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MINE CLOSURE PLANNING ISSUES: A FOCUS ON COAL MINING

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Abstract

Mine closure may occur due to various reasons. The closure policy with respect to the company's approach towards mine closure needs to be established and documented. Development of Closure strategy is a process whereby desired closure and post closure options are evaluated and documented, and a preferred option chosen. Organizations need to develop their own closure standard in line with their business goal. To facilitate effective planning, it is necessary that certain closure assumptions are made on which the Closure Management Plan can be developed. Closure costs are almost as site-specific as geology, but generalizations can be used to indicate the range of possible costs. Risk assessment is must for choosing the final strategy of closure. Mine completion is the ultimate goal of mine closure. This paper highlights these issues in the context of coal mining and associate environmental impacts.

***Key words**: mine closure, closure cost, financial assurance, mine completion*

Introduction

Historically, when a mineral body was exhausted, production ceased and mines were boarded up and abandoned. Today it is accepted that mine closure requires the return of land to a viable post-mining use, such as agriculture. It is not even sufficient to simply physically reclaim mined lands anymore as the socio-economic impacts of the closure must also be assessed and managed.[1]

In this paper, the author has tried to review the mine closure framework necessary for the Indian coal sector with the lesson from the framework in metal sector. The author has in the previous papers discussed the closure concepts for metal sector. Hence, the basic elements of mine closure concept and planning process have not been discussed here. Only the shift required for the coal sector from the existing mine closure framework is deliberated.

The mines close for reasons other than exhaustion or depletion of reserves. These include:

- economic, such as low commodity prices or high costs that may lead a company into voluntary administration or receivership
- geological, such as an unanticipated decrease in grade or size of the mineral body
- technical, such as adverse geotechnical conditions or mechanical/equipment failure
- regulatory, due to safety or environmental breaches
- policy changes, which occur from time-to-time, particularly when governments change
- social or community pressures, particularly from non-government organisations
- closure of downstream industry or markets
- flooding or inrush.[7]

By 2000 A.D. 500 Mm^3 of overburden was handled from coal mines only. This had to serious problems in respect of solid waste disposal.[8]

The Ministry of Coal and Mines, GoI (Government of India), has envisaged a largescale expansion of the coal production from the current figure of 380 MT (million tonnes) to 1061 MT by the year 2024/25 to meet the projected demand of 1267 MT of coal in 2024/25 assuming an annual GDP growth rate of 8%.

A 1999/2000 government estimate puts 26.1% of the Indian population as living below the poverty line (Manorama Year Book 2005). The per capita availability of forest land of 0.07 ha in India is extremely low to provide for the timber, fuelwood, and fodder needs of the country. Of the 100 MT of fly ash currently produced annually, only 20% is utilized for road construction, manufacture of pozzolana cement, and fly ash bricks. By 2024/25 the fly ash production has been estimated at 275 MT/year and this would be difficult to dispose.[4]

Belated planning and costing for mine closure after the feasibility study stage will result in reassumptions and recalculations.

Coal Mining and Impacts on Environment

Coal is one of the world's most plentiful energy resources, and its use is likely to quadruple by the year 2020. Coal occurs in a wide range of forms and qualities. There are two broad categories: (a) hard coal, which includes coking coal (used to produce steel) and other bituminous and anthracite coals used for steam and power generation; and (b) brown coal (sub-bituminous and lignite), which is used mostly as on-site fuel. Coal has a wide range of moisture (2-40%), sulfur (0.2-8%), and ash content (5-40%). These can affect the value of the coal as a fuel and cause environmental problems in its use.

The depth, thickness, and configuration of the coal seams determine the mode of extraction. Shallow, flat coal deposits are mined by surface processes, which are generally less costly (per ton of coal) than underground mines of similar capacity. Strip mining is one of the most economical surface processes. Here removal of overburden and coal extraction proceeds in parallel strips along the face of the coal deposit, with the spoil being deposited behind the operation in the previously mined areas. In opencast mining, thick seams (tens of meters) are mined by traditional quarrying techniques. Underground mining is used for deep seams. Underground mining methods vary according to the site conditions, but all involve the removal of seams followed by more or less controlled subsidence of the overlying strata.

Raw coal may be sold as mined or may be processed in a beneficiation/washing plant to remove noncombustible materials (up to 45% reduction in ash content) and inorganic sulfur (up to 25% reduction). Coal beneficiation is based on wet physical processes such as gravity separation and flotation. Beneficiation produces two waste streams: fine materials that are discharged as a slurry to a tailings impoundment, and coarse material (typically greater than 0.5 millimeters (mm) that is hauled away as a solid waste.

