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**THE DEVELOPMENT OF MINERAL RESOURCES IN AFRICA AND
PROTECTION OF THE PHYSICAL ENVIRONMENT**

I. INTRODUCTION

1. For a little more than 20 years, the Government of Guinea has been making efforts to develop the MIFERGUI project whose objective is to exploit 420 million tons of proven iron ore reserves in the Pierre Richaud deposit within the Nimba mountains. Not the least of the constraints affecting this project is the conservation of this region of Guinea, part of which has been classified as a heritage of mankind because of the wealth of flora and fauna to be found there. Certain species such as the viviparous toad are very rare in the world.

2. The MIFERGUI project, dating back before the 1990s in the history of the African mining industry, is one of those rare examples of mining projects which give pride of place to environmental considerations even though that importance, as earlier mentioned, was dictated by the fact that the heritage of mankind was involved. Indeed, in Africa, until times as recent as the Rio Earth Summit, the importance of the environmental impact of mining which was very well known and highly visible, had been minimized, perhaps on purpose, because the preventive or remedial measures to be taken to check the environmental problems caused by the mining industry would increase project costs and reduce the profit margins of the mining companies which were mostly foreign.

3. Since the awareness created by the Rio Conference of the need to preserve the environment, several African Governments now plan to take environmental protection measures in the mining and related sectors. In several countries, national Government and State agencies have been commissioned to conduct studies on the subject.

4. In some cases, plans have been made to incorporate those measures into existing laws on mining. In other cases, the idea is to group such measures under specific laws and/or regulations.

5. The impact of the mining industry on the physical environment varies widely for each stage of the industry, including exploration. To make things clear, the possible impact of each phase of the industry on the physical environment is considered. What is more, three case studies on Namibia, Ghana and Morocco have been conducted to illustrate the national effort and initiatives of the countries in terms of protecting the physical environment both during mineral resources exploration and development.

II. POSSIBLE IMPACT OF THE VARIOUS PHASES OF THE MINING INDUSTRY ON THE PHYSICAL ENVIRONMENT

II.1 Exploration

6. Exploration might require the opening of access ways (roads and bridges) which could affect forest areas (through clearing operations) or affect sources of water supply (through the contamination by displaced material during the construction of access ways and modification of the hydrographic network).

7. Exploration can also include drilling and excavating activities. There are two main factors to consider here:

- (a) The size of excavation; and
- (b) The fluids used in drilling operations.

8. Very extensive digging can have significant effect on the landscape. The fluids used may contaminate surface water resources near the site of operations and/or underground water resources.

II.2 Mining

9. Mining may be open cast or underground.

10. In both cases:

- (a) Often great masses of earth (and rocks) are moved sometimes through blasting with explosives;
- (b) The displaced earth is stored in a selected place;
- (c) Access roads have to be built; and
- (d) Infrastructural facilities put in place.

The result is a modification of the landscape with possible contamination of the air and water supply.

(a) **Open cast mining**

11. The impact of this type of mining depends on the extent of activities relating to clearing the barren rocks. The most spectacular impact of open cast mining on the environment is the moon landscape it creates.

12. Also noted is the contamination of the air by the dust resulting from the blasting and displacement of rocks and the gases released by explosives and the running of combustion engines.

(b) **Underground mining**

13. In certain cases (poor propping of the pits and mistakes in assessing geological structures (as was the case in the Holle potassium mine of the Congo in 1977), can lead to subsidence and the formation of dollines.

14. In other cases, the water supply could be contaminated by chemicals resulting from the oxidation of such sulphurous minerals as pyrites. Some acids containing substantial quantities of dissolved metals can also form and seep into the surface and underground waters.

(c) **Small-scale mining**

15. For lack of proper supervision of small-scale miners by appropriate national agencies, small-scale mining has generally been leading to wanton destruction of the soil and plant cover of mining sites.

II.3 **Processing**

16. This involves physical, chemical and even biological processes beginning with the crushing of rocks and ending with the dumping of waste on selected locations.

17. When mineral ores are processed at the place of extraction the following effects may occur:

(a) **Physical processing**

18. Crushing contributes to contamination of the air by solid particles created by the reduction of rocks into very small fragments.

