BAUXITE MINING IN BRAZIL
DIFFERENT VIEWPOINTS CONCERNING ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

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ABSTRACT

Like surface mining in general bauxite mining always leads to a temporary degradation of environment. Therefore several individual persons and stakeholder groups involved in the business environment of bauxite mining and alumina and aluminum production have given a statement from their points of view.

This paper deals with some basics associated with bauxite deposits and mines in Brazil as well as mining technology and the environment of the deposits. Furthermore effects of bauxite mining are taken in consideration and different viewpoints towards environment, society and Sustainable Development are compared and discussed.

INTRODUCTION

In 1997 the Collaborative Research Center (CRC) 525 firming the title "Resource-Orientated Analysis of Metallic Raw Material Flows" and the subtitle "Development and Application of Methods" was established at the Aachen University of Technology, Germany. The CRC 525 is funded by the Deutsche Forschungsgemeinschaft (DFG), the central public funding organization for academic research in Germany. The long-term goal of the research program is the identification of options for resource-sensitive supplying and processing of metallic raw materials in the area of conflict of technical developments and economic, ecological and also socioeconomic aims. An integrated resource management system for important metallic raw materials is to be designed and tested by the CRC 525 regarding the applicability of this framework in order to provide useful and efficient decision tools. The first phase of the research program (1997 – 1999) was focused on aluminum and aluminum alloys. For the second phase of the research program (2000 – 2002) copper was selected as complementary metal to be examined within the resource-orientated analysis of metallic raw materials. The Institute of Mining Engineering I is involved in the CRC 525 as contractor for studies on extraction of raw materials and waste disposal.

The main raw material for the production of primary aluminum is bauxite. In 1998 aluminum smelters produced 22.1 Mt of primary aluminum worldwide. Therefore, about 104 Mt of bauxite – 85% of the total world bauxite production – were digested to produce alumina (Al₂O₃) which is reduced to aluminum in smelters.

Brazil is an important producer of aluminum accounting for 5.4% of the world primary aluminum production in 1998. In terms of bauxite production the Brazilian share of the world production amounts to 9.6%. Brazil was the fourth largest producer and exporter of bauxite [Punkert-1999, USGS-2000].

BAUXITE IN BRAZIL

There are several major bauxite districts in Brazil containing more than 25 bauxite deposits and projects of which eight are currently mined. Brazilian bauxite is classified as lateritic bauxite which represents the majority of worldwide known deposits. It occurs in shallow seams of 2.5 m to 6 m thickness in average. Figure 1 gives an overview of the distribution of the deposits.

The most important producer of metallurgical grade bauxite is Mineração Rio do Norte S.A. (MRN), mining in the Trombetas region. Other producers of metallurgical grade bauxite are Alcoa Alumínio S.A., Companhia Brasileira de Alumínio (CBA), Alcan Alumínio do Brasil S.A. and Mineração Curimbatá, exploiting bauxite deposits in Poços de Caldas region, Ouro Preto region and Cataguases region. Furthermore two companies – Companhia Brasileira de Bauxita and Mineração Santa Lucrecia (MSL) Minerais S.A. – are mining non-metallurgical grade bauxite at the Rio Jari
area and near the Camoa River about 250 km south of Belém.

In 1998, total Brazilian bauxite production amounted to 11.96 Mt including about 0.53 Mt of non-metallurgical grade bauxite. MRN produced 9.32 Mt or 78.3% of the total metallurgical grade bauxite. The second largest producer was CBA with 1.18 Mt or a share of 9.9% [ABAL-2000, Ferraz-2000].

BAUXITE MINING

Worldwide, all lateritic bauxite mining operations use open pit mining methods. These methods lead to temporary degradation of land due to the necessary removal of vegetation, soil, and overlying strata before mineral extraction. Figure 2 shows an aerial photograph of the Trombetas mine as an example for a huge scale operation.

Depending on mine planning, mining method, and mining equipment the delay between removal of vegetation and start of rehabilitation varies between 1 and 3 years.

The mining method at the Trombetas mine is strip mining. Bulldozers remove vegetation and a thin layer of soil is mined separately for rehabilitation purposes. Afterwards overburden is excavated by draglines and stacked into mined out areas. The bauxite is topped with a lateritic crust which is ripped before backhoes load the bauxite on trucks. Mined out areas are prepared for rehabilitation by bulldozers. Strip mining is the basis for a relatively short period of uncovered surface of one year. Figure 3 shows mining activities at the Trombetas mine.

As the crude bauxite from the Trombetas deposit contains impurities a beneficiation is necessary. About 30% of the raw material is rejected in the washing plant. Thus the amount of raw bauxite extracted from the pit is more than 1.4 times the beneficiated product [MRN-2000].
Cataguases and Poços de Caldas regions. The operations are medium or small scale mines with capacities up to 1 Mt/a. The thickness of bauxite layers in the Cataguases region of the Minas Gerais Forest Zone varies between 0 m and 15 m at an average of 4 m. Subsequent to vegetation removal, soil and unproductive material are deposited aside for use in mine restoration. Bauxite is extracted in a bench system with 3 m high benches and loaded on trucks. As the raw material consists of bauxite and clay, a beneficiation is necessary. The ore recovery after washing is approximately 57%. This means an additional extraction of 75% of raw material compared to the beneficiated product.