Beneficiation plants produce large volumes of tailings and solid wastes. Storage and handling of coal generates dust at rates which can be 3 kilograms (kg) per metric ton of coal mined, with the ambient dust concentration ranging from 10 to 300 micrograms per cubic meter ($\mu g/m^3$) (above the background level) at the mine site. (Coal Mining and Production).

The lignite mines in Rajasthan and Gujarat are in general being planned to go beyond the 6:1 m3/t stripping ratio (Surka 7:1, Khada Saliya 9.4:1 and Giral 13:1). Use of such high stripping ratios often result in very large size external OB dumps, which in turn requires extra land for the mine. The recoverable reserves of minerals in India is presented in Table 1. It is evident coal enjoys longer sustenance in comparison to other minerals.

Table 1 : Recoverable reserves of mineral/ore in India (1995)

Table 1 Recoverable reserves of mineral/ore in India (1970 & 1995)

	Recoverable reserves (million tonnes)	
Mineral/Ore	1970	1995
Iron Ore (hematite)	8244	10,052
Iron Ore (magnetite)	2025	3,408
Manganese Ore	108	167
Bauxite	233	2,462
Copper Ore	244	461
Lead & Zinc Ore	107	176
Dolomite	1152	4,386
Limestone	73199	75,678
Chromite	9	86
Coal[1]	94000	210000

Note: [1]For coal it is total geological reserve

Mine closure has assumed a greater relevance of late due to increasing environmental concerns arising out of surface coal mining and its cascading impacts in various downstream operations.

Mine closure can be viewed as

".... the rehabilitation of disturbed lands to a safe, stable and productive post-mining landform, which is suitable and/or acceptable to the community..." (Allen and Briggs, 1999).

".... site rehabilitation and restoration to ensure that the closure of a mine will not compromise environmental quality in the future and will limit the extent of any prospective liabilities for both the operator, the government and the community" (Sasson, 1996).

".... returning mine sites and affected areas to viable and, wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and with human activity (Mining Association of Canada, 1994).

Mine Closure And Land-Based Income Generation

Mining is only an intermediate use of the land and a mine has to close once the mineable mineral deposit is exhausted. Closure of a mine means loss of jobs for the community and cessation of all the economic activities connected with the mining operation. Before mining started, the land might have supported agriculture or animal farming. After mining also the land in many cases can be made fit for agriculture, especially where a lot of topsoil is available. A few R&D trials in Neyveli, Ballarpur and Mahanadi coalfields to convert mined land to agricultural field show the techno-economic practicability of the idea. Of all the land uses, agriculture is the best in terms of providing employment opportunities to maximum number of beneficiaries.

It is also an imperative job for the mining company to leave the mine in a safe and stable condition eliminating all forms of risk for the community as they finally leave the mine. In the year 2003 AD, the requirement of a Mine Closure Plan has been introduced through the promulgation of an amendment to the Mineral Conservation and Development Rules 1988 under the MMDR Act 1957 for the non-coal minerals coming under the purview of the MCDR 1988. For the coal sector, preparation of mine closure plans has not become a legal necessity as yet, but the coal companies on their own are addressing the problem and for new coal projects, the Environmental Management Plan includes a chapter on mine closure(Banejee, S.P.). The steps in the closure sequence are depicted in Fig.1.