19. Gravimetric processes also contaminate the air when conducted dry and the water supply when conducted under wet conditions. The fine powder resulting from the gravimetric operations find their way into the water supply.

(b) **Chemical processing**

20. Among the chemical processes is floatation which uses chemical reactants that go into the drainage basins at the end of the operation. Generally, the toxic levels created in the drainage basins are very low but, over time, they may present some risks.

21. Another chemical process is lixiviation. Whether used on copper bearing or on gold bearing ores, the process uses chemical substances as the agent.

22. In the previous case sulphuric acid and chloride are used while in the second case cyanide is used.

23. At the end of the operation, the waters are stored in dams in which the solids sediment while the solution is recycled after decantation. However, some construction errors in the dymes can lead to leakage with the result that the toxic substances contained in the waste get into the surface waters around the dams area.

24. The third chemical process worth mentioning is amalgamation, using mercury. If this substances is not naturally is broken down by oxidation, it constitutes a real danger for the environment.

(d) **Wastes**

25. Wastes contain contaminants including solid particles from the processed ore, heavy metals in solution, chemicals used for the processing and other impurities.

Any failure to comply with this provision would draw a written warning from the Minister inviting the person concerned to take, by the deadline specified in the written notice, measures necessary to remedy the situation. If such holder fails to comply with the directions to the satisfaction of the Minister within the period specified or such further period as the Minister may on good cause shown allow in writing, the Minister may take steps to institute legal proceedings and to recover (in a competent court) the cost incurred in remedying the situation from the holder.

(b) Conditions that the applicant must satisfy with respect to environmental protection when applying for a prospection license. The applicant must submit with the application a document indicating the methods whereby the environment would be protected from his mining operations and the measures he intends to take to rehabilitate the mining area.

32. Given the diversity and complexity of the possible effects of the mining industry on the environment, this section of the act seems laconic particularly for a country like Namibia which has an old and important mining tradition.

33. The fact is that other legal provisions exist to protect the environment but are scattered in a multitude of laws which are enforced at random. To correct this situation, a directorate of environmental affairs has been created under the auspices of the Ministry of Wildlife Conservation and Tourism. One of the responsibilities of the directorate is to draft comprehensive legislation on the environment and laws on this are now being established.

The integrated environmental management plan of Rossing Uranium

34. Pending the passing of this law, Rossing Uranium Limited has, in the context of its Okandanje graphite mining project in North Central Namibia, requested Wamsley Environmental Consultants to prepare them an integrated environmental plan for the above-mentioned site. This plan whose details can be found in Annex I appears very interesting and is reviewed below.

35. The Okandanje project aims to produce 420,000 tons of graphite per year under open cast mining.

36. In the integrated environmental plan prepared from the exploration phase, the project implementation has been divided into four stages, namely:

- (a) Project identification;
- (b) Project definition;
- (c) Project implementation; and
- (d) Project completion.

A. The project identification phase

37. The project identification activities include exploration activities and a prefeasibility study to determine the viability of the project.

38. As mentioned in paragraph 30 (b), in line with the Minerals Prospecting and Mining Act of 1992, the prospection application was accompanied by a document showing the methods whereby Rossing would ensure the environmental protection of Okandanje (particularly with regard to road

construction, the building of slag heaps, existing farms etc.) and the measures to be taken to rehabilitate the site after mining.

39. This preliminary evaluation of the project's impact on the environment has been meticulously conducted along with the feasibility study. Conducting such an evaluation during the project identification phase is very important because this is the time when all project plans are made and all options considered.

40. Following the evaluation, the following elements were highlighted:

(a) Risk of water pollution from the dams for the waste dumps and even of the open pits because of the high pyrite and pyrrhotite content of the deposit.

(b) Risk of air contamination by dust blowing from the waste protection dams;

(c) Possible adverse effects on farms.

41. In seeking solutions to these problems:

(a) Contact was established with local farmers in order to inform them about this and to institute a permanent dialogue;

(b) Alternatives were proposed for the wastes including the adoption of dry waste;

(c) Recommendations were made for the temporary and permanent rehabilitation of the site.

B. Project definition

42. This stage was devoted to the project feasibility study comprising:

(a) The establishment of a pilot factory;

(b) The manufacture of product samples; and

(c) Market research.