In the Poços de Caldas region bauxite with an average thickness of 3 m to 5 m is excavated by backhoes and loaded on conventional dump trucks after vegetation is removed. Topsoil is stored for rehabilitation. The raw material is also washed to produce saleable bauxite [CBA-2000]. Figure 4 shows mining activities at the Três Barras Mine, Poços de Caldas region.

Figure 4: Bauxite mining and loading in the Três Barras Mine [CBA-2000]

ENVIRONMENTAL ASPECTS

Impacts of open pit mining have been discussed in a wide range of studies and are documented in a large body of literature (e.g. [Eggert-1994, Martens-1998, Martens-2000, Sengupta-1993, UNEP-1997]). There is no doubt that all environmental impacts can directly or indirectly be linked to the utilization of land. On the one hand this is due to alteration of land cover, e.g. buildings or infrastructure or mined land instead of vegetation, and can be measured by sealed area or soil erosion etc. On the other hand mining activities can also cause emissions like dust, noise, and vibrations. Mineral extraction can affect all three environmental media - land, water, and air (see figure 5).

Figure 5: Exemplary impacts on environmental media.

Looking at Brazilian bauxite mines, one has to differentiate between the deposits in prior uninfluenced regions in the north of Brazil, e.g. the Trombetas region, and deposits adjacent to urbanized areas, e.g. southeastern Brazil. The Trombetas mine is situated in the humid tropics of the rainforest climate, surrounded with undisturbed rainforest. Thus, any activity causes damage to environment (see figures 2 and 3). The annual demand for land amounts to 170 ha. This area is exposed to erosion by wind and water and does not contribute to any of its former functions. Vegetation and buildings in the surroundings are turned red by bauxite dust. Furthermore contamination of the river system with particles resulting in reduction of fish population is stated in literature [Moser-1996].

To meet impacts on the environment the mine operators in Brazil are obliged by law to a natural restoration. MRN has developed an integrated environmental management system to guarantee minimized effects in accordance with legal issues. Bauxite mines, which are not located in rainforest climates are generally confronted with similar environmental impacts. The more urbanized an area is, the more social and local economic impacts are caused by mineral extraction, e.g. resettlements and providing of jobs. Some environmental impacts like deforestation of areas which have already been affected before by men and rehabilitated after mining are not to be seen as critical as activities in formerly uninfluenced areas.

All bauxite mining companies run rehabilitation departments in order to meet legal conditions. Furthermore most deposits are partly owned by global acting aluminum producers and thus are influenced by their environmental policy. Those two factors and global
The commission on Sustainable Development (CSD) was created to monitor and report on implementation of the Earth Summit agreements. It was agreed that a five year review of Earth Summit progress would be made in 1997 by the United Nations General Assembly meeting in special session. This special session of the UN General Assembly took stock of how well countries, international organizations and sectors of civil society have responded to the challenge of the Earth Summit. Sustainable Development may be explained as "...development that meets the needs of the present without compromising the ability of future generations to meet their own needs ..." [UN-1997].

The consequences for the mineral extracting industry are on the one hand an increased responsibility for environment in order to leave intact ecosystems for future generations. On the other hand, before the background of exhaustible resources and the needs of future generations, mineral deposits have to be exploited in a responsible way. This has to be achieved by improved mining and processing methods.

**VIEWPOINTS CONCERNING ENVIRONMENT AND SUSTAINABLE DEVELOPMENT**

**General**

In the majority of the cases, companies taking care for environment in the context of mineral extraction undertake efforts in avoiding contamination and improvements in rehabilitation. Environment is interpreted to consist of flora and environmental media in the surroundings of a specific location. Other impacts, e.g. on fauna or humans, often remain unmentioned. The concept of Sustainable Development is interpreted as leaving a hopefully self-sustaining area after mine closure.

Roderick G. Eggert – Professor and Director of Division of Economics and Business, Colorado School of Mines (USA) – notes that mining, by its nature, poses major environmental challenges and quotes Georgius Agricola to confirm that environmental impacts of mining have already been noted in the 16th century. After years of over-exploitation of nature, environmental legislation came into force in industrialized countries beginning in the 1960s. Development of a worldwide concern of environment has led to the sustainability discussion. Environmental protection has become an important concern for mineral extracting industry as well as for governments, designing and implementing new environmental policies [Eggert-1994].
James R. Kahn – professor in the Economics Department at the University of Tennessee (USA) – gives a brief history of the sustainability discussion from an economical point of view. He quotes statements about economic growth before the background of scarcity of resources from the 1960s and thoughts about interchangeability between labor (human capital), artificial capital, and extractable natural resources. In his opinion, artificial capital cannot provide an adequate substitution for environmental resources. Sustainable Development, comprising present and future economic, social, and ecological needs, requires an expansion of stocks of artificial capital, human capital, and natural resources. At the same time he demands maintaining stocks of environmental capital which provide ecological services. Therefore he sees environmental policy as important and critical component of economic development [Kahn-2000].