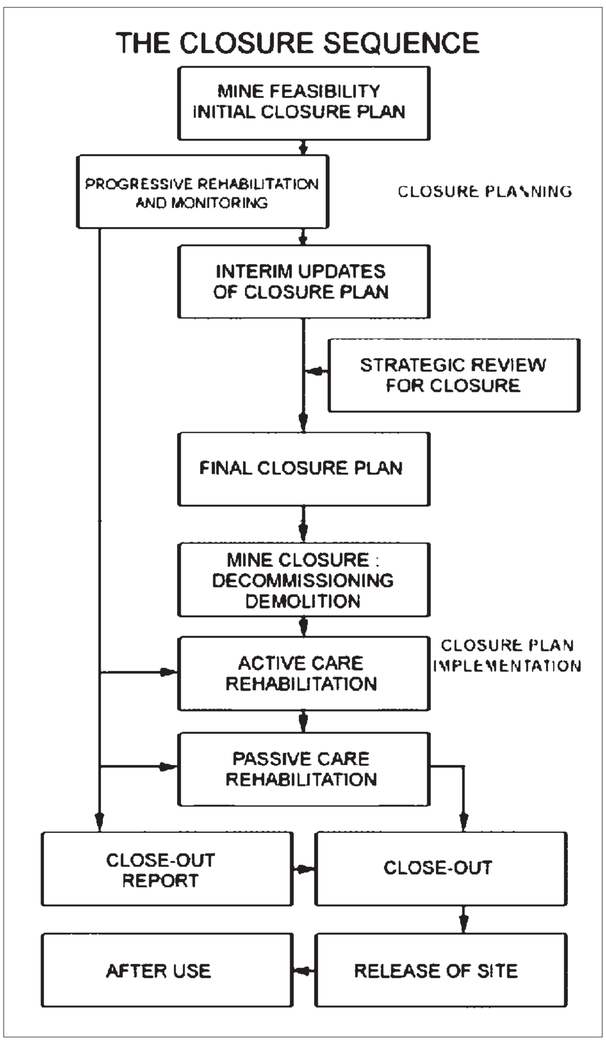

Fig.1 Closure sequence

Closure Objectives

Objectives for coal mine closure may be

- Prevent access to former underground workings;
- Remove unwanted infrastructure from surface areas;
- Ensure remaining infrastructure is "fit for purpose";
- Develop final landforms that are safe, permanent and compatible with subsequent land use as determined through consultation with stakeholders, including landowners and Government Departments
- Achieve a mine closure process that is in accordance with the existing statute
- Meet the prerequisite completion criteria developed during the mine closure process, and
- To enable the progressive relinquishment of leases and the refund of financial sureties.

The main planning criteria for coal mine rehabilitation can be:

- Consideration of the success and practicalities of previously implemented revegetation techniques;
- Issues relating to soil contamination and the burial and/or removal from site of the building debris;
- Increase opportunity for establishment of weed species and erosion of sediment from bare surfaces due to the disturbance of the soils and vegetation;
- The management of water and sediment control dams and the practicalities of long-term maintenance of pumps;
- The rehabilitation of existing and historically used sediment and water control dams in relation to the decanting of existing water, removal of contaminated material, mixing of sediment and non contaminated material, filling and capping of the areas and establishment of a stable surface;
- Management of existing weed populations, with particular emphasis on the reduction of lantana and pampas grass;
- Control of unauthorized access, particularly motor bikes and 4WD vehicles and rubbish dumping;
- Management of the site rehabilitation while still facilitating access for bushfire fighting;
- Suitable locations for the burial of " clean" material;
- Removal of residual coal from stockpiles;
- Availability of suitable capping material for disturbed areas such as dams and coal stockpiles;
- Availability of seed, and brush material to assist with the revegetation of the site; and
- Reshaping, burial and removal of hardstand area material that includes bitumen, concrete and building rubble.

The statute body may control this process by:

- Regular routine inspections through the mine closure process;
- Inspections and responses arising from specific complaints or incidents;
- Establishment of committees to review performance; and
- Holding security bonds that are sufficient to meet the costs of outstanding rehabilitation.[2]

Closure costs are almost as site-specific as geology, but generalizations can be used to indicate the range of possible costs. On the low end of the spectrum, small mines in Romania cost around US$1 million to close and rehabilitate. Closure costs for large lignite mines in Germany, on the other end of the scale, run to hundreds of millions of dollars.[1]

Financial assurance mechanism

The present practice of financial assurance levy is of fixed value irrespective of the existing and preferred environment quality in the core zone vis-à-vis the buffer zone. Activity based financial assurance structure needs to be worked which should be site specific.

The closure financial assurance amount has to be arrived based on

- Direct Closure costs which is calculated using the conditions that represent maximum closure cost.
- Indirect Closure costs including administrative costs.
- Mobilization normally 1 to 5 percent of the direct cost.

- Contingencies comprising of uncertainties and unexpected natural events, 2 to 5% of direct costs
- Engineering and Design to reflect current conditions, 2 to 10 percent of direct costs
- Profit and overhead costs which are normally not included in direct costs, which is 3 to 14 percent of direct closure cost.
- Closure and management to include inspection and supervision, which is 2 to 7 percent of direct closure costs.