43. Along with the feasibility study, a comprehensive project study was also conducted to take into account the discussions that the project promoters had had with all the people involved or affected by the project. These discussions focused, among other things, on the problems of air contamination by dust, water pollution, rehabilitation of the sites after the mining operations and social conflicts.

44. A project quality plan including a section on environmental quality control was also prepared.

45. The following approach was adopted for establishing the specifications and final estimates of project cost. Along with this approach, an evaluation of the project's impact on the environment was conducted focusing on the possible impact of the project in relation to:

- (a) Construction work;
- (b) Establishment and operation of the mine;
- (c) Establishment and operation of the factory;
- (d) Building and operation of infrastructural facilities.

Specific recommendations were made after due consideration of these issues.

46. In the same stage, there were also attempts to rehabilitate the area by planting some trees near the pilot dams in order to determine those species which could grow along the planned dams and to see what soil modification was necessary. Conducting this experiments at these stage has the advantage of enabling the rehabilitation programme to start immediately after the wastes begin to be dumped in the dams and this helps to minimize the problems of contamination by dust and those of water pollution.

47. At the end of the project definition stage, the environmental impact study was submitted to the Governing Board of Rossing Uranium Limited for approval.

C. Project implementation stage

48. This begins with the construction of the mine and continues with the handing over of the mine to its operators for their regular operations.

49. Concerning the construction of the mine, the bids for tender have to contain the environmental specifications of the project.

50. During construction of the mine, it would be absolutely necessary to control the implementation of the integrated environmental management plan. This requirement must be incorporated in the construction contract and a person should be assigned to exercise such control on a daily basis. To make his job easier, a control guide on environmental protection should be prepared along with the programme for rehabilitation and other environmental protection activities.

D. Project completion stage

51. It is prudent to prepare a project completion plan well before the mine closes down. This plan should have environmental aspects such as rehabilitation and long-term pollution control.

III. GHANA

52. The Minerals and Mining Law of 1986 empowers the Secretary for Lands and Natural Resources to make regulations:

- (a) Prohibiting mineral prospection near any water supply sources;
- (b) Preventing water pollution;

- (c) Ensuring public safety and the safety and welfare of workers;
- (d) Preventing injury to persons or property by chemicals; and
- (e) Setting penalties for offence against these regulations.

53. This provision has been revised and regulations concerning environmental protection are being prepared for incorporation into the Minerals and Mining Law.

54. The regulations envisaged will cover exploration activities and apply to mines already established and those in the pipeline.

55. As part of the preparation of these regulations, particular attention is paid to the life cycle of the mining project.

56. The following phases have been singled out:

- (a) Mineral exploration;
- (b) Mining;
- (c) Ore processing; and
- (d) De-commissioning

(a) **Exploration**

57. Before embarking on any exploration activities, holders of prospection licenses should determine the possible effects of exploration activities on the environmental protection of plants, air and water.

58. Exploration may include the opening of access ways to the zone of exploration. In such a case, a study of water supply sources in that zone and of the possibility of providing alternative drinking water supply to the local communities concerned becomes necessary. Furthermore, the access roads should be built only during the dry season and, during road construction, the following measures should be taken:

- (a) Provision of drainage;
- (b) Minimization of deforestation;
- (c) Concentration in the valleys of material displaced during road construction in steep sloped areas.

59. If exploration includes digging and drilling, the following provisions should be observed:

- (a) The size of excavations should be minimized;

(b) Fluids used for drilling should be discharged into a sump and be recycled as much as possible;

(c) Preferably, biodegradable fluids should be used; and

(d) Oil-based drilling fluids should be stored in steel or appropriate plastic tanks and be disposed of by incineration.

60. At the end of the exploration phase, care should be taken to do the following if the site is to be abandoned:

(a) Excavations should be sealed or backfilled;

(b) All refuse should be buried or removed;

(c) The exploration site should be fully rehabilitated within three months of abandonment.

b. **Mining**

61. For any projects affecting a land area of more than 10 hectares, the prospective company shall submit an Environmental Impact Assessment (EIA).

62. All provisions contained in the EIA shall be observed unless permission has otherwise been granted in writing.

63. If a project's EIA has been approved, but changes are contemplated that will significantly modify the expected impact of the project, then the company shall submit a supplement to the EIA describing those changes and their expected environmental effects.

