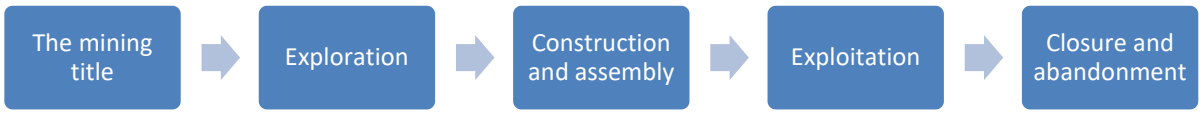
1. CONTEXT

The extractive processes of minerals generate modifications in the geomorphology of the intervened area; it changes the environment and requires a technical intervention in order to project an adequate closure of the Project.
During a Project for the exploitation of non-renewable resources, the closure of a mine can be scheduled when the resources of interest are exhausted, when there are changes in the legislation or when the change in the economic conditions of the market convert the contract into a non-renewable Project. viable.
It is important to clarify that mining is a finite activity, with a predetermined life period, according to the National Mining Agency, the following stages are established:



The mining regulatory entities require a closure plan before granting the mining title or exploitation permit in order to guarantee the adequate geomorphological reconformation of the exploited area.
The so-called “mine closure” is the process of closing mining operations, whether productive or exploratory, temporarily or permanently. The useful life of a mine is determined by the size and quality of the mineral deposit being mined.

The process of closing a mine is made up of rehabilitation and monitoring during a period of time that allows guaranteeing the continuity of the adaptation of the recovered area to the natural environment, the main objective is to carry out a technical closure that lasts, in all countries. Where mining takes place, one of the main challenges is to achieve long-term sustainable development, for which the closure and environmental remediation plans are instruments of vital importance to achieve this goal, thus guaranteeing that the area affected by the extraction is mimicked. with their environment to be the same or better than before being intervened.

2. STAGES OF A MINING PROJECT

As mentioned above, all projects have different stages, which are briefly explained below according to the National Mining Agency of Colombia:

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2.1 The mining title

What is a concession contract?

It is a contract signed between the State and an individual so the latter one can, at their own risk, conduct studies, exploration and exploitation activities of the minerals owned by the state within a specific zone. The minerals have to be exploited under the terms and conditions established by the law (Mining Code).

What rights are the under a concession contract?

A concession contract grants the right to conduct, within the given zone, the studies and works to establish the existence of the minerals covered in the contract and to exploit them under the principles, rules and criteria of the geology and mining engineering techniques. It also grants the right to install, assembly, and build facilities and equipment within and out the given zone necessary for the execution of the contract.

How to apply for a concession contract?

The awarding of mining exploitation rights is based on the "first come, first served" principle, with the exception of those zones declared as strategic zones by the National Agency of Mining–NAM. The strategic mining zones will be awarded through objective selection processes led by the NAM. In addition, mining rights can be negotiated among private parties and concession rights can be partially or totally transferred.

What are the phases of a concession contract?

A concession contract involves the following stages:
• Exploration
• Building and assembly
• Exploitation

Stages	Term Years	Extension Years	Term Reduction	
			Situation	Condition
Exploration	3 8		It may be less than 3 years as requested by the proposer	Compliance with the minimum obligations required at this stage
Building and assembly	3	1	It may be shorter if early exploitation activities are taking place and if the infrastructure and provisional assemblies allow it.	Prior written notice to the mining authority and submission of the Construction and Work Program for the early exploita-tion
Exploitation	24	30	It can be shorter if the concessionaire asks for extensions during the exploitation and building & assembly stages	