Soft guarantees (e.g. corporate guarantee) can be used where the risk of default is low; the closure plan and cost estimate is independently confirmed (i.e. the technical risk is low); the closure is of a short-term nature; and the company has appropriate financial strength to support the guarantee, such as an investment grade rating (Miller, 1998). Hard guarantees (e.g. letters of credit, trust funds) can be used where the risk of default is high; the timing of the closure is imminent; the closure must be continued over the very long term and the company does not have an investment grade rating (Miller, 1998).[3]

While many mining development projects contribute to the economic development of an area beyond the mine boundaries, they are often primarily implemented to ensure production. Economic benefits from these activities may therefore accrue only to a small part of the population and create "islands of development". When it comes to closure many of these facilities collapse and are not sustainable (Kapelus, pers. comm., 2001). Mine closure planning should be linked in with Local Economic Development Plans. Linkage with the planning frame work of local government, integrated development plans, can ensure that post mining land uses are compatible with surrounding development initiatives. This broader view provides a context against which the investments of the mine in human capital and infrastructure can meet local/regional development needs and create a mechanism for economic growth post closure.

Cut off date for declaring responsibility of abandoned mine rehabilitation in our country has to be fixed in consultation with the stakeholders. The closure plan for the mine as a whole should consist of

- Industrial area rehabilitation alternatative/closure plan
- Minesite rehabilitation alternatative/closure plan
- Tailings rehabilitationilitation alternatative/closure plan
- Special site rehabilitation alternatative/closure plan (Deloro Mine Site Cleanup Young's Creek Area Closure Plan, Final Report)

Different stages of closure and reclamation planning are indicated in Fig.2.

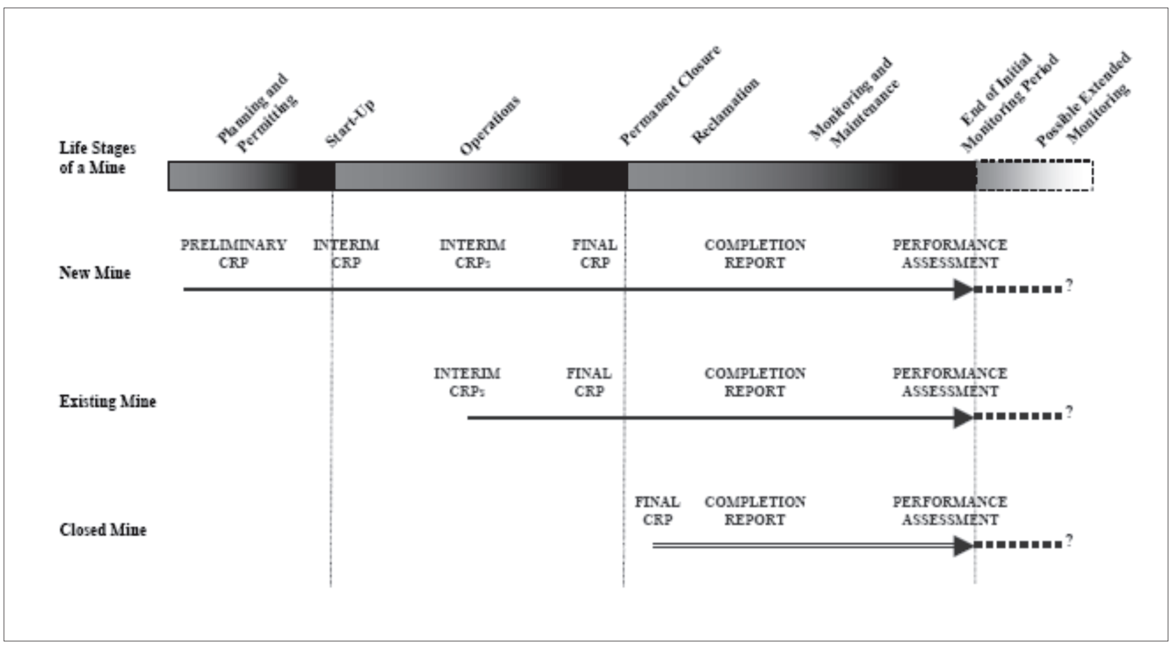

Fig.2 - Stages of Closure and Reclamation Planning (CRP) Through Life of the Mine[5]

Closure risk estimate

A risk based approach to mine closure can be a relevant tool to perceive the potential grey areas in the planning process. The model developed by Dr. David Laurance can also be used to produce quantitative estimates of risk by weighting and prioritizing the issues to produce the Closure Risk Factor. The relative importance of the following major mine closure issues at mine site are :

- Environment(RE)
- Safety and health(RSH)
- Community/public(RC)
- Final Land use(RLU)
- Technical(RT)
- Legal/financial(RLF)
- Other

Rating is done for each of the sub-issues within those broad areas. Using the formula, $CRF = \Sigma (RE + RSH + RC + RLU + RLF + RT)$, the Closure Risk Factor can be calculated.[10] This tool can be of high importance to estimate the risk related to mine closure process for the Indian coal mines.

