E1030

Mining Sector Environmental and Social Assessment, Mozambique

Final Report

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Impacto

SWEDISH GEOLOGICAL AB
## Contents

Contents

1. Introduction  
   1.1. The mining sector of Mozambique  
   1.2. The Project  
      1.2.1. Objectives  
      1.2.2. Project execution  
      1.2.3. Consultant’s staff being engaged in the Project  
      1.2.4. The Client’s participation  
      1.2.5. Acknowledgements

2. Baseline information  
   2.1. Socio-economic indicators  
   2.2. Existing documentation regarding mining environmental questions  
   2.3. Protected Areas  
   2.4. Background data regarding natural water quality

3. Policy, legal and institutional framework  
   3.1. Policy  
   3.2. Legislation  
      3.2.1. The Environmental Law (Lei n° 20/97)  
      3.2.2. The Land Law (Lei n° 19/97)  
      3.2.3. The Mining Law (Lei n° 14/2002)  
      3.2.4. Inconsistencies and debilities in the legislation  
   3.3. Institutional framework  
      3.3.1. General organizational framework  
      3.3.2. The Ministry of Mineral Resources and Energy (MIREME)  
      3.3.3. The National Directorate of Mines (DNM)  
      3.3.4. The Department of Environment (within DNM)  
      3.3.5. The Department of Mine Safety (within DNM)  
      3.3.6. The Ministry for the Coordination of Environmental Affairs  
      3.3.7. Provincial Directorates (DPREME)  
   3.4. Human resources  
   3.5. Laboratories and analytical services  
      3.5.1. Laboratory analysis in environmental work  
      3.5.2. Present market for analytical services  
      3.5.3. Existing laboratory capacity  
      3.5.4. Recommendations

4. Environmental conditions  
   4.1. Potential problems related to mining  
   4.2. Analysis of the various environmental aspects related to mining  
      4.2.1. Prospecting and Exploration  
      4.2.2. Non-efficient use of natural resources  
      4.2.3. Effects on landscape and morphology  
      4.2.4. Accumulation and spread of solid waste  
      4.2.5. Water use and/or pollution  
      4.2.6. Air pollution

Swedish Geological AB - IMPACTO
4.2.7. Soil pollution 31  
4.2.8. Effects on flora and fauna 32  
4.2.9. Noise and vibration 33  
4.2.10. Radioactivity 33  
4.2.11. Environmental emergencies 34  
4.2.12. Issues common to industrial establishments in general 36  
4.2.13. Occupational health and safety (OHS) 36  

5. Socio-economic conditions within the mining sector 38  
5.1. Socio-economic issues within the formal mining sector 38  
5.1.1. Employment conditions in the active mining companies 38  
5.1.2. Outlook for the future 39  
5.2. Socio-economic issues within the informal (artisanal) sector 39  
5.2.1. The deposits and their exploitation 40  
5.2.2. The work force and its organisation 42  
5.2.3. Socio-economic factors 43  
5.3. Summary of socio-economic conditions 45  

6. Strategic priorities for environmental and socio-economic supervision 46  
6.1. Environmental and socio-economic planning 46  
6.2. Definition of actions to be taken and future studies to be carried out 47  
6.2.1. General approach for the development of capacity 47  
6.2.2. Strategy for the raising of capacity 47  
6.2.3. Objectives and organisation 48  
6.2.4. Main environmental issues to be treated 49  

7. Consultation and participatory procedures 50  

8. References 50  

Annexes

Annex 1. Literature  
Annex 2. Quality of natural waters in Mozambique and worldwide  
Annex 3. Comments by Swedish Geological AB on “Regulamento sobre padrao de qualidade ambiental e emissoes”  
Annex 4. Summary of national laws governing land, resettlement and compensation  
Annex 5. Environmental reviews of mining sites  
Annex 6. Environmental capacity building within the MIREME - Terms of Reference  
Annex 7. Overview of new major mineral projects
1. Introduction

1.1. The mining sector of Mozambique

Despite a favourable geological environment, mining is still a less developed sector in Mozambique. Thus, mechanised mining is today limited to a moderate number of comparatively small operations exploiting gold, coal, tantalum, bauxite, industrial minerals and dimension stones. In contrast to this, artisanal mining for gold and gemstones is widespread.

Besides these traditional exploitations, a number of very large heavy minerals (titanium) projects are at an advanced stage of development and it can be expected that one or more of these will turn into operation within the next few years. This would dramatically change the mining scene of Mozambique. Another possibility for large scale mining in the not too distant future would be a reopening of the once large coal mines in the Tete province for which efforts are made presently. This would, however, require a rehabilitation of the Tete-Beira railway.

An overview of the new major projects that may come on-stream during the next few years is presented in Annex 7.

1.2. The Project

1.2.1. Objectives

It is the Mozambican Government’s policy to support private investments for the development of the country’s mineral resources. In order to achieve a sustainable development, the Government will need to supervise such developments regarding the environmental and social performance. Besides, the already ongoing artisanal and small scale mining activities are often carried out without regard to such aspects. The capacity of the Government to perform this supervision is not yet well developed. The present Project regarding Mining Sector Environmental and Social Assessment is one of the efforts to resolve this debility.

The objectives of the Project are summarised as six points in the Terms of Reference:

1. Compilation of existing information
2. Evaluation of the policy, legal, regulatory and institutional frameworks
3. Assessment of the environmental and social conditions within the mining sector
4. Definition of strategic priorities for future studies and work
5. Consultation and participatory procedures
6. Training
1.2.2. **Project execution**

The execution of the Project has included the following main components:

- Field visits to obtain information and data regarding environmental and social conditions at mine sites, including water quality determinations:
  - Mine visits in the Manica and Tete provinces 12-23 May, 2003
  - Mine visits in the Zambezia and Nampula provinces 17-24 August, 2003
  - Visit to the Chibuto titanium prospect in the Gaza province 26 August, 2003
- Interviews and discussions with authorities, companies and other stakeholders; cabinet and library research
- Training courses in Maputo
  - Mining and the environment 13 March, 2003 (14 participants)
  - Environmental monitoring and pollution abatement 8-10 April, 2003 (11 participants)
- Study tour to South African mining operations 1-7 June, 2003-09-01 (6 participants)
- Study tour to Swedish mining operations 24 September-5 October, 2003 (5 participants)

1.2.3. **Consultant’s staff being engaged in the Project**

Swedish Geological AB and IMPACTO have provided the following professionals for the execution of the Project:

- Bo Lundberg, mining environmental specialist and project manager
- Håkan Tarras-Wahlberg, environmental geochemist
- Tom Lundgren, hydro-geologist and solid waste specialist
- John Hatton, ecologist/anthropologist
- Bento Salema de Freitas, socio-economist
- Eckhart Hilmer, mining economist
- Madyo Couto, environmental specialist

1.2.4. **The Client’s participation**

MIREME staff has participated in the work in a number of different ways, for example, by: the participation in audit work at mining sites; the provision of information of various kinds; the facilitation of contacts with MICOA, university institutions and private companies; and discussions around conclusions and the formulation of proposals for further work. The principal participants from MIREME have included:

- Paulo Junior. DNM: Department of environment
- Manuel Simone. DNM: Department of environment
- Gerardo Valoi, DNM: Department of small scale mining
- Castigo Tembe, DNG

In addition to this staff based in Maputo, personnel from the Provincial Directorates (DPREME) in Manica, Tete, Quelimane, and Nampula have taken part in work within their respective provinces and in study visits abroad.
1.2.5. Acknowledgements

The Swedish Geological-IMPACTO team would like to thank all those who have contributed to the execution of the project. The National Director of DNM Estêvão Rafael Pale has given his valuable support in various respects; the heads of departments Gerardo Valoi and Paulo Junior have arranged for the efficient implementation of the tasks and also taken active part in the execution of the work; and the directors of the respective provincial directorates and their staff have facilitated the field work. It should also be mentioned that the reception at mines and mining sites has been very friendly and helpful.

2. Baseline information

2.1. Socio-economic indicators

The role of mining in Mozambique as a means for the inhabitants of the provinces to earn their living should be regarded against the background that the country does not own a developed industry sector and that the GNP per capita is very low. In fact, Mozambique has a position close to the bottom regarding economic development as indicated by a number of socio-economic indicators (Table 1).

Presently, mining is important mainly in providing a modest income from artisanal activities. However, large-scale mineral developments, that would provide full-time and long-term job opportunities, are expected to come on-stream within short.

Table 1. Social indicators for Mozambique in comparison to other similar countries. According to the World Bank (2000): “Country assistance strategy for Mozambique”.

<table>
<thead>
<tr>
<th>Social indicator</th>
<th>Mozambique (US$)</th>
<th>Sub-Saharan Africa</th>
<th>Low income countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross national product (GNP) per capita</td>
<td>230</td>
<td>480</td>
<td>520</td>
</tr>
<tr>
<td>Position in the United Nations Human Development Index</td>
<td>168 out of 174</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Life expectancy at birth (years)</td>
<td>47</td>
<td>51</td>
<td>63</td>
</tr>
<tr>
<td>Infant mortality (per 1,000 live births)</td>
<td>134</td>
<td>91</td>
<td>69</td>
</tr>
<tr>
<td>Child malnutrition (% of children under 5)</td>
<td>41</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Access to safe water (% of population)</td>
<td>24</td>
<td>47</td>
<td>74</td>
</tr>
<tr>
<td>Illiteracy (% of population aged 15+)</td>
<td>60</td>
<td>42</td>
<td>32</td>
</tr>
<tr>
<td>HIV/AIDS prevalence rate (%)</td>
<td>14.5</td>
<td>7</td>
<td>–</td>
</tr>
</tbody>
</table>
2.2. Existing documentation regarding mining environmental questions

There is a very limited amount of literature that has been published regarding environmental matters related to mining activities in Mozambique. Due to various factors, only in the past 10 to 20 years have some information been written. Furthermore, the existing information is scattered throughout various departments, libraries and institutions. However, most documentation regarding environmental issues and mining activities were found in the libraries of MIREME and MICOA, as well as in the library of Impacto.

The library of MICOA is located in the main building of this institution which is situated in Av. Acordos de Lusaka, nº 2115. The library is small, and very little information related to mining activities was found with the exception of three EIAs and one regulation. There is a fee of 25,000 Mt in order to consult the documents, and it is possible to take photocopies.

The library of MIREME is located in the building where the DNM and DNG are based, which is situated in Praça 25 de Junho, nº380. This library is in the process of moving from the 10th floor to the 2nd floor. Thus most books and documentation were still in boxes. However it was possible to consult some of the documentation, which includes mainly technical mining and geological information. It is planned to install a photocopy machine in the library.

The library of Impacto is located in the main building, in Av. Mártires da Machava nº 968. Although the library is small there is a number of documents (from reports, books, and articles) that deals with environmental matters of Mozambique. It is possible to consult these documents and to take photocopies.

A register of existing documentation has been prepared. It is divided according to the type of reference, the author, the title of the document, the year of publication, Nos. of pages and the location of the document. This listing is included in the Annex I.

2.3. Protected Areas

The majority of the parks and reserves of Mozambique were established in 1955, by the Portuguese authorities, since then three new national parks, Limpopo National Park, Chimanimani National Park and Quirimbas National Park, were established in 2001-2002. There are six categories of protected areas, namely (Figure 1):

- **Parques Nacionais** (National Parks);
- **Reservas Especiais** (Game Reserves);
- **Reservas Parciais** (Partial Reserves);
- **Regimes de Vigilância** (Vigilance Areas);
- **Coutadas** (Controlled hunting and photographic safari); and
- **Reservas Florestais** (forest reserves).
Mining cannot take place within protected areas without a special permit from the Government of Mozambique. The authority responsible for the administration of the protected areas is the National Direction of Wildlife and Forestry (Direcção Nacional de Flora e Fauna Bravia, DNFFB) from the Ministry of Agriculture and Rural Development (apart from the Niassa Reserve which is managed by a private society, and the biological reserves of Inhaca and Portuguese Islands that are managed by the Department of Biological Sciences from University Eduardo Mondlane). DNFFB has jurisdictional, management, and conservational responsibilities over the gazetted conservation areas.

There are seven National Parks, five Game Reserves, twelve Controlled Hunting Areas, two Vigilance Areas, and sixteen Forest Reserves.

At the moment, there are only few valid mining concessions that fall within protected areas. However, in the province of Zambézia there are a number of small concessions that are within the border zone of the Gilé Reserve. Furthermore, within the province of Inhambane, a large concession overlaps with about half of the area of the Pomene Reserve. Within these concessions on protected land, no mineral exploitation is presently going on.

Figure 1. Protected areas in Mozambique.
2.4. **Background data regarding natural water quality**

Background\(^1\) values regarding natural waters are important as they serve as data of comparison in evaluating the extent of contamination that often occurs, for example, in connection with discharges from mining operations. The concentrations of metals, many of them being toxic in higher amounts, are of particular interest. Background values often vary appreciably between different geological environments, as a result of variations in rainfall, due to different types of vegetation, etc. In the absence of precise data on the content of metals in natural waters in Mozambique, a number of samples representing background conditions were taken during May and August 2003 in connection with visits to mining sites. Waters at altogether twelve different sites unaffected by mining activities were sampled and analysed at an accredited laboratory in Sweden. A more detailed presentation of these data, as well as a comparison with data from other countries, is presented in **Annex 2**.

The study carried out is obviously restricted in scope: it was performed only in the dry season and it included a limited number of sites (and samples). Nevertheless, the results should serve in providing an initial guide regarding the quality of natural waters in Mozambique; assist in the interpretation of mine audits; and form the basis for planning further in-depth studies.

The results show that the chemical compositions of the Mozambican natural waters being sampled are rather similar to the waters from similar geological environments in other parts of the world. The water samples from the Tete province exhibit rather high pH values and relatively high hardness (the content of calcium and magnesium), which reflect the basic (silica-poor) character of the bedrock geology. This is also reflected in the high conductivity values in combination with low concentrations of salt ions (sulphate and chloride), indicating a high concentration of carbonate and bicarbonate. The neutralising capacity of these waters should thus be relatively high, which would strongly reduce the risk of spread of acid drainage from the oxidation of sulphide mineralisations (in the case that such mineralisations exist and come to be exploited).