64. All existing mining operations shall submit an Environmental Action Plan (EAP) every two years.

65. The plan will cover five years and shall comprise a two-year EAP and a three-year rolling plan for the subsequent years.

66. A company shall honour all commitments made in the EAP except where written permission has been given.

67. An EAP shall also be submitted for new projects as part of the EIA.

68. If mining operations require the use of a dredging machine, this shall be used only on the major water courses.

c. **Mineral processing**

69. Under no circumstances the recovery of gold by amalgamation be conducted on the dredges.

70. With regard to heap leach operations, the following shall be observed:

- (a) Containment of contaminated process liquors during extreme rainfall events. The EIA and/or EAP will specify the return period of the extreme rainfall event used in the design;
- (b) All discharge ponds should be equipped with a drainage and drainage monitoring system;
- (c) All heap leach pads should be equipped with an under-pad leak detection system; and
- (d) Neither surplus processing circuit water nor water drainage spent heaps should be discharged to the natural drainage.

71. Waste disposal is given particular attention. Because of the intensity and frequency of tropical rainfall, which minimizes evaporation, it is not possible to avoid the eventual discharge of

water from tailing impoundments and heap leach circuits at every mine. A regulation will be required to govern this situation.

72. Such regulations should emphasize the design of dams to contain wastes. It should also make provision for the treatment of contaminated waters before their discharge and indicate the measures to be taken in the event of unforeseen or necessary discharge.

73. In designing the dams, the following factors should be taken into account:

- (a) The dams receiving the rejects should have the capacity for permanent storage of tailing solids in an impoundment;
- (b) The tailing impoundment structures should be constructed of chemically stable materials in accordance with sound geo-technical, structural and hydraulic engineering design and construction practices to withstand the expected seismic activity in the area;
- (c) The capacity of the impoundment should be sufficient to contain the volume of tailing anticipated over the life of the mine, or alternatively, the impoundment will be designed and operated to provide staged increases in capacity;
- (d) An emergency spillway will be provided to pass the runoff from an extreme rainfall event and prevent overtopping of the embankment. The EIA or EAP will specify the return period of the extreme rainfall event and design criteria for the emergency spillway. In cases of staged construction, the EIA or EAP will specify the spillway configuration for each stage;
- (e) Where applicable, the tailing impoundment will be located downstream of the processing plant so that runoff and any spillage will report to the impoundment. Other upslope drainage shall be diverted around the impoundment;
- (f) Tailing may be deposited by sub-aerial deposition:
 - (i) To maximize consolidation of sediments;

- (ii) To accelerate the decay of degradable contaminants; and
- (iii) To minimize seepage.

74. Tailing water should be recycled as much as possible and used as process water.

75. In the rare event of a discharge to the natural drainage via the emergency spillway, the company shall immediately notify the EPC, the Mines Department and the Minerals Commission and explain the circumstances necessitating the discharge.

76. Any discharge to the natural drainage, other than via the emergency spillway, will not be permitted until the requirements of discharges to water are met.

77. Seepage from the impoundment will be monitored as specified in the EIA or EAP.

78. Where significant seepage of contaminated water is unavoidable, a seepage collection system will be constructed downgradient of the main embankment(s) and any seepage water will be pumped back to the impoundment.

79. Finally, these provisions could complement the regulation:

- (a) Phreatic water levels should be routinely monitored as specified in the EIA or EAP;
- (b) Stabilisation by revegetation of the main embankment(s) should commence within 12 months of the completion of construction.

d. **De-commissioning**

80. As part of the EIA or the EAP, a conceptual de-commissioning plan should be prepared.

81. The de-commissioning plan shall:

- (a) Nominate the end use(s) of all lands affected by the mining project;
- (b) Nominate the end use(s) of all buildings, housing and other mine infrastructure components.

82. The planned use of the lands and infrastructural facilities implies that a reclamation plan should be contained in the EIA and the EAP and included in the de-commissioning phase.

83. The importance of the reclamation plan is once again underscored by the effects of open-cast mining in Ghana. Indeed, during the coming years, open-cast mining could reach sizeable proportions in that country. With the amount of erosion in tropical areas, the effects of such mining on the landscape will be extensive so great attention should be paid to land reclamation.