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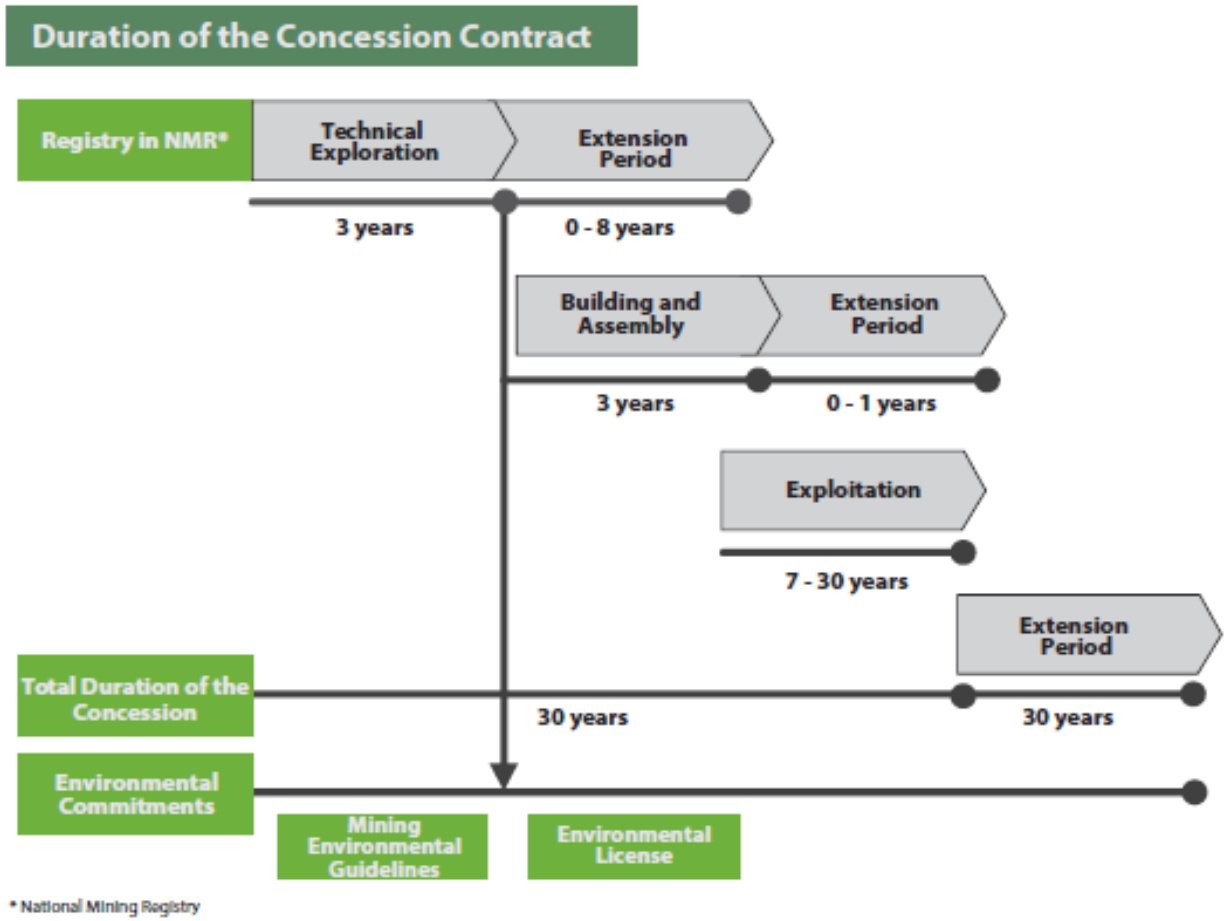
What is the duration of a concession contract?

A concession contract is signed for the term requested by the proposer, but no longer than thirty (30) years. Such term commences as of the registration of the contract in the National Mining Registry.



When a concession contract may be terminated?

A concession contract is not only terminated due to expiration of terms, but it can also be terminated if the concessionaire requests the termination by mutual agreement, if the concessionaire dies, or by a statement of termination.

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2.2 Exploration

Technical exploration is the first phase of the concession contract and must be carried out within three (3) years following the date of registration of the concession contract in the National Mining Registry.

What should be done in this phase?

During the exploration phase, the necessary works, studies and works are carried out to establish and determine the existence and location of the contracted mineral or minerals, the geometry of the deposit(s) within the concession area, in economically exploitable quantity and quality, the technical feasibility of extracting them and the impact they may cause on the environment and the social environment.
In this phase, the aim is to technically establish and calculate the reserves of the mineral or minerals, the location and characteristics of the deposits or deposits, the preparation of the mining plan, the means and methods of exploitation, and the scale and feasible duration of the expected production.

What is the Environmental Impact Study (EIA)?

The Environmental Impact Study (EIA) gathers all the information oriented to the knowledge of the supply and demand of the natural resources that can be used in the development of the mining Project, in order to establish the assignments, management and the degree of intervention that can be done on them. In this sense, the natural resources object of use, exploitation or affectation as a consequence of the execution of the exploitation activities must be related.
The concessionaire must submit the EIA to the environmental authority as well as the Works and Works Program (PTO) to the mining authority. For the processing of the Environmental License, prior approval of the Environmental Impact Study is required, which includes measures to prevent, mitigate, correct or compensate for the environmental impacts caused.

What does the Work Plan (PTO) consist of?

The Work Plan is the final report of the exploration phase that provides the technical basis, logistical, economic and commercial to make the decision to invest and develop a mining project. Before the expiration of the exploration stage, that is, 30 days before, the concessionaire

must submit the PTO for approval by the National Mining Agency. Said program, annexed to the concession contract, must contain the following elements:

1. Definitive delimitation of the exploitation area
2. Topographic map of said area.
3. Detailed cartographic information of the area and, in the case of marine mining, specifications
bathymetric.
4. Location, calculation and characteristics of the reserves to be exploited in the development of the project.
5. Description and location of mining facilities and works, mineral deposits,
benefit and transport and, if applicable, transformation.
6. Mining Exploitation Plan, which will include the indication of the technical guides that will be used.
7. Geomorphological Landscape and Forest Recovery Works Plan for the altered system.
8. Scale and duration of expected production.
9. Physical and chemical characteristics of the minerals to be exploited.
10. Description and location of the works and facilities necessary for the exercise of the easements inherent in mining operations.
11. Plan for the closure of the exploitation and abandonment of the assemblies and the infrastructure.