The metal contents in the sampled waters were generally very low. Thus, nearly all metals are on a level with concentrations recorded from other parts of the world in non-contaminated waters, or even being on the lower side.

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\(^1\) The terms *background values* and *base line data* are used extensively around the world, but not always in a consistent manner. However, most users make a clear distinction between the two terms, background values representing the environmental conditions prevailing prior to any disturbance, base line data denoting the status of an altered system at a particular point in time, prior to additional change.
3. Policy, legal and institutional framework

3.1. Policy
As stated in the Mining and Geological Policy (Política Geológica e Mineira, Resolução n° 4/98), the Mozambican Government is committed to the promotion of mineral exploitation through private investments. Thus, the Government holds the role of being regulator, promoter, facilitator and supervisor of mining activities. The policy also spells out that the Government intends to oversee mining developments in order to ensure mine safety and the protection of the environment.

3.2. Legislation
There are three main laws that are of relevance to the subject of environmental management in association with mining:

- The Environmental Law (Lei de Quadro Ambiente; Lei n° 20/97)
- The Land Law (Lei de Terra; Lei n° 19/97)
- The Mining Law (Lei de Minas; Lei n° 14/2002)

3.2.1. The Environmental Law (Lei n° 20/97)
The Environmental Law stipulates coordination of environmental matters between the various sectors and indicates that sectoral environmental regulations should be elaborated for, inter alia, the mining sector.

The most important aspects of this Law with a bearing on mining are:

- Article 10, which states that the Government shall approve standards for the control of environmental quality. The process of elaborating such standards is presently taking place (see further below).
- Article 14, that establishes zones of environmental protection within which a special certificate must be acquired in order to commence work.
- Article 15, that dictates the need for an environmental license for all development projects, including all types of mining activities.

Draft regulations regarding standards for environmental quality control (Padrao de Qualidade Ambiental e Emissões) is presently being reviewed by the different stakeholders and has also been examined within the framework of the present Project. The proposal includes a number of water discharge standards related to various industrial activities as well as certain standards for environmental quality. Our comments to the proposal included the following concerns: (i) Article 8 where we recommend the use of ambient air quality standards rather than emission standards; (ii) Article 14 where we recommend that the establishment of standards for the protection of aquatic life should wait until natural background conditions in Mozambique have become better known, and where we also recommend the use of WHO’s drinking water quality guidelines as a base for Mozambican standards for potable water; and (iii) Article 26 where we recommend that all the various mining and smelting activities stated in the draft should be grouped under one sole category of “mining and smelting” (see Annex 3 for the detailed observations).
In an annex to the Environmental Law, the Council of Ministers has approved Regulations for Environmental Impact Assessment (Regulamento sobre o processo de Avaliação de Impacto Ambiental, n° 76/98). These regulations introduce the concept of EIA in line with its use in most other countries, and define the requirements and procedures that the investor has to comply with in order to have his project officially approved. For example, the regulations state that public consultations are obligatory, in cases even public audiences.

3.2.2. The Land Law (Lei n° 19/97)

The most likely social impact associated with medium to large-scale mining will be associated with the loss of productive land and/or assets for small-scale farmers.

In terms of the Constitution of Mozambique and the Land Law all land in Mozambique belongs to the State. Individuals (and associations) may acquire, by default or through application, the right to use and occupy land through a variety of mechanisms such as customary tenure, continuous occupation of a piece of land for a number of years or official authorisation. Official title may also be granted on application but the lack of official title or registration of the land does not affect the land rights of bona fide right holders and they are deemed to enjoy the same benefits as holders of official titles. Although land may not be transferred (i.e. sold) and there is no “land market” per se, holders of land rights are able to transfer improvements, such as buildings, from one party to another.

The new Mining Law recognizes that mining activities requiring land must be in compliance with the Land Law (see below). A summary of the national laws governing land tenure, the taking of land and resettlement and compensation is presented in Annex 4.

It is highly probable that most occupiers and users of land in potential mining areas (i.e. rural and peri-urban areas) do not have official title to the land that they occupy and use. Nevertheless, the Land Law treats them as if they do have land rights.

In both rural and urban areas the right to use and benefit from all or part of the land, whether or not official title has been issued and registered, may be revoked and thus extinguished in the public interest. The Land Law clearly states that revocation, in the public interest, of the right to use and benefit from land is, however, subject to the prior payment of a just indemnification and/or compensation.

The Law does not refer to the procedures to be followed when land rights are to be extinguished. It does confer allocation rights on different levels of Government and these apply to the revocation of rights as well. Where small areas of land are involved (<100 ha) the Provincial Governors can deal with such issues and declare land rights to have been withdrawn from an individual, entity or community. The Law does not refer to the possibility of appeal against revocation of rights.
Other than stating that compensation should be paid when land is expropriated in the public interest, both the Constitution and the Land Law do not expand on issues related to compensation, in terms of the principles, forms, eligibility, valuation, adequacy, procedures, timing and responsibilities.

There are no specific guidelines regarding compensation and fairness and the principles and procedures are often drawn up and agreed to among the main stakeholders on a case by case or individual project basis. In recent cases in Mozambique it has generally been accepted that where people are displaced from land the principles of fairness and good practice are applied to compensation and resettlement. For instance, it is usually accepted that replacement land is provided which is, as far as possible, equal to or superior to the land foregone in terms of size, quality and location advantages. Compensation has also usually been paid on the basis of the full replacement cost of lost or displaced assets and has usually covered associated costs, such as transfers, transport, supervision and others.

It is sometimes problematic when only a very small portion of a Displaced Person’s (DP) land holding is required for a development project and where the loss of this small portion does not affect the overall viability or productivity of the whole land holding. Since the land cannot be freely transferred among people and there is no implicit value to the land, compensation in cash, for example, cannot be offered. At the same time it might be impractical or impossible to provide alternative small parcels of land in the immediate vicinity.

There may be a few cases where some people are occupying and using land for which they have no legal right of use and benefit. Such land may include, for example, total or partial protection zones or land for which other people and bodies have legal rights of use and benefit (i.e. rented housing and land). In some rural centres it may also be possible that people have been granted residential land by the authorities but they do not have “Authorisation” to use and benefit from the land or they have not been occupying the land in good faith for at least ten years. It has, however, been common practice in Mozambique to treat such cases in the same way as people with legal rights to use and benefit from land and that all DPs, regardless of their tenure status, should be provided with compensation and resettlement measures.

There is no explicit legal provision for DPs to appeal against levels of compensation or other resettlement measures provided although DPs have final redress to the courts. In rural areas the Land Law recognises the role of traditional leaders in planning and conflict resolution and grievance procedures should be based on the existing channels and practices.

3.2.3. The Mining Law (Lei nº 14/2002)

Mozambique has a new Mining Law, promulgated in 2002, which in all essential respects is in accordance with modern mining laws worldwide. Environmental protection is mentioned in the Mining Law particularly in the Articles 35-37, which define the following instruments for environmental management:
• Environmental Impact Assessment
• Environmental Management Plan
• Environmental Management Programme
• Environmental Monitoring Programme
• Mine Closure Programme
• Emergency Risk Assessment and Control Programmes
• Environmental Audits

In Article 37 the mining activities are classified according to level of environmental complexity and significance requiring that particular environmental instruments are being used:

Level 1  Small scale mining undertaken by individuals or cooperatives
Level 2  Quarrying and small scale extraction with mechanised equipment
Level 3  Activities not included in the preceding categories and involving mechanised equipment

The different levels call for different requirements and procedures. Thus, activities of Level 1 require only a “management according to basic environmental norms”; Level 2 requires an Environmental Management Plan; and Level 3 requires an Environmental Impact Assessment.

An important stipulation in the Mining Law is the Article 42 that recognises that mining activities requiring land must be in compliance with the Land Law in terms of acquiring rights over the land as well as compensation (see above). However, it is also stated in the same Article 42 that land use for mining operations shall have priority over other land uses when economic and social benefits related to these operations are greater.

General Regulations related to the Mining Law are expected to come out later during 2003 (Regulamento da Lei de Minas). These regulations provide detailed direction regarding the rights and duties in mining, but only treat environmental matters in a very general way. Thus it mentions the need for an environmental license and the need to comply with all obligations related to environmental questions.

Environmental Regulations for Mining Activities (Regulamento Ambiental para a Actividade Mineira) are presently being developed (7th draft) and it is the expectation that they will be approved of during 2003. The present draft of the regulations is a document that in great detail presents the classification of activities, the various environmental instruments to be used, the institutional and organizational setup for evaluation and permitting, and also provides brief directions in technical/scientific matters.

Occupational health and safety issues within the mining sector are treated in two regulations, one for underground mining and the other for open pit mining: Regulamento de Segurança Técnica para Trabalhos Mineiros Subterrâneos and Regulamento de Segurança Técnica para Trabalhos Mineiro a Céu Aberto (both of them identified as Diploma Ministerial nº 96/81). These regulations go into

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2 However, a permit is needed (a “mining pass”) and the miner has to “dispose of the waste safely”. No permit of this kind seems to have been issued up to now.
quite some detail, containing 242 and 147 articles, respectively. Being introduced in 1981, they are, however, somewhat out-of-date. For example, there are no standards given neither for noise nor for vibration. Other work related to mining as, for example, work in ore beneficiation plants is not covered. These regulations should be the subject of a revision.

3.2.4. Inconsistencies and debilities in the legislation

The different concepts and subdivisions in categories being used in the Environmental Law (and its regulations) and the Mining Law (and its regulations), respectively, are not always consistent. For example, in the Article 35 of the Mining Law, the principles referred to as “Environmental Management” (plans and programmes) do not agree with the terminology adopted within MICOA (based on the Environmental Law). In the language adopted by MICOA, the Monitoring Programme, the Closure Programme and the Environmental Audit are all included in the Environmental Management Plan. Furthermore, for MICOA there is no difference between a Plan and a Programme for Environmental Management. These inconsistencies should be removed through a revision of the legislation.

In this connection, it may also be relevant to question the use within the mining sector of several different environmental instruments that each requires its own examination by sometimes more than one group of experts, with the inherent risk of long drawn-out handling periods. There are also uncertainties in questions of duty and responsibility. The unification of some of the instruments under the umbrella of the EIA should be considered in order to simplify the process of permitting. Regarding the Closure Plan, such integration is also motivated from the point of view that planning for rehabilitation should influence already the initial choice of methods and design of an operation. To wait with such planning for up to one year after start-up of operations (as proposed in the draft for Environmental Regulations for Mining Activities) would be to overlook one of the main opportunities for environmentally friendly planning and management.

An additional inconsistency in the legislation is the classification in the Mining Law in categories of different levels of environmental impact, a subdivision which is not supported by the Environmental Impact Assessment Regulations already in use. In this case, it seems important to maintain in the legislation the categorization established in the Mining Law.

As stated above, there are no provisions in the legislation that regulate questions of compensation and resettlement associated with mining developments. Even if there seems to exist a good practice in dealing with such issues in Mozambique, the lack of legal base or other official guidelines constitute a shortcoming. Such legislation or governmental guidelines should be elaborated for the mining sector in close coordination with other industry.

According to the draft for Environmental Regulations for Mining Activities, on-going mining operations are given one year to adapt to the new regulations. There is no mentioning of responsibilities for rehabilitation at sites of former mining activity\(^3\) (so called environmental regulations). The practice is different in different countries as to liability for impacts that were caused before environmental legislation became valid, some countries requiring retroactive responsibility.
In some of these latter cases, it may not even be possible to identify a responsible firm or person. In this context, the impact of illegal artisanal mining represents a particular problem.

Many countries have introduced the use of Performance Bonds (or similar) as a guarantee for rehabilitation of the mining site (progressively during the operation or after the closing-down) even in such cases when the company in question fails to carry out such work or has become insolvent. Such arrangements do not occur in the Mozambican legislation and it is not known to us if the introduction of such Bonds has been considered.

### 3.3. Institutional framework

#### 3.3.1. General organizational framework

Mineral resources in Mozambique are the property of the State, but may be evaluated and exploited by private persons or companies by acquiring a mining title (reconnaissance license, prospecting and surveying license, mining concession, mining certificate). Such permits are issued by the Ministry of Mineral Resources and Energy (Ministério dos Recursos Minerais e Energia, MIREME) that through its National Directorate of Mines (Direcção Nacional de Minas, DNM) administers the Mining Law. Environmental issues related to mining are principally governed by the Mining Law and the Environmental Law with their accompanying regulations and, by that, are the responsibility of MIREME and the Ministry for the Coordination of Environmental Affairs (Ministério da Coordenação da Acção Ambiental, MICOA), respectively. The responsibilities and interaction of these two authorities are not yet finally defined.

The DNM is presently subjected to an institutional audit from which a draft final report is available (The CSA Group: DNM Institutional Audit). This audit has been conducted against the background of a proposed institutional reform, the latter outlined in the document Guidelines for the Proposed Institutional Reform (annexed to the CSA report). These documents provide a detailed analysis of not only the DNM organisation (present and future), but also locate this department in the framework of governmental structure.

In order to avoid too much of repetition of what has already been covered in these earlier documents, the present report will concentrate on such organisational matters that are directly related to environmental issues.

#### 3.3.2. The Ministry of Mineral Resources and Energy (MIREME)

MIREME is organized in four main units, namely National Directorates for Mines, Geology, Coal and Hydrocarbons, and Energy, respectively. There is presently no point in common between these directories regarding environmental matters, and no such coordination has been contemplated. It would, however, be logical and rational to coordinate the environmental supervision of coal exploitation with that for other minerals and, consequently, refer all such responsibilities to one and the same group of expertise within DNM. In line with this, the environmental evaluation carried out within this Project has included coal mines (see chapter 4).
3.3.3. **The National Directorate of Mines (DNM)**

The present DNM is organised in four departments: (i) Licensing and Control (mineral rights’ permitting), (ii) Inspection and Safety (inspection of mining operations), (iii) Small-Scale Mining (technical support, cadastre), and (iv) Mining Technology and Economics (technical project evaluation, promotion and environmental monitoring). The proposal for new DNM organization envisages a structure with five main departments, including a special Department of Environment with Sections for Environmental Management and Social Impact, respectively (*Figure 2*). It is notable that a Section of Environment also is suggested within the Department of Inspection and Safety, something that appears to constitute an overlap.

