1. INTRODUCTION

1.1 Sustainable Development and Mine Closure

Mining is usually a relative short-term finite economic activities that has been occurring for approximately 3000 of years. Before industrial revolution most mining was for high-grade minerals and therefore required comparatively modest excavation. However, with the industrial revolution, mining of minerals-coal, manganese, copper, zinc, gold, iron, nickel, lead, etc came into a big way. Such mining removed enormous tonnage of waste rock and tailing. For example (Sen, 2003): presently, India produces more than 585 million tonnes of minerals and about 85% of these come from surface mines. These results into an excavation of large tonnage of waste materials. Significant impacts of mining activities are occurring on the land, air, water, flora and fauna and it has been realized that unless corrective measures are taken the capacity of the earth to sustain the life may be in jeopardy.

The Brundtland Commission in 1987 resulted inter alia in the well-known definition of sustainable development namely, development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The Brundtland report provided the path, which has resulted in a more vocal public demanding that the governments create stronger legislation to compel the mining industry to be move environmentally sensitive.

United Nations Conference on Environment and Development in 1992 resulted in Agenda 21, the programme for environmental management for the 21st Century. It highlighted the need for environmental guidelines for natural resource development. In 1994, an International conference on Development, Environment and Mining was cosponsored by the World Bank, UNEP and the International Council for Metals and Environment (ICME). The main purpose behind it was to share ideas, perspective information and solutions with respect to the challenges surrounding sustainable mineral development.

Key points of the conclusion were (Wanda, 2003):

- Environment regulations do not act as a disincentive to investment provided that the regulations are realistic, transparent and stable;

- § The objective of rehabilitation of mine sites should be to restore them to a self-sustaining ecosystem that is as close as practical to its original state prior to the mining activity. There is a need for mechanisms that ensure the availability of funds to finance rehabilitation; and,
- § Principles of environmental management are being, adopted today by industry and these are seen as a vital part of efforts towards continuous improvement. The management system being adopted by industry depends on regulations and on corporate cultures. These systems are part of the industry's effort to demonstrate that mining is compatible with environmental protection.

The United Nations Division Economic and Social Affairs (DESA) And UNEP in 1997 framed guidelines for mining operations and discussed approaches to implementation, monitoring, enforcement and participation. UNEP in 1998 produced case studies on tailings management and developed a training manual of mine rehabilitation for health protection. Second Mining and Environment Roundtable was held in Berlin 1999 and guidelines including major section on mine closure planning and rehabilitation were resulted.

It is well known that once the process of economical extraction of mine is complete, there is need for its closure. The closure of a mine raises concern about the ongoing environmental management of the mine, unemployment and the social services like water, power and healthcare. So mine closure presents a complex mixture of environmental, economic, social and development issues. Implementation of mine closure and proper planning are important aspects of mining operations.

1.2 Mine Closure - What is it?

The Minerals Council of Australia defined mine closure as "a process, which begins during the prefeasibility phase of a project and continues through operations to lease relinquishment. It sets clear objectives and guidelines, makes financial provision and establishes effective stakeholder engagement leading to successful relinquishment of lease".

The Chamber of Minerals and Energy of Western Australia, 1999 defined mine closure as "a whole life process that typically culminates in tenement relinquishment. It includes decommission and rehabilitation".

Closure is a term reserved for the point of time at which revegetation has been completed, excess solutions have been eliminated to the extent practical, the maximum degree of passive management has been implemented, and a final surface and/or ground water monitoring programme has been initiated (Harvey and Mudder, 1998).

Closure means permanent cessation of operations at a mine or mineral processing site after completion of the decommissioning process which is signified by tenement relinquishment (Szwedzicki, 2001).

Mine closure encompasses all things-the rehabilitation, economic, dealing with community, funding of closure and post closure, cost estimation etc.

South African Policy concerning the granting of certificate in terms of Section-12 of the Minerals Act 1991 defined mine closure as "a process which must start at the commencement of mining and throughout the life of a mine. It should be executed within the work of sustainable development".

According to National Mineral Policy 1993, "Mineral deposits being exhaustible, once the process of economical extraction of mine is complete, there is need for its closure. Especially, where the mineral activities have been spread over few decades, mining community get established and closure of mines means not only loss of jobs but also disruption of community life. Wherever mine closure becomes necessary it should be orderly and systematically done. It should be so planned as to help the workers and dependants community rehabilitate themselves without undue hardship".

The Mineral Conservation and Development (Amendment) Rules 2003 defined mine closure as "steps taken for reclamation, rehabilitation measures taken in respect of a mine or part thereof commencing from cessation of mining or processing operations in a mine or part thereof".

Mine closure requires the mining, milling and environmental teams to work together to ensure that the decommissioning of mine and associated rehabilitation can be successfully achieved.

1.3 Objectives

Mine closure, mainly open pit mines, has required resolution of number of issues. Closure planning involves environmental protection issues, regulatory issues and community issues. Mining activities are ultimately responsible for impacts on

environment, local community, governments and mining company. Mine closure does not end with cessation of mining activities, but continues till successful relinquishment of lease. The project, “Devising appropriate strategy for ensuring environmentally sustainable mine closure in India” has the aim in providing effective whole mine life strategies for mine closure in India during all phases of mineral development starting from initial exploration to closure and final tenement relinquishment in environmentally sustainable manner. This project includes setting of objectives, defining completion criteria, planning, implementation of closure plan, review of closure plan, decommissioning, monitoring and reporting, whilst satisfying the following objectives:

- To leave sites in a condition which is safe and stable.
- The safety and heath of humans and animals are safe guarded from hazards resulting from mining operations.
- To reduce the need for long-term monitoring.
- To reduce the need for maintenance by ensuring physical and chemical stability of disturbed areas.
- To alleviate or eliminate environmental damage and thereby encourage environmental sustainability.
- To allow a productive and sustainable after use of the site which is acceptable to the mine owner and regulatory authority and local community.
- Environmental damage or residual environmental impacts are minimized to such an extent that it is acceptable to all the involved parties.
- Mines are closed efficiently and effectively.

1.4 Organization of the Thesis

This thesis has been organized into eight chapters.

CHAPTER 1 presents introduction. Apart from introducing the subject the chapter outlines objectives of the study and demarcates the area on which the study is focused.

CHAPTER 2 outlines a review of the literatures published by various authors on mine closure around the globe.

CHAPTER 3 presents changing context of mine closure, an Indian perspective. The chapter discusses the various policies, acts, rules, regulations and circulars that are related to environment and mine closure in India.

CHAPTER 4 presents an international overview of mine closure. The chapter deals with various policies, acts, rules, regulations and circulars in different countries. The chapter also outlines financial provisions of mine closure in different countries.

CHAPTER 5 describes the planning, implementation and review process of mine closure and also suggests for successful closure, proper planning and implementation should be done.

CHAPTER 6 presents the strategies for mine closure in India during all phases of mineral development in environmentally sustainable manner.

CHAPTER 7 describes a case example of Misma Mine, Papua New Guinea and a case study of Chora Mine, India undertaken to validate the closure planning.

CHAPTER 8 presents summary and conclusion and also highlights the limitations and further research in the area. The chapter 8 is followed by the list of references and an appendix (APPENDIX-1).