What are the phases contemplated by the Exploration Works?

The exploration works will be carried out in the following phases:
• Phase I. Surface Geological Exploration.
In this phase, superficial geological studies and characterizations of an area are carried out. determined and allow to establish the sectors with the best manifestations or indications geological that indicate the presence of a mineralized substance and to propose specific sites where the same substance can be evaluated through the application of techniques
direct or indirect.
• Phase II. Geological Exploration of the Subsoil
This phase seeks to delimit the potentially economic deposit, with more
size and mineral content, defining the true geological mining potential
of the deposit.
• Phase III. Evaluation and Geological Model.
With the results obtained in the previous phases, the true potential of the deposit is defined and the planning and design of the Works and Works Program (PTO) begins.

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• Phase IV. Program of Works and Works.
The Works and Works Program (PTO) is carried out. This PTO must be presented in a simultaneously with the Environmental Impact Study, before the competent authorities, and will be the
basis for the granting of the Environmental License, an essential requirement to proceed to the next stage of the concession contract: Construction and Assembly.

2.3 Construction and assembly

It is the stage in which all the infrastructure required to start the exploitation stage is prepared.

What is mining construction and assembly?
Construction works are those infrastructure works that are essential for the normal operation of the support and administration tasks of the mining company. For its part, the mining assembly consists of the preparation of the mining fronts and installation of the works, services, equipment and fixed machinery necessary to initiate and advance the extraction or collection of minerals, their stockpiling, their internal transportation and processing.
The constructions, installations and assemblies must have the characteristics, dimensions and qualities indicated in the approved Work and Construction Program (PTO). However, the concessionaire may make necessary changes and additions that must be previously reported to the Mining and Environmental Authorities.

What are the general actions of construction and assembly works?

A. PTO Layout Adjustment

Once the Works and Works Program, PTO, has been approved, the concessionaire must carry out a specific planning on the activities to be carried out within the mining project to Short, medium and long term. Likewise, on constructions and support facilities for the development of the mining operation with the least environmental impact and affectation, ecologically sensitive areas. In case of changes and/or additions to the PTO designs, The concessionaire must previously inform the mining and environmental authorities competent.

B. Opening and development of mining fronts and infrastructure works for the benefit and Transformation

It consists of the preparation, implementation and start-up of the essential works for the extraction and uptake of minerals, their storage, internal transport and benefit.

The mining fronts must also be formed according to the characteristics of the reservoir and environmental sensitivity of the work area; also establish the structures and basic designs that ensure the stability and safety conditions of the extractive operation.

C. Civil and infrastructure works
Are those works necessary for the normal operation of the support tasks and management of the mining operation. These works must be commensurate with the magnitude of the mining project and consider environmental restrictions.

2.4 Exploitation

The exploitation phase includes the set of mineral extraction operations found in the concession area, storage, benefit, and closure and abandonment of assemblies and infrastructure.

When does the exploitation phase start?

The commercial exploitation period of a contract formally begins at the expiration of the Construction and Assembly period, and about which the concessionaire will give written notice to the mining and environmental authorities. The start date will be taken into account as the contractual start of the operation.

How long does the exploitation phase last?

The exploitation period is the remaining time, discounting the stages of exploration and construction and assembly, with the corresponding extensions. The formal start date will be taken into account for all purposes of the contract.

2.5 Closure and abandonment

The mine closure plan is an environmental management instrument that includes all the technical, legal and social actions required to guarantee the achievement of the closure or completion objectives, as well as compliance with current regulations in all aspects involved, whether environmental, technical and/or socio-economic

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What considerations should a mine closure plan take?

The Mine Closure Plan contemplated in the PTO must consider the conditions of the area before the exploitation (Environmental Baselines), during the development of the activity, the completion of the activities and the subsequent use of the land. The Plan must also contemplate the positive and negative impacts generated by the activity during its operation, which must be conveniently documented in the corresponding Management Plan; also, analyze the response of the territory to the natural processes of its environment.
Mine closure and abandonment activities will be taken into account from mining planning and during the execution of the mining project.
Closure is the activity that seeks to rehabilitate the areas used by mining once operations have concluded. The main objective of this work is to ensure that the areas used by the operation are compatible with a healthy and adequate environment for the development of life.
In fact, this operational stage can take many years, since periods of at least 5 years are estimated for the observation of the restored areas after closure.