*Figure 2. Organization chart of DNM.*
3.3.4. The Department of Environment (within DNM)

The proposed Department of Environment is presently being staffed. A principal unit within this Department will be the Environmental Protection Unit (Unidade de Protecção Ambiental) that will be created by the enactment of the Environmental Regulations for Mining Activities (Section 3.2.3). According to the draft of these latter regulations, the main tasks of this unit would be (summarised/generalised):

A. Evaluation of the different environmental programmes and studies presented by mining companies with recommendations to MICOA (through its proposed new unit for Unit for Mining Coordination) regarding approval, rejection or need for completion.
B. Supervision and control of environmental performance by mining companies in relation to approved plans and basic norms
C. Supervision of environmental policies for the mining sector and coordination with other governmental entities or private organizations

The corresponding list of responsibilities of the Department of Environment in the Guidelines for the Proposal for Institutional Reform include:

1. Responsibility for the development of the mining environmental regulations
2. Establishment of the environmental licensing procedures and the participation in their application together with MICOA
3. Development, actualisation and administration of the Environmental Management and Information System (EMIS)
4. Realisation of environmental audits and baseline studies to upgrade the knowledge of the environmental conditions of the mining areas

The two listings of responsibilities are partly in accordance, but not wholly. As we have seen, the development of regulations, including licensing procedures, is already well advanced. Notwithstanding, the upcoming EMIS project (planned to start up in November) includes an analysis and recommendations to be carried out by an external consultant regarding the Department of Environment, both concerning the tasks, the organisation and the interaction with MICOA. Even if this analysis may seem to enter the process rather late, it could be of definite importance in order to arrive at an optimal final product (cf. Section 3.2.4).

Regarding the staff for the Department of Environment, two qualified professionals are already in place, including the intended head of department, and have taken part in the recent mine auditing carried out within this Project in the provinces of Zambézia and Nampula. Two more professionals are planned to be employed for this department during this year.

3.3.5. The Department of Mine Safety (within DNM)

The Department of Mine Safety is responsible for the enforcement of mining regulations for mineral exploration and exploitation. Thus, its main duty is a controlling function regarding permits, delimitation of areas, rational use of resources, safety in mines, and reporting of accidents. It has been the tradition in most countries that bodies of this kind also have the responsibility for occupational health and safety (OHS), that is the working environment, as opposed to the exterior
environment (the surrounding nature and its population). Even if companies more and more tend to combine their administration of these issues into one sole unit within the company, there are some good grounds for maintaining the distinction. One reason for this is that legislation is different, the base for OHS work being labour legislation or specific regulations regarding health and safety at the work place. This unit will, consequently, have to liaise with both the Ministry of Health and the Ministry of Labour. Existing general labour legislation in Mozambique has no specific provision for mining. However, there is a specific legislation regarding safety in work for the mining sector from 1981, now pretty outdated. It should therefore be of high priority to develop new OHS legislation for this sector and to include, this time, a wider scope of labour issues.

In the plans for the new Department of Mine Safety it is suggested the creation of a special Section for Environment, which would, inter alia, be responsible for the revision of environmental regulations, the control of closure plans and land reclamation, and the settlement of local disputes on environmental matters. For this purpose, the Department of Mine Safety would coordinate and supervise inspections carried out by the Provincial Directorates. This seems to constitute a clear overlapping with the duties of the Department of Environment and should be changed. By reserving the responsibility for general inspection and OHS questions for the Department of Mine Safety and all what is usually regarded as environmental issues (the external environment) to the Department of Environment, a clear line of division is attained. Besides, much of the actual field work will in both cases be carried out from the Provincial Directorates, maybe often by the same personnel. An alternative would otherwise be to merge the two Directorates (Environment and Mine Safety) into one.

### 3.3.6. The Ministry for the Coordination of Environmental Affairs (MICOA)

The MICOA is a Ministry of moderate size with some hundred professionals in its staff. Small regional offices exist in all provinces. It was created in 1994 and its activities have since then principally been financed with donor money channelled through the UNDP. It is administrating the Environmental Law, the latter stipulating that the MICOA should manage by coordinating the work of sector Ministries (as indicated by its name). It is organized in four directorates for Environmental Impact Assessment, Land Use Planning, Environmental Promotion and Education, and Environmental Management (wetlands, coastal areas, biodiversity, etc), respectively. Apart for a number of specific projects to which the UNDP-coordinated funds are directed, the MICOA has very small financial resources available for the carrying out of its responsibilities. The personnel is generally young and few persons have higher education from abroad. They are not seldom in the focus for criticism from NGOs and the relations are frosty.

### 3.3.7. Provincial Directorates (DPREME)

The MIREME’s organisation comprises ten provincial directorates that respond to MIREME in technical matters, but depend administratively and financially of their respective Provincial Government. The basic organisation comprises a Provincial Director and two departments (Department of Mineral Resources and Department of Energy). The staff of the departments usually include 2-4 technical people at a medium educational level. The knowledge and experience
in environmental matters vary appreciably (usually modest though), but the interest for learning is apparent. This was reflected in the positive response to the theoretical/practical training offered within the frame of this Project in four of the northern provinces. “But, it should be for several weeks rather than for two or three days” was a general comment.

It can be assumed that a considerable part of the future DNM work on environmental supervision within mining areas will be carried out by personnel from the provincial offices. It is therefore of prime importance that suitable training in basic environmental principles and field techniques be provided. This need should be attended to by thorough training led and performed by the Department of Environment of DNM.

### 3.4. Human resources

There is no specific higher education in mining topics in Mozambique. Neither is there any university education in broader environmental subject matters. However, the Faculty of Science at the Eduardo Mondlane University in Maputo has a Department for Geology and a Department for Biology, both subjects with relevance for the special field of environment in mining.

Polytechnic Universities are planned to be started up in certain provinces within the next few years, in the Tete province including a Department of Mining Engineering. The plans seem still to be very preliminary. Education at an intermediate level is offered at the Institute of Geology and Mining in Moatize (the former centre for coal mining in the Tete province).

In Mozambique’s somewhat older generation of technical professionals there are many who graduated in its time from universities in the former Eastern Europe, among them quite a few mining engineers and geologists. Some of these are presently engaged in environmental work within MIREME and the Provincial Directorates. Among a younger generation, a fair number of students have obtained degrees through scholarships at various universities abroad. Of the 30-50 scholarships per year that are benefiting Mozambicans, maybe 2-4 are for studies within the field of environment.

It is estimated that there are about 50 professionals with a foreign higher level education in the environmental sciences who are presently active in Mozambique within their field of expertise. The market seems to be in balance even if it is expected that there will be an increased need for persons with this specialty in the future. Given that the job market is too limited, nevertheless, for any more massive education to be justified nationally, the most effective support for forming professionals for the sector of mining and the environment is probably by the provision of directed scholarships for studies at South African or other foreign universities.
3.5. **Laboratories and analytical services**

3.5.1. **Laboratory analysis in environmental work**

The impacts of mining activities on the environment may be varied and wide spread. Hence, the analytical capabilities need to be correspondingly wide-encompassing. Mining may cause pollution to water, to air and the contamination of soils and sediment. This means that laboratories need to be able to analyse solid, liquid and gaseous samples. In practice, the monitoring of the impacts of mining are usually concentrated to assessing impacts of solid and liquid discharges. The contamination originating from the current mining activities in Mozambique include: acid rock drainage, suspended solids, toxic metals and a variety of oil based contaminants. The overview presented in Table 2 may exemplify the possible need for determinations.

*Table 2. Tentative need for laboratory and field determinations for the investigation of air, water, solids, and biological matters for environmental work within the mining sector of Mozambique.*

<table>
<thead>
<tr>
<th>AIR</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic characterisation</td>
<td>Temperature, LEL (lower explosion level or levels for carbonatisation)</td>
</tr>
<tr>
<td>Major constituents</td>
<td>Content of particulates (dust). H₂SO₄ O₂ CO₂ NH₃. Chlorous and nitric (nitrogen) gases, methane</td>
</tr>
<tr>
<td>Trace elements</td>
<td>Most other elements, besides Hg, exist on particulates (as solids). Halogen gases could be of interest</td>
</tr>
<tr>
<td>Organo-chemical constituents</td>
<td>Volatiles, espec. BTEX and chlorinated solvents.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WATER</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic characterisation</td>
<td>Temperature, pH, conductivity, turbidity, alkalinity, COD BOD TDS</td>
</tr>
<tr>
<td>Major constituents</td>
<td>K Ca Na Mg Fe P SO₄ NO₃ HCO₃ CO₂ Cl NH₄ NO₃</td>
</tr>
<tr>
<td>Trace elements</td>
<td>As Cd Cr Cu Hg Co Pb Sb Mo Ni U Zn</td>
</tr>
<tr>
<td>Organo-chemical constituents</td>
<td>Various</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SOLIDS</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic characterisation</td>
<td>Particle size distribution, density, paste pH</td>
</tr>
<tr>
<td>Major constituents</td>
<td>K Ca Na Mg Fe P S N</td>
</tr>
<tr>
<td>Trace elements</td>
<td>As Cd Cr Cu Hg Co Pb Sb Mo Ni U Zn</td>
</tr>
<tr>
<td>Organo-chemical constituents</td>
<td>Various</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BIOLOGICAL MATTER</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic characterisation</td>
<td>Biodiversity, species frequency, trace element uptake</td>
</tr>
<tr>
<td>Major constituents</td>
<td>Identification of taxa and species; biological indicators</td>
</tr>
<tr>
<td>Trace elements</td>
<td>As Cd Cr Cu Hg Co Pb Sb Mo Ni U Zn</td>
</tr>
<tr>
<td>Organo-chemical constituents</td>
<td>Methylated mercury</td>
</tr>
</tbody>
</table>
3.5.2. Present market for analytical services

The present requirement for environmental analysis within the Mozambican mining sector is small\(^4\). First, the exploration and exploitation activities are at a modest level; second, most types of mineralisations presently being worked do not require sophisticated analytical work; third, any major undertaking by large-scale companies will involve the setting up of their own laboratory facilities; fourth, analysis of metallic elements in water (of main importance within the mining sector) is nowadays usually carried out by use of large “machines” (Induced Coupled Plasma and similar sophisticated instruments) of high capacity requiring big investments; and fifth, analytical services is nowadays a global market with strong competition.

Besides this virtual lack of a commercial market, it can also be concluded that there are presently no major scientific environmental baseline study being planned, neither within the mining sector, nor, as far as we know, in any other sector. Even the MICOA, due to its lack of resources, has only very limited need for analytical services.

This situation of low demand for analytical services may change if new mineral deposits are found and developed, or if major scientific programmes are started. However, it is highly unlikely that the market for the next few years will justify major investments in new laboratory facilities. Occasionally there will certainly be a need for services, but they are bound to be somewhat limited in scope.

3.5.3. Existing laboratory capacity

From interviews conducted with Mozambican environmental experts and discussions with representatives of Ambra Lda, which is the major local supplier and retailer of instruments and chemicals for analytical laboratories in the country, it is concluded that laboratories that could serve the environmental sector only exist in the Maputo area. In this latter area, altogether twelve laboratories were identified that would represent plausible candidates for the type of analysis that is required (Table 3).

Table 3. Laboratories in Mozambique that could possibly provide services related to environmental work within the mining sector.

<table>
<thead>
<tr>
<th>Institutional (national) laboratories</th>
<th>Laboratories at the University of Eduardo Mondlane</th>
<th>Private laboratories</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Laboratory of Hygiene and Water</td>
<td>Laboratory at the Department of Chemistry</td>
<td>Mozal Laboratory</td>
</tr>
<tr>
<td>National Ministry of Geology and Mining - Laboratory</td>
<td>Laboratory at the Department of Geology</td>
<td>Mozambique Gas</td>
</tr>
<tr>
<td>National Institute of Agronomy - Laboratory</td>
<td>Laboratory at the Department of Civil Engineering</td>
<td></td>
</tr>
<tr>
<td>Agua Mozambique</td>
<td>Laboratory at the Department of Chemical Engineering</td>
<td></td>
</tr>
<tr>
<td>National Laboratory of Food and Water Control</td>
<td>Laboratory at the Faculty of Agronomy</td>
<td></td>
</tr>
</tbody>
</table>

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\(^4\) This does not preclude that there would not be requirements for analysis for geological and exploration work, for which purpose the chemical laboratory of MIREME-DNG is going to be upgraded.
All of these laboratories cater to their own needs of product control or research. For this reason, and probably because of a lack of market, none of the laboratories offer their services commercially. However, according to University staff, it is deemed possible and fully realistic for these different laboratory units to cooperate in developing special technical and organisational units for supplying laboratory services to external clients. Further, there are no formalities hindering the individual departments or faculties to undertake external missions on a commercial basis.

The instrumental standard of the laboratories varies, but in many places is the equipment old and worn. There are some higher-quality analytical instruments at hand in Maputo, but some of these are not in operation. Especially within the university departments, the lack of funds for spare parts, instrument service and reagent chemicals hamper the activities. Well trained technical staff seems to be less of a problem.

The MICOA has earlier had plans to cooperate with the Laboratory at the Department of Civil Engineering at the University of Eduardo Mondlane with the view of creating an environmental laboratory for its needs. This plan has now been abandoned due to the lack of resources (and needs?). The small number of analysis that the MICOA presently requests are carried out in the MIREME-DNG (soils) and in the National Laboratory of Hygiene and Water (water).

### 3.5.4. Recommendations

It is to be foreseen that the new Department of Environment in DNM will require analytical services in the near future, both for the control of discharges from mines and for the determination of background conditions in various natural environments. The needs will be significant and long term, even if they will not sustain any large-scale investment in laboratory facilities. Analysis of solid samples (soils and sediments) will be less of a problem as soon as the new laboratory for geological purposes within MIREME is functioning.

The analysis of water samples is more of a problem, particularly when it comes to the determination of the very low concentrations of metallic elements. The most rational solution to this requirement is to use any one of those high quality laboratories that offer their services from abroad. A majority of these laboratories on the international market are certified as to quality, offer quick services, and need only small samples that can easily be sent by DHL or any other courier company. For the determinations in water of the less demanding non-metal elements and compounds, we recommend to establish close cooperation with one or two of the national or university laboratories. Cross-checking between laboratories may be necessary in the beginning (including samples sent abroad), but after the establishment of strict routines there should be good possibilities to achieve a reliable quality in the results.

