

2. LITERATURE REVIEW

During the last fifteen years a lot of work has been done and a good amount of literature on the issue of mine closure and related areas have been published. Consequently many procedures for mine closure planning have emerged. It is important that a synthesis be carried out and an attempt to be made to devise a strategy for ensuring environmentally sustainable mine closure. This review emphasizes the following important literature, which have come into focus during recent times on the issue of mine closure.

- q **McKenna (1996)** said about the new concepts for lease-closure landscape design. It includes designing for closure, use of landforms and natural analogs, boulder ground, robustness in design, landform grading, terrain analysis of reclaimed land, geotechnical hazard assessments, choices in closure design time-frames, passive maintenance, determining post closure monitoring goals, engineering tailings, engineering other substrates, use of test plots and field demonstrations, geomorphologic monitoring of reclaimed lands, defining closure goals, and visiting other mines.
- q **Sassoon (1996)** suggested that if the mining industry is honestly going to embrace the concept of sustainable development, and a commitment to care for the environment, then restoration and rehabilitation are an essential part of developing a mineral resource. Planning for closure is the way to ensure that environmental management of a project will minimize the long-term impacts and will have the additional benefit of reducing the final costs.
- q **Swart et al. (1997)** discussed the principles and application of risk assessment and management as the basis for environmental management within the mining industry. The concept of environmental risk assessment and management, when applied correctly will mean that the mine will be identifying managing environmental issues beyond those set by current legal requirements and management strategies.

- q **Gao et al. (1998)** introduced theories and methods for ecological restoration of mines and presented a case study of the ecological restoration in the Shanxi Bauxite Mine. In the process of ecological restoration, an integrated technical system consisting of stripping, mining, peeled-off and rehabilitation was established with the integration of engineering reclamation and biological reclamation; some techniques such as advanced farming techniques and biotechnologies were also employed. These measures considerably improved crop yield and soil fertility of the mine, accelerated ecological rebuilding processes, and controlled soil erosion effectively.

- q **Brodie (1999)** said that the decision to proceed with mine decommissioning, generally involves a number of complex and interdependent factors like potential for reopening, legal requirements, contingent liability, asset depreciation, due diligence, and public relations and the decision to delay mine decommissioning is commonly not in the best financial interests of the mine operator.

- q **Lima et al. (1999)** introduced the closure plan concept into mine planning which provides an opportunity to meet the responsibility not to leave adversely affected land and not to leave waste and tailings products for future generation. Closure plans provide methods and techniques for rehabilitation of areas impacted by mining, ensuring that mine closure will not compromise the environmental quality of an area in the future.

- q **Tuttle et al. (1999)** said that closure planning includes a systematic evaluation of the area to be developed, the development activities planned, the goals and objectives of the corporation in re-establishing landforms and ecosystems at the same time as running an effective operation.

- q **Bell (2000)** described some of the innovative practices used to establish native ecosystems in bauxite, mineral sand and coal operations across diverse

biogeographic zones of the Australian minerals industry (which is dominated by coal, gold, bauxite, iron ore, base metals and mineral sand operations) that is widely scattered across a continent which has a wide range of climatic zones ranging from the moist temperate in the south through the hot deserts in the centre to the moist tropical in the north.

- q **Carter (2000)** suggested that maintaining up-to-date closure and rehabilitation plans can reduce the possibility of unpleasant surprises after mining ceases. An integrated mine closure plan is probably the most effective strategy available to ensure that environmental compliance, rehabilitation, and cost control efforts provide satisfactory results.

- q **Gerard (2000)** examined the effectiveness of bonding by drawing on evidence from hard rock mining on public lands in the western United States.

- q **Clark et al. (2001)** said that comprehensive mine closure for abandoned mines, presently operating mines, and for future mines remains a major challenge for virtually every mining country in the world. To accommodate the need to close abandoned mines and to ensure that existing and future mines are appropriately closed, the amalgamation of a diverse stakeholder community, new and innovative method of financing closure and major policy and legislative changes will be required to ensure post mining sustainable development.

- q **Mchaina (2001)** discussed the environment management and technical considerations for the decommissioning, closure, and reclamation of a mine site.

- q **Sinha (2001)** reviewed the Indian national policies on environment affecting mine closure planning and provided a perspective on the restructuring policy frameworks and institutional arrangements of environmental management in the country. He observed that, there is no dearth of good intentions expressed through

policy documents, but much remains to be done to incorporate the provisions into command and control approach.

- q **Szwedzicki (2001)** proposed a program for mine closure. This program for mine closure is intended to assist mining companies in providing effective life-of-the-mine strategies for mine closure during all phases of mineral development.

- q **Hoskin (2002)** said that it is possible that mining in the 21st century could become a model of an economically viable, environmentally sensitive, socially responsible industrial sector producing sustainable and decentralized benefits and increase capacities in the communities which will endure long after a particular mining operation closes. For this true stakeholder partnerships need to emerge in association with each mining operation. National governments need to articulate clear policies and rules for environmental impact assessments including mine closure and site rehabilitation.

- q **Zyl et al. (2002)** suggested that closure plans should include site closure issues as well as economic, social and employee matters. Closure objectives and plans should be developed in close partnership with the communities who might be affected by closure as well as the regulatory authority. This means that options for closure plans are provided upfront to all involved in the decision-making process and these plans should include the costs.