Steps to follow

Like any operational system, this stage has several steps that can be executed efficiently with long-term planning:

Productive shutdown: Once production stops, the number of workers is reduced and only a limited workforce is retained to permanently shut down the mining equipment. In some cases, the mining company may offer retraining or early retirement options to its workers before the mine closes. Prior to this closure stage, the impacts that the closure will produce on the affected communities, its sustainability when the finite resource is depleted, and the containment plans that must be implemented must be studied and addressed. These tasks are normally carried out with the intervention and interaction of the authorities, the communes and the mining companies, and begin in the early stages of project execution.

Decommissioning: Small teams or contractors dismantle or dismantle mining processing facilities and equipment. Pipelines are drained, equipment and parts are cleaned and sold, buildings are reused or demolished, materials are recovered from storage, and waste is disposed of or confined.

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Remediation: The cleaning of the contaminated area to safe levels by removing or isolating contaminants, if applicable. At mine sites, remediation often consists of isolating contaminated material in pre-existing tailings storage facilities, passivating tailings or tailings dams and waste rock piles, and collecting and treating any contaminated mine water if necessary, avoiding and/or controlling the generation of acid drainage.

Reclamation: The physical stabilization of impacted land (dams, rock piles), landscaping, restoration of topsoil, and return of land to a useful purpose.

Restoration: The process of rebuilding the ecosystem that existed at the mine site (where applicable) before it was disturbed. The science of mine reclamation has evolved from simple revegetation activities to a discipline that involves the use of native plants to allow the natural ecosystem to develop over an extended period of time.

Rehabilitation: The establishment of a stable and self-sustaining ecosystem, although not necessarily the one that existed before mining activities began. In many cases, complete restoration may be impossible, but successful remediation, recovery, and rehabilitation can result in the timely establishment of a functional ecosystem.

Post-closure: Monitoring programs are used to assess the effectiveness of reclamation measures and to identify any corrective action that may be necessary. In addition, closed mines may require long-term care and maintenance after mine closure, such as continued treatment of mine working discharge water, periodic monitoring and maintenance of tailings dam structures, and monitoring of the remediation technologies in use, the periodic monitoring of constructed or recovered wetlands, as well as both surface and underground watercourses.
Although the mine closure steps are listed above in a linear fashion, mining operations often begin closure and remediation during active operations.

Mining companies should consider mine closure plans as a measure to achieve sustainable development and, above all, to mitigate waste from the depleted project.

The result of the strategy of this mining stage is, naturally, to achieve a better relationship with society and the environment.

It is known that mining generates transformations in the shape of the land and in the environment. That is why companies carry out mine closure plans as a strategy for the eradication, step by step, of the impacts that they may produce: acid drainage, tailings, final residues.

For this, it is important and necessary to establish monitoring and control processes that weigh on all the actors involved in production for the correct analysis of the effectiveness of the previous strategy.
Mining must know how to offset the demand for minerals in the world. That is a commitment for future generations and, above all, sustainable development.

This environmental management instrument is made up of technical and legal actions carried out by the owners of mining activities. In addition, it is intended to adopt the necessary measures before, during and after the closure of operations, in order to eliminate, mitigate and control the adverse effects of the project.

The preparation of a mine closure plan implies the preservation of ecological aspects such as:

- landscape security
- Protection of water resources
- sustainable land use
- These factors focus on socio-economic issues for the improvement of the life of society.

It is important to note that the interests of society prevail over business interests. Mining companies help support the populations surrounding mining operations.

3. ARGOS CLOSURES

As the decision has been made to carry out the technical closures of some exploitations, the Argos organization has developed the technical processes of closure and abandonment of some mining titles, in this case we will talk about 4.
Two of these closures were carried out in underground mines and 2 open pit mines, which were followed up by photogrammetry.

3.1 San Judas Underground Mine Closure

Coal mine, a closure is carried out that includes the stabilization of the affected areas, water management and landscape restoration.

Before and after the empradization of the slopes.


Before and after support stabilization


3.2 San Martin Underground Mine Closure

Coal mine, a closure is carried out that includes the stabilization of the affected areas, water management and landscape restoration.

Before and after slope stabilization.


Before and after the coformation of the ditches for surface water management:


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2.1 Open Pit Mine Closure Fishing

A process of conformation and profiling of the slopes is carried out, they are landscaped and revegetated.

Before and after photography:

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2.2 Chámeza Open Pit Mine Closure

The Chámeza title corresponds to the Pozzolana export.
For this closing, the following activities were carried out:

- Reconformation of the slopes


- lawn installation


- excavations

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- Construction of a supporting buttress


- Adaptation of sedimentation ponds


- construction of gutters


- Revegetation and planting


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Initial view and final view of the project:


REFERENCES

National Mining Agency ANM (Entity of the national government of Colombia)
National Code of Mines of Colombia
Argos SA

BIOGRAPHICAL NOTES

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