The analysis for mercury related to contamination from artisanal mining is a possible future need if Mozambican authorities decide to embark on an investigation of this potentially serious problem. This would mean the analysis for mercury in such media as natural soils; stream sediments; water (less likely as the solubility of mercury in water is extremely low); fish (or other fauna); and human hair and blood. Such analyses require very sophisticated equipment in order to determine
accurately also extremely low concentrations, as well as strict routines for cleanliness and inter-
laboratory quality control. The setting up of such capacity in Mozambique would require a great
investment, considerable time and it would hardly be a sustainable measure.

4. Environmental conditions

4.1. Potential problems related to mining

The mining industry of Mozambique is not yet very well developed, so the related environmental
matters are not as serious and extensive as in some of the big mining countries. However, problems
do certainly exist and there will also be potential environmental impacts associated with any new
mining operation starting up.

Altogether 22 different mining sites were visited and briefly audited as part of the present Project.
These sites are located within the main mining provinces of Manica, Tete, Zambezia and Nampula.
The results of the findings, supported by a number of chemical and physico-chemical analyses\(^5\), are
presented in a standard protocol format in Annex 5. In the following presentation, frequent
references are made to these Reviews.

In order to present an analysis of the current situation, a general overview of mining environmental
issues, as met with in different countries, is presented as a background and reference. To
systematize the discussion we will subdivide the subject into 13 different issues representing the
main impacts of concern. The first issue regards exploration activities, which is an environmentally
less offensive activity (Section 4.2.1). The main part of the presentation concerns impacts that are
related to the activities within an industrial area (mine, treatment plant and waste disposal facilities,
Sections 4.2.2 - 4.2.12). Finally, the Section 4.2.13 will briefly cover the field of occupational
health and safety, an issue that has previously been managed separately from environmental
matters, but which to a certain degree overlaps with the latter. Thus, the different issues to be dealt
with include:

1. Prospecting and exploration activities
2. Non-efficient use of natural resources
3. Effects on landscape and morphology
4. Accumulation and spread of solid waste
5. Water use and/or pollution - Acid Mine Drainage
6. Air pollution
7. Soil pollution
8. Effects on flora and fauna
9. Noise and vibration
10. Radioactivity and uranium
11. Environmental emergencies
12. Issues common to industrial establishments in general
13. Occupational health and safety

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\(^5\) All analytical laboratory results presented in this report were carried out at the certified laboratory Analytica AB in Sweden.
4.2. Analysis of the various environmental aspects related to mining

4.2.1. Prospecting and Exploration

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>◊ Land disturbance</td>
<td>• Construction of access roads</td>
</tr>
<tr>
<td>◊ Erosion</td>
<td>• Drilling activities</td>
</tr>
<tr>
<td>◊ Encroachment on wilderness areas</td>
<td>• Trenching and sampling</td>
</tr>
</tbody>
</table>

**General background:**
Prospecting and exploration work includes all of the different search activities that ultimately may result in the discovery of an exploitable deposit. Ideally it starts with the employment of regional surveys, like geological mapping or aero-surveys covering large areas. This investigation phase rarely causes any substantial impact on the environment. Based on the findings from the initial work, restricted areas are chosen for follow-up and, in case of success, detailed drilling and sampling in chosen areas are carried out. The main environmental impact of such work is usually the construction of access roads in sometimes sensitive terrain. This can cause severe erosion, particularly in mountainous areas and areas of high rain fall. Other effects of exploration activities may be the clearing of vegetation and contamination associated with the establishment of camps. Oil spillages and other spread of chemicals are other potential hazards. Even if each separate case may seem rather harmless, the localization of such activities to a great number of places in sometimes virgin or sensitive terrain justifies careful consideration. Measures include, for example, the use of helicopter for transport instead of making roads and careful restoration of any disturbance on leaving the area.

**Present situation in Mozambique:**
The environmental effects of exploration work in Mozambique are fairly small, partly due to the present low exploration activity in the country. Impacts are mainly related to the work carried out by the companies investigating heavy mineral sand deposits, and consist of smaller or larger pits from where material has been taken for the beneficiation tests. Road construction in relation to these latter investigations has had a rather small impact on nature. Neither can it be argued that new access roads have considerably contributed to an increase in slash and burn farming.
4.2.2. Non-efficient use of natural resources

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>◊ Incomplete recovery of ore reserves in mine or deposit</td>
<td>• The use of unsuitable mining methods</td>
</tr>
<tr>
<td>◊ Poor recovery of metals/minerals in the beneficiation process</td>
<td>• Inferior beneficiation methods and/or poor optimization of processes</td>
</tr>
<tr>
<td>◊ Wastefulness regarding consumption of water and energy</td>
<td>• Slack management and work routines</td>
</tr>
</tbody>
</table>

General background:
“Ore” is a technical-economic term and means a “concentration of minerals (a mineralization) that can be extracted at a profit”. Thus, a mineralization may constitute an ore or not depending on such factors as the size (volume) of the deposit, the ore grade, the cost of mining and ore treatment, and the world market price of the contained metals or minerals. Knowing this, it is obviously in the interest of all involved parties that an operation is carried out as efficiently as possible. That would mean that:

- The deposit is exploited as completely as possible or, in other words that as little as possible is left in the ground after termination of the operation.
- The beneficiation process is as efficient as possible, meaning that as little as possible is lost in the treatment process (high recovery).
- The usage of water, energy and other resources needed for the operation is as efficient as possible.

Generally speaking, large deposits (even those of low grade) justify large investments and a high degree of mechanization. Reversely, many small deposits may only be economically feasible to exploit if artisanal methods are used, that is little or no investment in equipment is involved.

An obviously unfortunate situation is when a large deposit, which would be possible to exploit by rational and mechanized methods, is taken over by artisanal miners and exploited in a primitive way: valuable minerals (in case of a large scale operation) are left in the ground and, furthermore, much is lost in the beneficiation process. It is seldom that such a half-exploited or “ruined” deposit can be exploited further by mechanized methods: the opportunity for a more complete, rational exploitation has passed.

Present situation in Mozambique:
It is often difficult to judge to what degree of completeness a deposit should be exploited as it depends on economic considerations that maybe only the company in question is in a position to assess. It is also sometimes difficult to judge if a deposit that is presently worked by artisanal miners would be economically exploitable with mechanised methods, in this latter case due to the lack of information regarding size, form and grades of the deposit. However, several of these latter deposits have been evaluated by competent mining companies (Review 16 and in the Province of Niassa) and have presumably been found to be too small to justify a larger investment. Also at
Munhena (Review 13), where the artisanal miners have managed to get help from the outside for the opening up of a large-scale pit, it is quite obvious that this deposit cannot sustain an investment into a regular mine. Thus, we have encountered no clear examples of sites where artisanal mining prevents a more systematic and complete exploitation.

It is also sometimes complained that the methods used by artisanal miners are too primitive and that too much, maybe more than half, for example, of the contained gold is lost in the process. This may sometimes be true, but it should also be remembered that also artisanal mining follows its economic rules: marginal deposits may not justify even small investments in tools. It is also common that the same material or waste is treated repeatedly (Review 20) whereby the total rate of recovery of a deposit is improved considerably. A special complication in searching for an improved recovery of gold is the reality that some of the most immediate improvements at hand are such environmentally less desirable techniques as amalgamation of gold with mercury or the use of cyanide leaching.

4.2.3. Effects on landscape and morphology

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>◊ Visual and aesthetic effects; change in land form</td>
<td>• Excavation of open pit mines</td>
</tr>
<tr>
<td>◊ Land use in competition with other utilization</td>
<td>• Establishment of industrial areas for ore dressing</td>
</tr>
<tr>
<td>◊ Destruction of natural habitat</td>
<td>• Areas of tailings and waste</td>
</tr>
<tr>
<td>◊ Land subsidence</td>
<td>• Underground mining</td>
</tr>
<tr>
<td>◊ Land/soil erosion; changes in river regime due to</td>
<td>• Road construction</td>
</tr>
<tr>
<td>siltation and flow modifications</td>
<td>• Inadequate rehabilitation after closure</td>
</tr>
<tr>
<td>◊ Abandoned equipment, plants, buildings, excavations</td>
<td></td>
</tr>
</tbody>
</table>

**General background:**

The methods used in present day modern mining are, in principle, not very different from what they were 50 years ago. However, due to technological improvements it has become economic to exploit on a large scale also such deposits that are low in grade. Open pit mines are becoming the rule as opposed to the previously prevailing underground excavations. This development means the movement of increasing amounts of ore, overburden and other waste rock, and the formation of bigger pits and larger deposits of waste. For this reason the visual effects of mining are accentuated and the potential conflict with other users of the ground is aggravatcd. Such disputes may involve the general public, who dislike the disappearance of nature or scenery, or other alternative users of the land like forestry or farming interests. Conflicts with the tourist industry are also fairly common. Conflicts of interest of the type just described may in extreme cases prevent the development of a mining project or require very substantial modification of original plans (for example, the employment of underground extraction instead of open pit mining). Nearly always

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6 This is not to say that there are no possibilities to encounter larger deposits for industrial mining in other areas, at deeper levels, etc. provided that proper exploration work is carried out.
they make heavy demands upon the planning and execution of mining operations. Possible measures include strip mining with successive backfilling and rehabilitation of the disturbed ground (for stratiform deposits like coal), the filling up of open pits, the creation of lakes from open pits or tailings dams, landscaping and revegetation of waste deposits, etc. The extraction of beach or river deposits require very special care not to cause erosion from winds, running water or waves.

The issue of landscape impact is dealt with primarily during the planning stage of a mining venture. The problems met with are usually very site-specific.

**Present situation in Mozambique:**

Up to now, there seem to have been few conflicts regarding land use associated with mining in Mozambique. The main reason for this is that mines have been situated in sparsely populated mountains or in poor areas of subsistence farming. The only direct conflict we heard of during our mine visits was the complaints of farmers regarding the use of wood from the forest within the bauxite mining area of Mina Alumina (Review 4); legally the farmers are encroaching upon the company’s concession area. At the AUSMOZ alluvial gold operation (Review 1), the farmers, formerly cultivating in the valley where mining now is carried out, have been compensated (some of them even being employed by the company).

With the new big projects for heavy mineral sand exploitation (titanium) coming up, the issue of land use has come to the fore more than before. Of particular sensitivity are the exploitations planned within areas immediately inland from the sandy beaches of the sea front. Even if there are no tourist installations in the areas in question, some people argue that the whole of the Mozambican coast line should be reserved for touristic developments and fishing. However, an ongoing operation, of a similar kind as those anticipated in Mozambique, at Richards Bay in South Africa, demonstrates well how it is possible to carry out mining of this kind in an environmentally acceptable way; the basic principles for achieving this are progressive rehabilitation of areas being mined and revegetation. Full-grown forest will be affected in at least one of the projects (Review 10); at the same time, a certain part of this forest will be preserved and also hopefully protected from the slash and burn farming, which is already getting close to the area. One of the large planned projects is located at Chibuto (Review 9) about 50 km inland from the coast in an area of less environmental value. From this point of view, this project would be preferable in competition with those close to the sea. Nonetheless, a planned tailings dam at Chibuto, as big as 5 km$^2$ in size, demonstrates a possible occupation of land like never before in Mozambican mining.

Extensive erosion and silting of rivers are associated with small scale mining at various sites. One example of this is at the Mimosa site where the extensive mining has caused strong erosion of the steep mountain slopes with the result that some of the areas are “totally devastated”, lacking trees or vegetation and thus lying open to further erosion; the total area affected in this place is at least 100 ha. Subsidence features are common in the slopes.

Surface subsidence related to underground mining has occurred at one of the shafts at Moatize (Review 7) where the roof of the inclined adit has collapsed about 10 m vertically along a stretch of about 50 m, affecting a local road.
There are a number of closed-down and abandoned mines in Mozambique, but proper closure and clean-up have never been carried out (not to mention rehabilitation of the ground). Thus, there are remnant skeletons of beneficiation plants at several places (Reviews 2, 3, 11, 12). The majority of these “ruins” are probably harmless in character, but the remaining treatment plant at the Mavita asbestos mine, closed in 1987, should be more of a concern. Here, asbestos is spread over the site and also occurs in transport pipes and storehouses (Review 5).

Quarries and sand pits are numerous, although each area of exploitation is limited in extension. Conflicts regarding land use are seldom very apparent, but obviously represent a latent problem. The workings are usually at the surface and shallow. However, steep walls may sometimes result from stone quarrying and, if access is not prevented (which is seldom the case), the pits may be dangerous to humans as well as animals (Review 8). Reclamation work is of need in a great number of places where exploitation has been discontinued.

4.2.4. Accumulation and spread of solid waste

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>◊ Potential threat from toxics in solid waste</td>
<td>• Tailings deposits</td>
</tr>
<tr>
<td>◊ Sediment runoff from mining sites</td>
<td>• Waste rock heaps</td>
</tr>
<tr>
<td>◊ Accidents due to lack of stability of waste material; tailings dam failures</td>
<td>• Leaching heaps</td>
</tr>
</tbody>
</table>

General background:

Waste rock: Modern mining usually involves the movement of large quantities of material. Thus, overburden and sterile host rock excavated in order to reach the ore body often make up several times the tonnage of the ore being extracted. Top soil is usually removed separately and protected in order to be used in the rehabilitation of the area. Waste rock does to a great extent originate from the host rock surrounding the actual ore body. It does often contain ore minerals, but in too low amounts for their economic utilization. Nevertheless, these sometimes potentially toxic elements or compounds may be released through weathering and cause pollution of the surroundings (cf. the subject of “acid mine drainage” further below). Consequently, the choice of suitable sites for such left over rocks, the methods and design used for their deposition, and subsequent protection from deleterious leaching of their toxic constituents, represent a very important task, both economically and environmentally, in any mining operation.