84. The reclamation plan shall be executed to achieve the following standards:

- (a) Restoring the chemical and physical stability of the land;
- (b) Chemically and physically stabilizing non restorable land so as to encourage revegetation.

85. The reclamation plan shall encompass all land on the concession to be disturbed by the company and any of its tributors. It shall:

(a) Identify land which is restorable (such as the tops of waste dumps and land used for stockpiles) and land which is non- restorable (such as deep open pits and the steep outer faces of waste dumps);

- (b) Identify the quantities of reclamation media required;
- (c) Identify the sources of reclamation media to meet the required quantities;
- (d) Identify applicable reclamation techniques;
- (e) Develop a planned approach to progressive reclamation as an integral part of the mine plan;
- (f) Try out refined reclamation techniques each time feasible;
- (g) Commence reclamation as soon as possible after the commencement of operations.

86. The directives for the EIA and the EAP are attached in the Annex.

III. 3 MOROCCO

87. Morocco has already prepared a draft decree on environmental protection in the mining and allied sectors.

88. The draft decree is currently under study by the competent Moroccan authorities.

89. The issues treated in the draft document are as follows:

- (a) Definition of technical framework;
- (b) Authorization of mining operations;
- (c) General environmental protection measures;
- (d) Protection of hydrographic networks;
- (e) Atmospheric protection;

- (f) Protection from noise pollution;
- (g) Building of dumping sites;
- (h) Land reclamation;
- (i) Monitoring and control;
- (j) Penalties.

a. **Technical framework**

90. This section of the draft decree deals with the definition of terms used in the document and goes on to designate the persons to whom the decree, once signed, will apply.

b. **Authorization of mining activities**

91. After indicating that the technical, economic and social studies of the project should specify the measures that the company intends to take to protect the environment, this second part of the text defines what documents should be attached to the studies.

92. The documents are the following:

- (i) Maps giving geo-technical, hydrographic and meteorological information on the region;
- (ii) Maps of the geographical location of the mining facilities;
- (iii) A topographic map of the site of the proposed mine showing such things as:
 - . Built-up areas
 - . Plantations
 - . Springs, drills and pumping stations
 - . Water courses, water supply systems etc.
- (iv) A technical note justifying the choice of proposed works and equipment that will be used to protect the environment. This note should describe the mode of construction selected, the materials to be used and the layout for waste evacuation. It should also be accompanied by detailed plans of each construction work;
- (v) A note on measures that will be taken to reclaim the site.

93. Section II of the draft decree concludes by stating that the mining authorities may require the prospective company to provide an environmental impact assessment (EIA) of the projects depending on:

- (i) The nature of minerals prospected;

- (ii) The scope and duration of the project;
- (iii) The technical processes that would be used;
- (iv) The climatic features of the region; and
- (v) The geographical location of the mine.

c. **General measures for environmental protection**

94. These measures are built around the technology, equipment and material and provide for sanction applicable in the case of damage to third parties and/or the environment.

95. In section three of the draft decree, it is mentioned that:

(a) The prospective mining concern should take every measure to secure the best available and environmental-friendly technology to prevent, reduce, check and control any risk of pollution from mining operations;

(b) The prospective mining concern should include in his specifications book on equipment and machinery, the performance of the environmental protection equipment relative to existing standards. The book should also specify the performance of the equipment needed to renovate or expand the existing plants;

(c) The mining concern shall be responsible for any damage caused to third parties and/or the environment through the mining activities.

96. The other provisions of section three of the draft decree invites existing mining concerns to:

(a) Adapt their facilities gradually to new standards over a period of three years beginning from the entry into force of the environmental protection decree;

(b) To set up machinery to monitor and control the effects of their activities on the environment.

b. **Protection of the hydrographic network**

97. The provisions under this section of the draft decree:

(a) Prohibit the dumping of liquid pollutants into the waters of the hydrographic network in excess of the thresholds set under existing regulations;

(b) Invite mining concerns to treat used water so as to eliminate or reduce contained pollutants to the levels fixed under existing regulations.

e. **Atmospheric protection**

98. In addition to general provisions, it is forbidden to release into the atmosphere solid or gaseous pollutants beyond the levels set under existing regulations. The draft decree holds the mining concern responsible, as and where the state of technology permits, for recycling and/or treating gaseous effluents so as to eliminate or reduce pollutants to the levels set under existing regulations.

f. **Waste disposal facilities**

99. This provision of the draft decree spells out the obligations of the mining concern regarding the dumping of wastes resulting from mining operations.