Closure Policy

The policy with respect to the company's approach towards mine closure needs to be established and documented. A Mine/Facility Closure/Completion Policy sets the high-level aspirations and directions that the company sets for mine closure. The Policy will typically make commitments about the closure process, stakeholder engagement, environmental minimisation of risk, meeting regulatory requirements, social and community aspirations and continuous improvement. Such policy should recognise that it is possible to predict the legacy of a mine at its conception, to include closure as part of mine planning, to identify risks and opportunities for reliable financial planning and costing and to determine end land use objectives and principles in consultation with the community; all of these factors show the need for progressive rehabilitation and to consider the needs of the community affected by closure.

Closure strategy

The development of the strategy is a process whereby desired closure and post closure options are evaluated and documented, and a preferred option chosen. The Closure Strategy process must be documented and cover at a minimum the following:

a) Outcome of the closure and post closure aspects and impacts assessment;
b) Descriptions and evaluations of alternative closure and post closure options;
c) Selection criteria for closure and post closure options;
d) Description of the preferred closure and post closure option;
e) Details associated with any on going research on closure options.

Development projects are required to submit the complete and comprehensive Closure Strategy (and associated Closure Management Plan) as part of the final investment approvals process.

The Closure Strategy must be developed and implemented by a multidisciplinary team. The team members must have appropriate seniority skill levels and experience. Where appropriate, the requisite skills and experience or legal advice may be resourced through external consultants. There must be clear allocation of responsibility for the ongoing management of the Closure Strategy.

Closure standard

The organizations need to develop their own closure standard in line with their business goal.

Closure Assumptions

As closure planning occurs some time before the actual closure decision is made, there is a high degree of uncertainty regarding the specific constraints and circumstances of closure. Therefore, to facilitate effective planning, it is necessary that certain assumptions are made on which the Closure Management Plan can be developed. These assumptions are typically generated during the early stages of planning and must be tested and refined progressively with the Closure Implementation and Operation. Many of these assumptions impart a degree of risk and may therefore have considerable implications if incorrect.

Mine completion- the ultimate goal

Mine completion is the goal of mine closure. A completed mine has reached a state where mining lease ownership can be relinquished and responsibility accepted by the next land user. To achieve this in an environment of increasing regulatory and stakeholder expectations requires that superior outcomes are developed and implemented in consultation with relevant stakeholders, including local communities.[7]

Conclusion

The ideal way of integrating mine closure planning is at some stage the mine has to be able to finally walk away and at that time, the community and government have to be satisfied that no detrimental impacts remain.

References

1. Mine Closure As A Framework For Sustainable Development, Daniel Limpitlaw, School of Mining Engineering, University of the Witwatersrand, Johannesburg
2. Mine Rehabilitation & Closure Plan, Wallarah & Moonee Collieries
3. Financial guarantee for mine closure, Hernani Mota de Lima; Flávio Luiz da Costa; Robson Peixoto; Valdecy Caldeira
4. S P Banerjee, A review of the environmental management practices in the Indian mining sector.
5. Mine Site Reclamation Guidelines For The Northwest Territories, Indian and Northern Affairs Canada, Yellowknife, NWT, January 2006 Version
6. Deloro Mine Site Cleanup Young's Creek Area Closure Plan, Final Report
7. Mine Closure and Completion, October 2006, Dept. of Industry, tourism and resources. Australian Govt
8. Mrinal K. Ghose and Sampurna Nand, Rehabilitation And Revegetation Strategies For Mine Closure
9. R. Sundar Singh, Dr.V.M.S.R.Murthy, Dr.Gurdeep Singh, R. Subramaninan, Mine Closure - Strategic approaches
10. David Laurence, Mine Closure Risk Modelling- A Continuous Improvement Approach
11. Gurdeep Singh, Environmental issues with best management practice of coal mining in India.