Tailings deposits: Deposition of tailings in tailings impoundments, is the traditional method to collect the fine waste that is discharged from beneficiation plants, usually in the form of a slurry. This is the waste formed after that the valuable minerals have been extracted, which, however, always contains remains of metallic minerals and other compounds of environmental concern. This arrangement for waste control, used at practically all reasonably modern mines in the world, usually constitutes the environmentally most important construction at a mine site. It is mainly a facility for the collection and deposition of solid waste, but also serves as a means of controlling process water (recirculation to the beneficiation plant, precipitation of slimes and chemical
compounds for purification, pH corrections, decantation to nature, etc., the exact scheme depending on the local conditions).

Large quantities of solid material are successively collected in a tailings impoundment. In extreme cases, surface areas of several km² do occur, as well as dam structures more than 100 m high. The integrity of such constructions is obviously of greatest concern as they may pose a threat both to the safety of the local population and the environment. In fact, a series of dam failures have been reported from various parts of the world, a few of them with a fatal outcome. Consequently, the design, construction, management, and decommissioning of tailings impoundments must be based on sound technical and scientific knowledge and modern risk analysis.

**Present situation in Mozambique:**
Waste rock has in Mozambique usually been deposited directly on the surrounding land and tailings have been discharged to nearby rivers. This is a practice that still prevails at some mines (Review 4) and at all artisanal operations. Simple waste rock heaps and tailings impoundments have occasionally been established also in older times (Review 2), but only during this year has the first really proper tailings dam in the country been constructed at the Marropino tantalum mine (Review 11), this being done according to South African design and under supervision from specialists from this same country. An effort has also been made at the nearby Morrua tantalum mine to construct an adequate dam, although not of the same high standard.

Needless to say, the large multinational companies that plan exploitation for titanium, all have detailed plans for how to treat and deposit the waste.

### 4.2.5. Water use and/or pollution

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>◊ Overexploitation of groundwater resources</td>
<td>• Excessive use of process water</td>
</tr>
<tr>
<td>◊ Changes in groundwater table</td>
<td>• Discharge of contaminated water from tailings</td>
</tr>
<tr>
<td>◊ Withdrawal of water in competition with other utilization</td>
<td>• Acid mine drainage (AMD) from mines</td>
</tr>
<tr>
<td>◊ Contamination of surface water used for drinking, irrigation, aquaculture, recreation</td>
<td>• AMD from tailings and waste rock disposals</td>
</tr>
<tr>
<td>◊ Suspended solids in drainage</td>
<td>• Contamination by reagents used in mineral processing</td>
</tr>
<tr>
<td>◊ Contamination of groundwater wells and springs</td>
<td></td>
</tr>
</tbody>
</table>

**General background:**
Water is an integral component of all mining ventures. Its main use is in the processing of ore and some operations consume large quantities of water. In addition to this fundamental service of facilitating the concentration of the useful components of the ore and aiding in the removal of the waste products, water is also used in drilling, as a means of dust suppression, etc. Besides, water is also used domestically. The environmental significance of water has to do with the consumption of a scarce resource to the detriment of other usage, its spoliation for alternative utilization due to it
being contaminated, and its function as an effective transport medium for contaminants to the surroundings.

*Water consumption.* The consumption of water in a mining operation may represent a major environmental issue. In fact, in a desert terrain where it even may be necessary to resort to using fossil groundwater, water consumption can easily constitute the one serious factor of environmental impact. Measures include: the reduction in the amount of process water needed, effective circulation and reuse of water inside the plant (or equivalent); recirculation of water from the tailings impoundment; and reduction of evaporation. In other words, an intelligent design and an efficient management of the water system at the mine site.

*Contamination through the release of process water.* Unlike in many other industries, the main adverse effects from mining operations is usually related to the composition and disintegration of the raw material in itself and less from introduced chemical compounds. In the discharge from a plant, we may thus differentiate between contamination of “natural” origin and contamination by process chemicals. Contamination from natural sources does in its simplest form consist of fine rock particles in water suspension (high turbidity). This silting may have a detrimental effect on fish, plants and the more primitive organisms, but the material is usually made to precipitate in the tailings impoundment. Another main concern originating from the raw material is the often high contents of dissolved heavy metals and metalloids, for example, copper, lead, cadmium and arsenic, in the discharge. Sufficient dwell time in the tailings impoundment and appropriate pH control will in most cases prevent too high concentrations in the water let out to nature. Other methods for precipitation are evaporation and precipitation by natural organic material in wetlands. In certain cases, water treatment in special plants may be necessary.

*Process chemicals* embody a row of compounds of which cyanide and mercury are those causing the main concern. Other chemicals to which attention has to be given include xanthates and other flotation agents, sulphuric acid, copper sulphate and ammonium nitrate.

*Cyanide* is used in industrial operations mainly for the leaching of gold from ground ore but is sometimes also used as a depressor in flotation. The cyanide disintegrates rather soon in nature and is in this way made harmless; before this happens it is highly toxic to man and animals and has to be handled with great care.

*Mercury* is mainly used in artisanal gold mining as a means of extracting gold by amalgamation from a heavy mineral concentrate. Mercury is particularly toxic as vapour or in its organic (methylated) form; the latter is readily taken up by, for example, fish and reaches the human body with the food. Being a natural element, mercury does not disintegrate and therefore does never leave the ecocycle. On this ground its use is being restricted or banned in many countries. Mercury is widely used for amalgamation of fine gold in artisanal mining, at which it is regularly released to air (fumed off by heating of amalgam to recover gold) or water (surplus mercury from the amalgamation process). Carefully managed, the spread of mercury to nature could be minimized, but the idiosyncrasy of artisanal miners and the lack of public control usually frustrate such efforts
for mitigation. For this and other reasons, this widespread type of mining activity represents a serious environmental concern.

_Acid Mine Drainage (AMD)_7. Rocks or mine tailings that contain appreciable amounts of sulphides have the potential to cause Acid Mine Drainage (AMD). AMD is generated when sulphide minerals oxidise, releasing sulphuric acid and hence metal ions into solution. Typically, AMD is formed in abandoned mine adits or in tailings impoundments and waste rock deposits. The serious effects of AMD upon water quality and upon aquatic biota, especially fish, have been known for over a century. The first accounts of the problem originated from areas around the lead and zinc mines in Wales, now it has become a worldwide problem associated with mining. It has been shown that sulphide waste rock may contain sufficient amounts of leachable metals to present serious problems for decades or even centuries if acid is generated and not neutralised.

The pollution strength of each individual source thus depends on its:

- Sulphide content.
- The potential for sulphide oxidation and thereby generation of sulphuric acid.
- The ability of the material to neutralize the acid formed (mainly through the neutralizing effect of carbonates).
- Bacterial action that may act as a catalyst for oxidation.

The actual concentrations of metals, of which some will be toxic, will of course also depend on the actual contents of such metals in the ore or rock material (leached out from the same sulphide assemblage that is producing the acid, or leached from other rocks/materials that are subjected to the acid drainage). It should also be noted that relatively high metal concentrations may result from metals’ liberation from their corresponding sulphide minerals even if the acid that forms is neutralised; however, a majority of the metals have a much higher solubility in acid than in neutral solutions.

AMD will not develop in such areas where the ore or the surrounding bedrock and soils have the properties to immediately neutralise any acidity that may occur. Hydrocarbonate ions are the main agents in such neutralisation. This means that when ores are high in carbonate matter or where the host rock consists of limestone or marl, no AMD problems will arise.

An experienced geologist, based on his knowledge of the local bedrock geology and the chemical-mineralogical composition of rocks, will usually be able to give an approximate estimation of the potential threat of AMD formation in an area where mining is considered.

In such cases when it is unavoidable to discharge process water to nature (usually via the tailings dam), artificial liming may be an effective method to reduce the concentrations of toxic metals. Another method that sometimes has given good results is the release of the metal-rich water to natural wetlands. In this way metals are removed naturally from the water by means of the uptake of such elements by plants living in this milieu (sedges, reeds, etc.)

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7 Also called Acid Rock Drainage, ARD; Mining-Influenced Waters, MIW; and acid drainage.
Present situation in Mozambique:
Mozambique in general, and particularly the mountainous parts of the country where mining takes place, have a high rate of rainfall and host a large number of major rivers. Process water for mining operations are usually taken from minor rivers (Reviews 11, 12) or even from the mine itself (Review 2). Thus, there seem to be no conflict over water supply with other users. Recirculation of water from the tailings pond is carried out at the Marropino mine, but possibly more as a measure to reduce pumping costs than to preserve water (that is anyhow abundant, but at some distance).

In the case of artisanal mining, the reliance on water can be more precarious as there are usually no facilities for pumping water from one place to another. The ore is usually taken to be washed in small ponds in streams/rivers or in their immediate vicinity. In one of the sites being visited, mining activity was very low due to a dry stream bed and the necessity to carry water in buckets to the place from a source at some distance (Review 18). During the rainy season these same mining sites may be flooded whereby mining is made impossible.

Mercury is widely used for amalgamation and is finally driven off to the air by heating in order to recover the gold. This practice is common in the Manica and Niassa provinces and in the north-western part of the Tete province, that is in the areas where work techniques have been influenced by miners from the neighbouring countries. There is also the tendency that mercury is used primarily for the capture of the less easily extracted gold from bedrock deposits, while the alluvial gold is more easily won by simple panning. Retorts for the recovering of the mercury are not used or in many areas not even heard of. One of the several obstacles for introducing the use of retorts is the small scale of the workings and the tendency by most miners to carry out the amalgamation and consecutive burning in very small lots in order to recover money for their daily living. There is a suspicion that mercury contamination may be quite serious in areas of intensive washing, but there are few or no data to support this assumption. The analysis of one sample of suspended solids in a stream from a mining area (Review 13) gave a content of 0.11 mg/kg, that is about the double of what in many countries is stated as the natural background. This sole analytical result must probably be regarded as inconclusive, but calls for more extensive and systematic investigations.

Acid drainage (AMD) is related to sulphide ores, the kind of deposits that are not being exploited in Mozambique at the moment. However, two earlier mines, the Monarch mine (gold with sulphides) and the Mundonguara mine (copper sulphides) (Review 2 and Review 3, respectively) produce mine water that flows from the mine galleries to the surrounding nature. These mine waters are relatively high in sulphates as demonstrated by the analytical data. These latter data in combination with site measurements also strongly indicate that the acid solutions being formed are immediately neutralised, presumably by carbonates in the gangue and the surrounding host rock. Consequently, the pH is as high as 7.4-8.0 and no AMD is formed. This favourable situation of an intermediate-basic (neutralising) composition of the bedrock seems to be predominant in at least the northern part of the Manica province as well as within the Zambezi river watershed; also in this latter region are the pH values of natural water manifestly high (pH 7.8-8.0) (Annex 2).
In spite of the high pH, the mine water at the Monarch mine is clearly elevated regarding certain elements. Arsenic is the element of immediate concern with a concentration of 33 mg/l to be compared with the WHO recommended drinking water standard of 10 mg/l, and with the risk that concentrations in drainage water from the tailings area could be even higher regarding both arsenic and metals. An analysis of the non-weathered old tailings showed a content of 3.8% of sulphur (presumably in the form of sulphide minerals) and the very high concentration of 0.5% of arsenic. A rehabilitation study of the property is presently being carried out within the framework of the World Bank support.

Cyanide as a process chemical for the leaching of gold was previously used at the Monarch mine, presumably the only place in Mozambique where such leaching has come to be used. It is not to be expected that any left-overs or residues of this chemical should still exist as tanks and vessels have been open to natural degradation for years. However, at our visit the present owner had prepared for resume cyanide leaching, but this time at an artisanal level. This is to our knowledge the first time such a type of artisanal activity is planned or performed in Mozambique.

The presently active mines in the country do not use offensive process chemicals in their ore treatment. Neither are such chemicals going to be used in the beneficiation of heavy mineral sands.

At the Chipanga coal mine (Review 6), mine water is discharged to a wetland, which seems to remove quite effectively the suspended coal and clay particles.

### 4.2.6. Air pollution

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>◊ Spread of fine mineral dust of detriment to humans and nature</td>
<td>• Dusting from dry tailings deposits</td>
</tr>
<tr>
<td>◊ Acidification of water bodies and soil from smelter gases</td>
<td>• SO$_2$ emissions from smelters</td>
</tr>
<tr>
<td>◊ Contamination from air transported particles, metals and other substances</td>
<td>• Emissions of lead, arsenic and other substances</td>
</tr>
<tr>
<td></td>
<td>through smelter gases</td>
</tr>
<tr>
<td></td>
<td>• Release of methane from coal mines</td>
</tr>
</tbody>
</table>

**General background:**

The major air pollutants related to mining and smelting activities are particulate matters and gases. Their origin may be dusting from mines, roads or dry tailings deposits, and gases from smelters or fuel combustion. Dust or gases may present a hazard to the health of people or the natural environment, or they may constitute a nuisance due to odours, dusting or the formation of smog. While other pollution related to mining usually occurs within a geographically limited zone, air pollution may reach distant areas.

Particulate matters are of various sizes and composition, the finest fraction under 10 µm (PM$_{10}$) being of major concern due to the ability of such particles to penetrate into the human lungs. The

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8 It occurs, though, in nearby Zimbabwe and in several other countries.
level of hazard involved depends on the chemical and physical characteristics of the particulate matter; for example, the level of metals like lead or arsenic may be high.

The main gases of concern are sulphur oxides (SO$_2$), nitrous oxides (NO$_x$) and carbon monoxide (CO). Apart from the potential health hazard, these substances may contribute to the forming of acid rain or photochemical smog. Mitigation is through removal of gases by wet or dry scrubbing, the control of dust emissions by means of extractors and precipitators, and the suppression of dusting from open areas by water sprinkling, chemicals or other methods.

**Present situation in Mozambique:**

Dusting from open pits or beneficiation plants occur at many of the Mozambican mining sites, however at a moderate level. Usually, it mainly affects the workers within the site, but in the Moatize area there seem to be a rather widespread dusting problem from coal stored in open heaps (Review 7). At the Chipanga coal mine there is presently a programme under execution for the control of the fine coal particles by sprinkling of water and the planting of trees (Review 6).

At the Mina Alumina bauxite mine, where dusting is presently a serious problem within the plant, new dust filters are now being installed, which will reduce this problem considerably (Review 4).

When full production will commence at the Marropino tantalum mine, including blasting in the open pit and crushing of the ore in the plant, the control of dusting will presumably be an important issue (Review 11).