(a) Such waste should be stored in an area built with a view to reducing, if not actually preventing, seepage;

(b) The storage area should also be stable in order to contain the accumulation of waste;

(c) The storage area should be so located as to minimize the action of atmospheric agents that can carry away solid particles;

(d) A protection zone should be erected around the dumping area;

g. **Rehabilitation of mined areas**

100. The following measures are suggested:

(a) A reclamation plan should be prepared for the mined areas and be implemented as soon as mining operations begin;

(b) Reclamation should be carried out in such a way that public safety on lands which have been mined will be ensured and the lands in question can be used again. Proper landscaping should also be built into the reclamation exercise;

(c) Medium- and long-term harmful effects on the mining area should be eliminated after mining operations have ceased.

h. **Monitoring and control**

101. In this provision the mining concern is expected to conduct waste analyses twice a year. Guidelines for conducting such analysis are annexed to the proposed decree.

102. The same provision gives mining agents, in accordance with Morocco's mining regulations, the latitude to take or give samples of pollutants for analysis in case certain anomalies are observed. The mining concern bears the cost of this exercise.

103. What is more, this section of the proposed decree stipulates that the aforementioned mining agents may conduct or have trials conducted on the machinery or other equipment acquired by the company and likely to create or to control pollution.

i. **Penalties**

104. In accordance with Morocco's mining regulations, penalties are set for any infringement of one or all the provisions of the proposed decree. Guidelines for preparing the environmental impact

assessment, controlling wastes from mining and related facilities are annexed to the present report.

IV. Conclusions and recommendations

IV. I Conclusion

105. Taking into consideration current world trends of thought on nature conservation, several African countries now realise the need to address environmental problems arising from mining activity.

106. The logical conclusion of such awareness should be the drafting of regulations in the form of laws and provisions to be integrated in existing legislation. Thankfully, efforts are being made to do this in Africa.

107. A review of the future regulations and practices to protect the physical environment from the effects of mining and related industries submitted to the secretariat shows that while some countries feel that radical measures are needed to cope with the problems of environmental degradation resulting from mining activity, others, compelled by the concern to minimise the amount of investment in the mining sector and to encourage investors who are for the most part foreigners, would rather suggest caution.

108. Two trends are therefore emerging in the approaches adopted by African countries to address the problem at hand: a constraining approach which makes the granting of a prospecting or mining licence subject to the submission of an environmental impact assessment and a rehabilitation plan, and a casuistic approach which considers certain characteristics of the project before deciding whether the prospective mining operator should be made to submit an environmental impact assessment.

IV. 2 Recommendations

109. It is not for the secretariat to decide on which approach is best but for member States to solve this delicate problem in full exercise of their sovereignty. However, the secretariat would like to stress the problems raised by the environmental degradation caused by the extractive and related industries and to maintain that these problems require the taking of serious measures. The regulations designed by the countries to address the problem should be dictated by the concern of each State to advance its interest and priorities. Keeping this in mind, the secretariat would suggest that when preparing environmental protection regulations to control the effects of the mining and related industries, African countries should accord particular attention to making:

(a) A clear and precise definition, in mining and geological terms, of the various phases of the project;

(b) A clear and precise definition of corresponding environmental protection measures;

(c) Future regulations include a clause making mandatory the submission of an environmental impact assessment and a rehabilitation plan before a prospection or mining license is granted;

(d) A clear and precise definition of the tasks of those government structures responsible for enforcing the environmental regulations that would offset the adverse impact of mining and related industries and the obligations arising therefrom;

e) A clear and precise definition of penalties for the infringement of nature conservation regulations;

(f) Sure that competent and fully equipped national technical structures as well as control and audit mechanisms are set up to monitor the implementation of the programme to protect the environment from the adverse effects of the mining and related industries.

INTEGRATED ENVIRONMENTAL MANAGEMENT AND MINING

PROJECT LIFE CYCLE

ENVIRONMENTAL STUDIES