Werner Schenkel and Karl Otto Henseling – working for the German Federal Environmental Agency – present rules for resource utilization. Concerning exhaustible resources they demand not to exceed a level which can be substituted by equivalent renewable or even higher quality ones. Furthermore, material flows into the environment have to be looked at before the background of load-bearing capacity of environmental media. Nature’s ability to react on anthropogenous interventions must not be stressed in terms of time [Schenkel-1998].

In 1996, Werner Gocht – Member of CRC 525 and head of the sub-program “Economics of Resources” – predicted that in the 21st century mining companies have to accept protection and management of resources as essential measures in raw materials extraction [Gocht-1996].

Example of bauxite mining in Brazil

Statements of several scientist, researchers, and stakeholders concerning bauxite mining in Brazil, especially in rainforest climates, can be found in literature. In the following passages, statement from very different points of view might give a general idea of the discussion towards environment and sustainability.

After mentioning facts about the Brazilian aluminum economy, Claudio and Christine Moser – committed to rainforests and environment from a social point of view in dialog with ecclesiastical stakeholder organizations (e.g. the German GKKE) – describe the bauxite mining activities at the Trombetas mine with special emphasis on some negative impacts. Apart from the aforementioned impact on environmental media (contamination of parts of Rio Trombetas with particles), they have a critical opinion about the local community’s dependence on the company and the company’s influence possibilities. Furthermore a conflict in land use between bauxite extraction and utilization by “Quilombolas” – descendants of escaped slaves, living adapted to natural conditions – are described [Moser-1996].

In contrast to Moser, Hans Plaettner – an individual aluminum user doing statistical research on aluminum production – puts more emphasis on the socio-economic use of aluminum production. He handles the topic if aluminum production is responsible for destruction of rainforests. Comparing the damage caused by small indigenous communities, farming land after clearance by burning for a few years, to benefits resulting from bauxite mining, also considering rehabilitation, he concludes that mining is less harmful to environment than some kinds of farming. One item of his statements is the aspect that land used for bauxite mining means more social and economic benefit than the same amount of land used for few years for farming after clearing by burning [Plaettner-2000].

Sliwka and Bauer – researchers and collaborators of CRC 525 – have visited the Trombetas bauxite mine in 1999. They describe mining activities and point out that the discussion of sustainability has several dimensions: economy, ecology, and social aspects. Within the economic dimension both effects on the domestic economy as well as regional and local economical developments have to be considered. Compared to the national importance as major bauxite producing location and therefore important for a whole branch of industry and international trade the local economic effects are rather low. An economic as well as social aspect is creation of job and training of skilled workers. The ecological dimension is composed of degradation of land on the one hand and environmental policy, rehabilitation efforts, and investment into technological improvements which benefit environment on the other hand. As prior to bauxite mining the region was mostly uninhabited, the main social aspect at Trombetas mine is stated as the conflict of mining land use in contrast to former use by “Quilombolas”. Additional to the confrontation with the mining industry they were restricted in their normal way of life by environmental laws. Access, hunting, fishing, and collecting fruit in the surroundings of the mine was forbidden in order to protect the environment and to prevent slums. Meanwhile, access and collecting fruit is tolerated but still illegal. Some development programs which are supported by MRN were established to develop self-sustaining structures. One program is planting seedlings for rehabilitation purposes. In their conclusion, Bauer...
and Sliwka note that MRN identified several problems while operating the mine and started efforts for solutions. In terms of ecology they especially stress success in rehabilitation and reduction of pollution. The social dimension is mentioned in context with improved coexistence with “Quilombolas”. The company’s ability to recognize ecological effects and willingness to take social responsibility, developed while operating the mine is seen very positively.

**DISCUSSION**

The general statements on mining, environment and Sustainable Development clearly express the role of mining – especially open pit mining – as destructive to land cover and landscape. Thus, effective measures to protect the environment have to be taken. This is seen as an important task for minerals extraction industry as well as for legislation. Sustainability in mining has derived from ecological discussions and is more and more expanded to social dimensions. Solutions for negative environmental and social impacts have to be developed creating a balance with economic factors.

The example of Brazilian bauxite mining shows that, comparing the statements, results always depend on the observers point of view. The statements of Moser and Moser on the one hand and Sliwka and Bauer on the other hand show a positive trend towards increasing sustainability within less than one decade. Whilst one viewpoint is more social orientated the other is mainly focussed environment. Government and company have been facing problems and developed effective measures. This confirms the general statements about the linkage of effects arising from mining and developing strategies considering all aspects of development towards sustainability.

Progress in the discussion about sustainability is very much dependent on participation of stakeholders. The growing awareness of people of the world concerning impacts of human actions will force international operating companies and thus their suppliers to detailed environmental reporting. In future this might result in “sustainability reports”.

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