Mozambique has only one bigger smelter, which is the modern alumina plant of Mozal that relies on imported raw material (bauxite). The review of this plant has not been part of this Project.

### 4.2.7. Soil pollution

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>◇ The contamination of agricultural soil</td>
<td>● Transport of metals and other substances related to mining operations by air, water or vehicles</td>
</tr>
<tr>
<td>◇ Contamination of ground in inhabited areas</td>
<td></td>
</tr>
</tbody>
</table>

**General background:**
The contamination of soils is primarily associated with discharge of contaminated water, Acid Mine Drainage, dust deposition and fall-out from smelters. So, sources and effects are usually dealt with under these headings. However, specific soil standards are currently being introduced in many countries. Mercury contamination is a problem in areas with artisanal gold mining.

**Present situation in Mozambique:**
Tailings material from sulphide mines does often contain elevated concentrations of toxic metals, as is the case at the Monarch and the Mundonguara mines (both presently idle). Especially the tailings left at the Monarch mine, and which are currently being eroded and transported down the slope to the vicinity of human settlements, contain as much as 0.5% (5330 mg/kg); this
concentration is about 300 times the value above which negative effects on the fauna is to be expected (17 mg/kg according to the Canadian legislation) and 500 times the standard for agricultural soil used in for example England (10 mg/kg) (Review 2).

Mining waste produced at bauxite and tantalum mines appears to be free from higher amounts of toxic elements.

Regarding the spread of asbestos at the Mavita mine, refer to Section 4.2.3 and Review 5.

Mercury, spread to nature through amalgamation, has a very low solubility in water, and will mainly end up in soil, stream sediments or in organic material (mainly in streams). The more exact status on this matter within the Mozambican areas of artisanal mining is not known (see Section 4.2.5).

### 4.2.8. Effects on flora and fauna

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>◊ Destruction of natural habitat in mining area</td>
<td>• The combined effect of contamination radiating from mining operations</td>
</tr>
<tr>
<td>◊ Destruction of adjacent habitat</td>
<td>• Deforestation related to operations or the activity of intruding settlers</td>
</tr>
<tr>
<td>◊ Disturbance of wildlife</td>
<td></td>
</tr>
<tr>
<td>◊ Loss of forests</td>
<td></td>
</tr>
<tr>
<td>◊ Impacts on aquatic life, flora and micro fauna</td>
<td></td>
</tr>
</tbody>
</table>

**General background:**

The manifold disturbances and contamination discussed further above give rise to various impacts on the flora and fauna. This influence may regard the physical removal of plants and animals; the physical disruption of soil and its macro-organism and micro-organism communities; the loss of wetlands; the destruction of wildlife habitat; and the toxic effects of acid solutions, heavy metals, cyanide, etc.,. Measures to be taken include, on one hand, due regard to these potential effects in planning and operation, and, on the other hand, proper rehabilitation of such impacts that are unavoidable. The issues to be considered fall within the very extensive area of nature conservation and ecological management, and questions to be solved sometimes become very complex. Environmental measures and procedures are based on experiences as well as scientific knowledge; the latter is, however, not always available. Hence, the toxicity of substances on different organisms and in different ambience represents a wide area of scientific research that is still very incomplete.

**Present situation in Mozambique:**

There is no mining in Mozambique today that is directly affecting National Parks or other nature reserve areas. It is also seldom that mining affects forests that can be regarded as being more or less primary. However, such issues may come into question in the near future when forests in coastal areas and inland may be affected by the large-scale exploitation of heavy mineral sands (see Section 4.2.3 and Review 9).
Artisanal mining is often causing much destruction of the landscape and the vegetation, even if it hardly is justified to talk about the extermination of valuable biotopes or rare species. No rehabilitation is made in such areas by the miners and small efforts in this direction by authorities have been seriously hampered by the fact that miners often return to areas of previous mining for repeated extraction (Review 20).

### 4.2.9. Noise and vibration

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>◦ Effects on human health</td>
<td>• Mine blasting</td>
</tr>
<tr>
<td>◦ Damage to buildings</td>
<td>• The operation of crushers, vehicles and other heavy equipment</td>
</tr>
<tr>
<td>◦ Soil movement</td>
<td></td>
</tr>
</tbody>
</table>

**General background:**

Noise is generated by mining equipment, processing plant haulage vehicles and, intermittently, by blasting. It affects workers as well as surrounding residents. Measures of mitigation include planning (separation of operations from living areas), the construction of acoustic barriers, enclosing high noise sources, and limiting hours of operation.

**Present situation in Mozambique:**

Mozambican mines are usually located in unpopulated areas or at least at some distance from human dwellings. Real large-scale operations with heavy machinery are also still missing. However, the possible development of heavy mineral exploitation will make great demands on wise planning and management to avoid impacts of this kind.

### 4.2.10. Radioactivity

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>◦ Gamma radiation</td>
<td>• Radiation from natural sources</td>
</tr>
<tr>
<td>◦ Uranium as a toxic</td>
<td>• Uranium and thorium in ores being exploited</td>
</tr>
</tbody>
</table>

**General background:**

Natural gamma radiation ("radioactivity") from bedrock and soils depend on the contents of uranium (U), thorium (Th) and one of the isotopes of potassium (K$^{40}$). Radiation in areas of elevated radioactivity may reach 10 times the general background or more, a situation that is not uncommon in some countries. Such anomalies depend on an increased content of U or Th (often both) in the local bedrock or in beach sand, occurring in special minerals and rock types.

The typical natural gamma radiation, measured in the unit µSv/h, is for common rocks <0.1; special granites 0.2-0.3; phosphates 2; and carbonatites and heavy mineral sands 2-25.

High gamma radiation associated with natural waters (usually springs or wells) is usually due to high contents of radon gas, a natural decay product of uranium that has been concentrated by ground processes. Such radon-containing water should not be drunk, but escapes to the air if the
water is stirred. Irrespective of the radioactivity, increased concentrations of uranium in natural waters is a health concern due to its chemical effect, and the WHO has issued a guideline value of 2 µg/L for drinking water.

**Present situation in Mozambique:**
The heavy mineral sand deposits in Mozambique (like similar deposits in other countries) exhibit a high gamma radiation originating from thorium (mainly) and uranium in the mineral monazite. This monazite will have to be separated from the concentrate during the treatment of the sand as it is an unwanted ingredient in the product. This is relatively simple due to its low magnetic properties. The monazite will then be returned to the pit from where it came together with the remaining sand.

Mozambique adheres to the rules regarding radioactivity established by the National Nuclear Regulator in South Africa. These rules accept dilution during deposition of waste as a means of limiting radiation. However, it also requires that workers that will be exposed to elevated radiation be registered for regular health control.

Thorium and gamma radiation is also often associated with carbonatitic phosphates and tantalum mineralizations in Mozambique.

**4.2.11. Environmental emergencies**

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>◊ Catastrophic failures of tailings dams</td>
<td>▪ Deficient design or management of tailings or other waste disposal structures</td>
</tr>
<tr>
<td>◊ Collapse of underground workings and their consequences at the surface</td>
<td>▪ The use of unsafe exploitation methods</td>
</tr>
<tr>
<td>◊ Accidental spillage of toxic substances</td>
<td>▪ Poor facilities for storage and transport of toxics</td>
</tr>
</tbody>
</table>

**General background:**
Tailings dam failures are usually considered as the main risk of an accident in conventional mining. One or two major dam failures at mines are usually reported every year in the world. Such dams are sometimes very high (up to 100 m) and may contain millions of tons of tailings slurry that moves as a heavy liquid if the containing wall is broken. Some of these accidents have caused deaths of humans and serious impacts on agricultural land, fishes in rivers and valuable nature reserves. Dam stability control (a quite intricate specialty) is therefore nowadays taken very seriously in most countries, both by authorities and the mining companies. Design of new tailings impoundments will have to be carried out by specialists within this field. There is also a rich literature on the matter. Simple rules of thumb are:

- To avoid placing a dam upstream from human settlements
- To locate the dam in such a way that water from the natural drainage will not enter (and possibly fill up) the impoundment
- To design and construct the dam according to the rules of engineering design
- To incorporate an adequate spillway in the dam for emergency discharges without risking the integrity of the dam structure
- To monitor the dam regularly and not permit a fill-up that does not leave a free board of at least 1 m
- To keep the water pond, that constitutes an integral part of the dam, as small as possible and located as far away as possible from the actual dam wall
- To vegetate the dam wall for erosion control
- To arrange for adequate security and protection of the installations against sabotage and other damage

Other hazardous situations in mining concern workers’ accidents while extracting ore:
- Workers hit by falling rocks at steep walls or underground
- Collapse of mine galleries (particularly common in artisanal mining in loose sediments)
- Gas explosions in coal mines

Furthermore, emergencies can be associated with the accidental discharge of toxic chemicals to the surroundings of a mine. Cyanide discharges from gold mine operations are not totally uncommon and may cause lethal effects among humans and animals. Fortunately, the cyanide ion disintegrates naturally already after a short period (usually a matter of hours).

In the absence of major dams and associated potential risks, artisanal mining gives rise to problems due to the construction of numerous pits and waterlogged areas. This represents a risk for people in such areas (not least children) as well as animals, as openings may serve as traps and cause fall accidents. Stagnant water also supports malaria.

From the viewpoint of workers’ health and safety, blasting using explosives and the construction of too steep walls in pits are the main hazards met with. Well run companies fence their industrial areas and are keeping guards against intrusion, which is seldom or never the case in artisanal mining.

**Present situation in Mozambique:**

Even if primitive tailings dams have existed previously, the construction of a proper impoundment at the MarropINO mine would count as a break-through for environmental concern in Mozambican mining (see Section 4.2.4 and Review 11). It is to be expected that this tailings dam can serve as a model also regarding dam safety, that is in the design of the structure as well as in the actual management of the facility.

Compared to the situation in many other countries, the artisanal mining in Mozambique has a low degree of technical development and more seldom includes deep underground extraction of ore. In spite of this, there are many instances of dangerous work in steep slopes and relatively deep pits. The main victims of this risk-taking is of course the miners themselves, but worked-out areas left with numerous open trenches and pits may represent hazards also to non-miners, children or animal life.
4.2.12. Issues common to industrial establishments in general

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil and fuel spillages</td>
<td>• Vehicle servicing</td>
</tr>
<tr>
<td>PCB</td>
<td>• Leaking transformers</td>
</tr>
<tr>
<td>CFC</td>
<td>• Leakages from refrigeration plants and air-conditioning</td>
</tr>
<tr>
<td>Spread of scrap</td>
<td>• Deficient materials handling</td>
</tr>
<tr>
<td>Uncontrolled spread of sewage</td>
<td></td>
</tr>
</tbody>
</table>

General background:
These are pollution aspects that are common to most other industrial activities. The main concern is related to the movement of vehicles and the potential damage from spills of oil or gasoline.

Present situation in Mozambique:
The practice within the mining sector regarding these general issues reflects well the tolerant general attitude (and lack of resources) in the Mozambican society as a whole. However, the influence from major foreign investors with a higher standard in these questions promises to have a positive effect on the whole sector.

4.2.13. Occupational health and safety (OHS)

<table>
<thead>
<tr>
<th>Potential problem</th>
<th>Source or reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intoxication by inhalation (cyanide, mercury, other toxic material)</td>
<td>• Fugitive emissions within the plant</td>
</tr>
<tr>
<td>Intoxication by polluted water</td>
<td>• Handling of chemicals, residues and products</td>
</tr>
<tr>
<td>Silicosis</td>
<td>• Explosives handling</td>
</tr>
<tr>
<td>Gamma radiation and radon</td>
<td>• Lack of adequate equipment, sound routines and satisfactory safety control</td>
</tr>
<tr>
<td>Exposure to heat, noise, vibration</td>
<td>• Unsanitary living conditions</td>
</tr>
<tr>
<td>Physical injuries due to accidents</td>
<td>• Social upheaval</td>
</tr>
<tr>
<td>Spread of HIV/AIDS</td>
<td>•</td>
</tr>
</tbody>
</table>

General background:
Occupational health and safety encompass such issues as the exposition of workers to toxic chemicals and materials; dust and fugitive emissions within a plant; heat, noise and vibration; and unsafe work practices and conditions. In this context it is important to make a distinction between occupational health and safety (internal or workplace environment) and environmental issues (the so called external environment). These are two separate conceptions that, in spite of a certain kinship and overlap, relate to two different problem areas. Thus, occupational health and safety constitutes the area of workplace environment as opposed to the external environment that concerns public areas and the nature as a whole. Furthermore, occupational health and safety are labour rather than environmental issues; as such, they basically concern the relationship between the employer and the employees, while the external environmental questions concern the relationship between companies and the world around. Therefore, different legislation govern the area of workplace environment and the external environment, and different authorities are responsible for supervision.
Hence, the management of occupational health and safety is different from that of managing the external environment and the two fields require different types of expertise. There are overlaps, however, and industry has often chosen to co-ordinate closely between these two sectors of responsibility.

**Present situation in Mozambique:**

Generally speaking, health and safety questions have a low standing in Mozambican mining. Hearing protectors, dust masks, and hard hats are only sometimes used and, if used in a workplace, often only by part of the work force. This lack of awareness and discipline, which in fact should be the responsibility of the employer to enforce, was in one of the bigger mines brushed aside with the explanation that the workers only were temporary labour. In one of the granite quarries visited, dry drilling was employed, the workers wearing no or inadequate dust masks, with the inherent serious risk for them to contract silicosis. In the same quarry a worker had been hit fatally by a falling granite block the week before. It appears that much of immediate improvement can be achieved within this field even with limited resources. Thus, inspections, training and the conduct of awareness programmes should be carried out.

If the recognition of OHS must be said to be poor in the mechanised mining, artisanal mining is characterized by the nearly complete lack of such awareness. It is certain that this is partly due to a lack of resources, but even in this case awareness campaigns should serve in attaining quite some improvements. A very particular issue is the use of mercury at amalgamation and the inherent risk for inhalation of toxic fumes from this metal.

Cyanide has not yet come to use in Mozambican artisanal gold mining. However, such attempts at the Monarch mine site (Review 2) indicate that such methods may also come to be used here, and not necessarily under very controlled conditions; authorities should prepare themselves for this eventuality. As indicated in Section 4.2.10, the requirement for expertise within the field of radioactivity represents a new task for DNM with a direct bearing on OHS questions. This need will have to be satisfied by means of training and study visits, with subsequent transfer of knowledge to provincial authorities and to such companies that do not have their own expertise in this field.

**4.3. Summary of environmental issues**

The Mozambican mining sector shows a number of different environmental problems that should be confronted. However, in comparison with many other countries, the problems are modest in magnitude and should be possible to master. Thus, the number and extent of environmental liabilities from former activities are limited and the degree of pollution from ongoing operations is moderate. Even within the area of artisanal mining, where the impact on topography, the spread of mercury (in certain areas) and problematic social implications are reasons for concern, are the problems less extensive than in many other countries where corresponding activities are taking place. This not totally alarming situation is, however, not the result of any superior public environmental supervision, but rather reflects the inoffensive character of most deposits being exploited (for example, no present mining of sulphide ores) and the small scale of the operations.
5. Socio-economic conditions within the mining sector

5.1. Socio-economic issues within the formal (mechanized) mining sector

The weak world market for ores and metals during the last two decades, as well as the civil war, have affected Mozambican mining in a very negative way and there are only a handful of proper mining companies presently active. Consequently, employment within the mechanized mining industry is down to about 500 job positions. To this come 200-400 persons employed in stone quarries and sand winning activities. The largest of the presently active mining enterprises is the coal mine of Chipanga in the Tete province with its work force of 190 employees.

5.1.1. Employment conditions in the active mining companies

The social conditions related to workers within the formal, mechanised mining sector, are on the whole very similar to the conditions in other industrial undertakings in Mozambique. In broad outline, the sector shares the characteristics and deficiencies of other rural enterprise. This is due to the marginal profitability of many of these mining and quarrying activities, and the grave general unemployment situation that puts little value on labour. This means, in a nutshell, low salaries, low security of employment and work safety conditions that are of a mediocre or poor standard. Particularly regarding the questions of occupational health of safety, there is ample room for improvements (Section 4.2.13).

However, the survival of these mining operations, although relatively small in size, is important not only for the employment they after all provide, but also as a preservation of mining skill that may be needed in the course of revival of the mining industry. A particular case is the coal mining industry at Moatize (province of Tete) that before the war (which brought a standstill to the mines and the railway for export of the product) used to employ several thousands of people. The present small Chipanga coal mine, the only one presently active within this coal field, is of great value as a means of maintaining skills and mining traditions in wait of the foreseen resumption of larger scale operations (Review 6).

A very special organisational setup in Mozambican mining is presented by some of the companies extracting precious stones. These companies invite individual miners to exploit for stones within their concession against their service in return of selling what they find to the company. Consequently, the activity is artisanal in character, but occurs within the lease of a company, and the income of the worker does only depend on what he finds and what the company is willing to pay. From the point of view of the worker, the positive part of this deal is that land for mining is granted and that there is a purchaser immediately available, the negative part is that he is totally in the hands of the company and its valuation of the finds (Review 22 and Section 5.2.2).

Partly due to the present low activity within the formal mining sector, the matter of land conflicts and compensation is for the time being not a very major issue. Principles of fairness and good
practice are generally applied to compensation and resettlement issues, as was done recently during the planning for the MOZAL smelter near Maputo. However, legislation or governmental guidelines should be elaborated in order to provide more definite rules for compensation and avoid any possible arbitrariness (Section 3.2.4).

5.1.2. Outlook for the future

It is generally expected that Mozambique will experience during the next few years the opening up of one or more large mining ventures, mainly within the sub-sector of titanium in heavy sand. This would bring in international mining companies, which from their home countries (or world-wide activities) are committed to high standards in social, economic and environmental matters. In fact, several of these companies have been carrying out extensive field investigations within their respective concession areas, employing such higher standards. It is expected that these new mining ventures will provide Mozambique with tax/royalty income, job opportunities, as well as labour conditions that will constitute a considerable improvement in relation to the poor principles that used to prevail (and still are dominating) in the country.

5.2. Socio-economic issues within the informal (artisanal) sector

The informal (artisanal) mining sector constitutes a different and very particular socio-economic domain. The following account will concentrate on describing and analysing the socio-economic issues related to such activities. The presentation is based on findings during field visits, which are documented in the Reviews of Annex 5, mainly under the headline “Socio-economic impact”. It also draws heavily on the two Artisanal Mining Baseline Surveys carried out within the framework of the World Bank support in 2000 and 2003, respectively.

In order to systematize the discussion we will subdivide the subject into three different issues, namely (i) the deposits and their exploitation, (ii) the work force and its organisation, and (iii) social and socio-economic factors.
5.2.1. The deposits and their exploitation

<table>
<thead>
<tr>
<th>Main issues</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>◇ Location of deposits</td>
<td>• Central and northern part of the country, scattered distribution of deposits</td>
</tr>
<tr>
<td>◇ Metals and minerals being exploited</td>
<td>• Gold, semi-precious stones, tantalite</td>
</tr>
<tr>
<td>◇ Main type of deposits</td>
<td>• Alluvial deposits, hard rock, (mining waste)</td>
</tr>
<tr>
<td>◇ Exploitation: Ore extraction</td>
<td>• Manual digging in pits</td>
</tr>
<tr>
<td>◇ Ore processing</td>
<td>• Milling, panning, sluice-boxes, hand picking</td>
</tr>
<tr>
<td>◇ Process chemicals</td>
<td>• Little concern apart from mercury, (cyanide) in some areas</td>
</tr>
</tbody>
</table>

A main part of Mozambican mining consists of activities with very simple equipment and which are carried out on a very small scale; thus, it deals with artisanal mining in the full sense of the word. The great majority of these activities are found in the five provinces of Manica, Tete, Nampula, Zambézia and Niassa, that is in the central and northern part of the country. More recently, some activities of this kind have also started up in the province of Cabo Delgado, in the very northeast of the country. The actual locations of the deposits are within certain regions of these provinces, but occur, within these regions, in a rather scattered manner. Each deposit is usually small or medium-sized.

Table 4. Data regarding the number of miners being engaged and the commodities being mined. Estimation based on interviews with MIREME officers and the environmental reviews being carried out.

<table>
<thead>
<tr>
<th>Province</th>
<th>Nos. of miners</th>
<th>Main production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Gold</td>
</tr>
<tr>
<td>Manica</td>
<td>2,000-6,000</td>
<td>3</td>
</tr>
<tr>
<td>Tete</td>
<td>1,000-3,000</td>
<td>3</td>
</tr>
<tr>
<td>Nampula</td>
<td>2,000-6,000</td>
<td>3</td>
</tr>
<tr>
<td>Niassa</td>
<td>5,000-1,0000</td>
<td>3</td>
</tr>
<tr>
<td>Zambézia</td>
<td>500-3,000</td>
<td>3</td>
</tr>
<tr>
<td>Cabo Delgado</td>
<td>100-300</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>10,600-28,300</td>
<td>3</td>
</tr>
</tbody>
</table>

Gold is by far the most important commodity being exploited. Furthermore, in the pegmatite areas of Nampula, Zambézia and Cabo Delgado, semi-precious stones (mainly aquamarines and tourmalines), and tantalite are mined. (Table 4). The deposits being exploited are either alluvial deposits in river/stream beds or workings in the loose, weathered (or partly weathered) upper part
of hard rock deposits. This goes for gold as well as the semi-precious stones, while tantalite is recovered mainly from weathered rock or loose overburden.

The extraction of the ore is always with artisanal methods and the use of simple tools like spades, picks and, occasionally, wheelbarrows. Explosives are never used, nor any mechanized equipment. In fact, it seems that most of the mineralizations that are worked are not sufficiently good to support the investment in more mechanised mining. The arrangement for a caterpillar in order to open up a larger pit at the Munhena mine in the Manica province (Review 13) is an exception to this rule. Workings are never very deep and usually are the pits (usually vertical as the topography is generally flat) not more than 1-2 m deep, seldom reaching 4 m. Horizontal galleries from pit bottoms, which is a common practice in many other countries, are rarely seen. Alluvial gold deposits are often seen to be reworked several times with successively less return and finer gold.

The principal method for gold processing is panning, usually using a locally made wooden pan. Sluice-boxes of varying sophistication (but usually primitive) are also in use. Small ball mills were observed at least at one mine (Review 13). Precious stones are usually recovered by sieving and hand-picking.

Mercury is often used for the amalgamation of gold from the concentrates that have been obtained through panning. It is then driven off by heating to the air. Such procedures are common in the provinces of Manica, Niassa and in Tete (in the frontier area) where the influence of foreign miners is strong and mercury easily available. In Zambézia and certain parts of Tete no mercury is being used. Amalgamation is usually carried out individually and daily, and, consequently, in very small lots in order for the miner to be able to cover his daily need for food and other necessities. Retorts (for the retention of mercury) are not being used and most miners do not even know that such tools exist. The first intention for use of cyanide in leaching for gold in an artisanal manner was seen at the Monarch mine (Review 1). Such methods are often used in other countries, including in Zimbabwe.
5.2.2. The work force and its organisation

<table>
<thead>
<tr>
<th>Main issues</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>◦ Employment rate</td>
<td>• Generally: 30 %. In mining: 10,000-28,000 individuals</td>
</tr>
<tr>
<td>◦ Origin of work force</td>
<td>• Locals, outsiders, foreigners in frontier areas</td>
</tr>
<tr>
<td>◦ Composition of the work force</td>
<td>• Young men (all steps), women (and children) in transport, ore processing and support</td>
</tr>
<tr>
<td>◦ Gender</td>
<td>• Former company miners; most are unskilled</td>
</tr>
<tr>
<td>◦ Professional skill</td>
<td>• Groups of 5-6 persons (family members, friends)</td>
</tr>
<tr>
<td>◦ Organisation</td>
<td>• Central government, provincial government, village secretaries, traditional authorities</td>
</tr>
<tr>
<td>◦ Authority structure</td>
<td>• Few conflicts; often mutual business dependence</td>
</tr>
<tr>
<td>◦ Relation to mining companies</td>
<td></td>
</tr>
</tbody>
</table>

An estimate of the number of miners being active during the last few years within the artisanal sector results in between 10,000 and 28,000 miners, depending on the time of the year, as well as the temporary access to good deposits (Table 4). There are very few formal job opportunities available in these parts of Mozambique. This is a result of the overall unfavourable economic development in rural areas which, in turn, is related to the steady demise of important agricultural activities; locally it is also related to the closure of some larger-scale mines that used to exist.

The Mozambican miners are generally young men, mostly aged between 20 and 35, that come from local communities. Women (and children) are also involved, mainly in transporting, panning and supporting activities. Some women bring their children to help on some of the mining activities. These children may also take care of their younger brothers/sisters. The local miners are subsistence farmers who during one part of the year, usually in the dry, non-agricultural season (5-7 months) are exploiting minerals. Accordingly, this mining is complementary to the farming and could be called subsistence mining. This work force of local people usually dominates, but often there is also an inflow of people from other regions.

In Niassa a special situation prevails in that a great majority of the miners are illegal immigrants. During a gold rush 1990-1994, about 30,000 people entered Mozambique from Tanzania. They were driven out by the use of the military in 1993-94 only to be returning, but in lower numbers, from 1995 and onwards. Many of these miners have formed families in Mozambique and settled permanently. In the same manner have many persons entered from Zambia and Malawi for the exploitation of deposits located in the NW part of the Tete province.

The mining is being performed in loosely structured groups of up to six miners. The members of such groups comprise mostly family members, relatives and friends. In some areas, DPREME has attempted to organize miners in groups of 20 and to legalise the activities, but without much success.

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9 Based on consultation with G. Valoi of the DNM.
Some of the older miners of the communities used to work in mining companies that existed in former years, and have received some sort of training. However, in general, most of the miners have little or no formal training.

As a direct result of the remoteness of most mining activities, the prevailing authority structure may differ significantly from what is the norm in other, less remote, parts of the country. In general terms, the authority structure rests within four main nodes of power, namely; (i) Central government; (ii) Provincial government; (iii) Village based authorities (so called “Village secretaries” introduced by the governmental authorities); and (iv) Traditional and religious authorities. The importance of each of these authorities differs from area to area, with the traditional and religious authorities having greater importance in the more remote regions.

The two baseline surveys that have been performed indicate that the role of the traditional and religious authorities in controlling mining activities is strong. These traditional leaders are often involved in the demarcation of mining plots as well as the collection of “tributes” or “gifts” (a form of taxation, thus) which, of course, conflicts with the state’s role as a facilitator and controller of mining activities.

Exploration work by mining companies has not given positive results regarding gold deposits for commercial exploitation. For this reason there are presently no conflicts between the formal and the informal sectors. Regarding tantalite, there have been such controversies previously, but presently the mining companies are buying the produce of the artisanal miners. One company even actively visits them and buys on spot (Review 12). Regarding semi-precious stones, some producers rely totally on the production of the artisanal miners, who are invited to exploit the company’s concession area (Section 5.1.1 and Review 22).

5.2.3. Socio-economic factors

<table>
<thead>
<tr>
<th>Main issues</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>◊ Living quarters</td>
<td>• Traditional villages, mining camps</td>
</tr>
<tr>
<td>◊ Living standard</td>
<td>• Lack of most infrastructure</td>
</tr>
<tr>
<td>◊ Safety in work</td>
<td>• Poor, but the risks are modest</td>
</tr>
<tr>
<td>◊ Sanitation</td>
<td>• No latrines. Lack of clean water especially in</td>
</tr>
<tr>
<td></td>
<td>camps</td>
</tr>
<tr>
<td>◊ Health</td>
<td>• Lack of hospitals; miners resort to healers</td>
</tr>
<tr>
<td>◊ Education</td>
<td>• High illiteracy: 70-80%. Absenteeism from schools</td>
</tr>
<tr>
<td></td>
<td>is extensive</td>
</tr>
<tr>
<td>◊ Revenue from gold mining</td>
<td>• About 33 g Au per year at a value of 198 $</td>
</tr>
</tbody>
</table>

Mining activities in Mozambique date some centuries back, and as a result a number of mining communities have been established for certain periods. However, with time most of these
communities moved to other places, whether due to the civil war or simply because new sites were discovered. As a result two types of mining communities have emerged: (i) village type settlements where miners live in existing rural settlement; and (ii) mining camps, which are more transient in nature.

The village style appears to be the more common type of settlement. These are villages that usually have existed for long periods and whose origins are not necessarily coupled to the nearby existence of exploitable minerals. The miners are then villagers that for a certain time of the year (mainly during the dry season) are active miners whereas during the remainder of the year they may be involved in other activities, most commonly in farming activities. The villages are permanent settlements with families that may have lived there for several generations. The village-type of settlements has the advantage of having more space, and thus provides a greater opportunity for ensuring survival through agriculture.

The mining camps are at best semi-permanent and they owe their very existence to the presence of exploitable minerals. The inhabitants are mostly miners (e.g. mostly young men), that originate from distant communities, provinces or even neighbouring countries. These miners may be highly mobile, moving from one site to another as new finds are reported. The houses in these camps are usually primitive shacks that are not built to last, and these types of camps may appear and disappear within a few years only. However, if the mineral deposits that are exploited are sufficiently large, these types of camps may gradually take on more permanent characteristics, as has happened nearby some gold deposits in Manica, Tete and Niassa.

Most of the Mozambican mining areas are situated in remote, inaccessible and what are, even at modest Mozambican standards, poorly developed areas. This fact has important consequences as the miners often have only limited access to many essential services (health services, schools, municipal services). This is especially the case for the miners that live in mining camps, where the inhabitants may be subjected to a wide variety of social risks such as reduced food security and social disintegration (the miners do often not live with their family). Furthermore, residents of mining villages are more prone to contracting diseases. Hospitals and clinics are usually far away and the miner may be happy to have access at least to a traditional healer.

The illiteracy rate in the northern provinces is as high as 70-80% to be compared with 60% for the country as a whole. Schools are sparsely distributed and many children have long way to school. Still most children seem to attend school, for example in the morning, followed by giving assistance to their parents in their work in the afternoon. Teachers, though, complain over the frequent absenteeism.

Just as difficult as it is to estimate the number of artisanal miners is it to estimate their production. However, the common yield is obviously modest, and there is no manifest affluence among the miners. Less often, miners may be seen to have bought bicycles or small radios, but the general impression is that the revenue usually goes to pay for the most essential things like food and clothes. CSA Group (2003) estimate from Zambézia that an average gold miner produces about 33 g of gold per year, which is selling for 198 S. This is about equal to the national per capita per
year, but about the double of the figure from the province in question. If it is taken into account that
most miners only work for six months of the year (the dry season) and during the rest of the year
are doing farming, it is obvious that artisanal mining represents a very valuable contribution to the
family economy.

Using the same annual production figure of 33 g of gold per worker and presuming that there are,
roughly speaking, 20,000 miners\(^{10}\) (Table 4), would mean a total production of 660 kg at a sales
value of more than 4 million $\(^{11}\). This should be compared with an official production in 2001 of 22
kg of gold and a total value of the mineral production in the country of slightly less than 1 million $
(including bauxite, coal, etc). Thus, even if the figures are very uncertain, there is an indication that
the total revenue is considerable (although not extremely high). A great value lies in the fact that
the income is so well distributed, improving the meagre economy of many families. The profit
made by the buyers, probably leaves the country to a large degree. The same is probably true for
the revenue by many of the miners who come from the neighbouring countries. Taxes collected by
the State are minimal; in fact, the trade does not seem to leave much margin for taxation.

5.3. Summary of socio-economic conditions

Mechanized mining in Mozambique employs less than 1,000 individuals at the moment. The
general condition regarding job security as well as occupational health and safety is mediocre or
poor. However, the new major mining ventures that are anticipated are expected to bring about
major improvements by introducing modern principles in social, socio-economic and
environmental management. Such an import of modern international standards is expected to
constitute an important step in the establishment of a socio-economically sound mining industry in
the country.

Artisanal mining in Mozambique employs in the magnitude of 20,000 people, who extract gold
and, to a lesser extent, precious stones and tantalite. The work is often carried out by local farmers
(both men, women and sometimes children are taking part), but in border areas mainly by men
from the neighbouring countries of Tanzania and Zambia. The mining is usually carried out in
groups of 5-6 family members or friends, and it often occurs only during the non-farming dry
season.

The main environmental concerns are related to the use of mercury for amalgamation, which
occurs mainly in areas of foreign influence, and the direct physical impact on the landscape,
including the siltation of rivers.

From a socio-economic point of view, the artisanal mining provides valuable income in areas
where there are virtually no other sources of cash income, often as a complement to farming. A
very approximate estimate indicates that the total annual revenue from these activities is around
4 million $. This means a good contribution to local economies even if few or none of the miners
get anything like rich. A great value lies in the fact that the income is so well distributed, improving

\(^{10}\) the great majority of the artisanal miners are gold panners
\(^{11}\) The local miner is usually paid 188 $/oz.
the meagre economy of many families. It is true that the State does not collect much taxes from this business, but, in fact, the trade does not seem to leave much margin for taxation.

There are presently no conflicts between the formal and the informal mining sectors. A decisive reason for this is probably the character of the deposits, being small and not overly rich. In fact, regarding tantalite and precious stones there is often an intimate cooperation between the formal mining company and the artisanal miner, the latter selling his product to the company.

6. Strategic priorities for the environmental and socio-economic supervision of the mining sector

6.1. Environmental and socio-economic planning

Environmental performance, in a broad sense, consists of three main areas of concern, namely (i) proper environmental questions (the impact on the surrounding nature and its population), (ii) questions of workers’ health & safety (the internal environment), and (iii) general aspects of socio-economic impact in the region where mining occurs.

As we have seen above, the environmental problems in Mozambican mining are locally prominent, but generally manageable; the health & safety questions are much neglected; while the socio-economic subjects are either related to “subsistence artisanal mining” or to the new, anticipated, major exploitations. Regarding artisanal mining, the treatment given here is complemented by more detailed specific baseline studies of this particular sector carried out in 2000 and 2003 (Chapter 8).

The risks for major accidents affecting the general population due to tailings dam failures, spillages of toxic chemicals, etc. are presently quite low owing to the small size of the operations and their use mainly of gravimetric methods for mineral beneficiation. This situation may change in the near future with the start-up of large-scale operations, but will have to be managed within the framework of companies’ EIA studies and management plans.

In spite of this our subdivision into subject matters, the environmental and socio-economic issues within industrial mining undertakings are always closely interrelated. The consequence of this close interrelation is that the various issues have to be managed in an integrated manner, both within each separate company and when it comes to governmental supervision. Thus, planning of the governmental supervision should be well integrated and as much as possible carried out within one and the same unit within the MIREME (DNM) and with closest possible cooperation with MICOA. In line with this, we favour the establishment of a competent and multidisciplinary staff within DNM that develops an integrated action plan regarding the external environment, socio-economic aspects as well as health & safety questions, with the view of developing regulations/guidelines, environmental instruments, profound technical/scientific knowledge and supervision.
In conclusion, it is not practical to have fixed, separate plans for environmental management and the management of social issues; they should be managed in a highly integrated manner. Moreover, such integrated plans should be dynamic plans including all of the various tasks that are assigned to the supervising agencies. Development of plans and work agendas should go hand in hand with the building of capacity within the agencies as described below.

6.2. Definition of actions to be taken and future studies to be carried out

6.2.1. General approach for the development of environmental capacity

The present control and guidance in environmental matters performed by MICOA, MIREME, and the Provincial Directorates (DPREMEs) are weak. This will now be attended to with the creation of a Department of Environment within the DNM. The building of capacity within this new unit must be seen as the overall most important task for environmental progress in the sector. The strengthening should be an integrated effort in which also the DPREMEs are included and where the ambition should be to convey the skill and knowledge as efficiently as possible also to miners, MICOA staff and other stakeholders.

Simply speaking, public environmental management consists of two branches, one administrative/legal for permitting purposes and one technical/scientific for the fundamental understanding of the environmental issues. The upcoming Project on Environmental Management and Information System (EMIS) will support the development of capacity regarding the first-mentioned by analysing the questions of permitting responsibilities and procedures, as well as designing a management and information system (a tool for the handling of present and new information). However, the very extensive field of technical/scientific matters remains to be developed and it is suggested that considerable support will go into this topic. In defining such a programme it should be realised that specific support has been proposed for the artisanal mining sector in a report for DNM and the World Bank with the title “Artisanal Mining in Mozambique: Second Baseline Survey Report”; Swedish Geological-IMPACTO has been instructed by DNM not to duplicate this proposal.

6.2.2. Strategy for the raising of capacity

The guiding principles for a support to the DNM in environmental matters should be the following:

- **Long-term support:** The support should be for an extended period, that is at least for 2-3 years. This is in appreciation of the fact that the field of environment is both extensive and complex, requiring considerable knowledge and skill in specific topics as well as interdisciplinary thinking.

- **Focus on products:** Training and capacity-building should aim at the raising of knowledge and capacity by means of the elaboration of well-defined products as audit reports, guidelines, maps, handling instructions, etc.
• **Genuine participation by DNM professionals:** The support from external consultants should be conducted in such a manner that the local staff becomes well involved in all steps of the work, including the preparation of the final product.

• **Progressive spread of skill:** After a first period of knowledge build-up within the Department of Environment at DNM, focus should be on the strengthening of the Provincial Directorates. It is thought realistic to include during the project period four provinces in the work: the provinces of Manica and Zambezia in a first effort and the provinces of Tete and Nampula as a second stage.

• **Emphasis on field work:** After an introductory period for building capacity through work in the office, a considerable part of the remaining time should be spent in the field for the study and investigation of real conditions.

• **Cost coverage:** The project should provide for all the needs for the carrying out of the work, including the necessary instruments, laboratory costs, transport and allowances.

### 6.2.3. Objectives and organisation

To begin with, the objectives of the suggested support project will be to primarily develop capacity within the Department of Environment of DNM. An external consultant should be engaged to define, mentor, and supervise the training activities, as well as to ensure the technical/scientific quality of the undertaking. This consultant should establish plans for training and development work; provide training material, relevant literature, and arrange for contacts with international scientists; supervise the carrying out of training exercises (which preferably should deal with existing problems in the environmental management of the sector); define long-term monitoring activities for the establishment of baseline data and supervise their execution; supervise the implementation of a management and information system based on the products and proposals provided by the EMIS project; and assist in establishing rational work routines regarding the environmental permitting and control.

As soon as a certain level of competence has been reached within the Department of Environment of DNM, the knowledge acquired will be transferred to the DPREMEs according to special training plans to be set up. Such activities require that technical/scientific guidelines have been elaborated, pictorial power-point presentations have been developed, instrument manuals are available, and that certain field instruments have been procured. Nonetheless, the involvement of the DPREMEs should come as early as it is meaningful and practically possible. The external consultant should supervise also the activities within the provincial authorities, even if the main teaching will be done by the staff from the Department of Environment within DNM. In spite of being given this training task, the continued raising of capacity within the DNM will run in parallel with the efforts within the provinces. Regarding field surveys, all work should be carried out in close cooperation between the DNM staff and the respective DPREME.
6.2.4. **Main environmental issues to be treated**

Much of the building of capacity should be through the execution of a number of work tasks, each of them leading to its particular product. The detailed choice of sites and topics to be covered will be made in consultation between the consultant, the DNM and the relevant DPREMEs. The following fields should be covered:

1. The execution of environmental audits at former mining sites. Suggested targets for these investigations are the Mundonguara copper mine, the Mavita asbestos mine, and the coal mines in Moatize.

2. The monitoring of baseline conditions within existing mining areas with emphasis on surface water quality and the flora/fauna

3. The carrying out of baseline studies in regions where future mining is expected to take place or in areas of ecological sensitivity. It is suggested, for example, to study groundwater conditions as well as the vegetation characteristics of coastal areas hosting deposits of titanium-rich heavy mineral sands.

4. The spread and the properties of mercury when released to nature, and the potential impact on flora/fauna (including fish) and human health.

5. The elaboration of technical/scientific documents in different topics related to the environmental management within the mining sector. Such topics could include, for example, (i) natural surface waters and their physico-chemical properties; (ii) rehabilitation methods and procedures in mining areas; (iii) toxic metals release from ores in association with mining enterprises; (iv) environmental issues related to the exploitation of heavy mineral sands; (v) naturally radioactive materials, their impact on humans, the handling of such material, and related international regulations.

6. The development of systems and efficient procedures for the evaluation of Environmental Impact Assessments and related technical/administrative instruments (environmental management plans, closure plans, monitoring plans).

7. Overview of principles and procedures for the consultation of stakeholders and the general public in association with new mineral ventures.

8. The addressing of such socio-economic factors as resettlement and compensation in cases involving land acquisition for mining purposes.


10. The possible financial framework for revenue sharing with local communities.
11. The development of guidelines for occupational health and safety matters at mining sites. This task should be effectuated in close cooperation with the Department of Mine Safety within the DNM.

12. The purchase of field instruments for physico-chemical measurements on natural waters, and the elaboration of guidelines for their use.

13. The evaluation of suitable local laboratories for mining environmental work and the establishment of close cooperation, including the appraisal of analytical accuracy.

The Terms of Reference for the execution of a project based on this proposal is attached as Annex 6.

7. Consultation and participatory procedures

A number of consultations related to major new mining developments have already been carried out. They have been conducted by MICOA and directed to the local authorities, the population of the sites in question and NGOs. MIREME has also participated in these meetings. The consultations and the participatory procedures employed in the development of the major Mozal smelter seem to have served as models for later efforts within this field. Regarding the few smaller mining projects that have started up in recent times, the requirements for consultation seems to have been dealt with in a less formal manner.

The subject of consultation and participation is one of several issues in which there are no clear subdivision regarding obligations and functions between MIREME and MICOA. It should therefore be included in the tasks of the consultant that will be chosen for the execution of the Project for Environmental Management and Information System (EMIS), within which the respective tasks and responsibilities of MIREME and MICOA will be considered. Furthermore, the definition for the mining sector of the detailed content of the Environmental Impact Assessment process, within the framework of which consultation and participation should fit, will be included as a task of the consultant chosen for the implementation of the EMIS project.

8. References


CSA Group and MEPC, 2003: Artisanal mining baseline survey, Mozambique-II. MIREME-DNM.