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A Review on Indicators of Sustainability for the Minerals Extraction Industries

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SUMMARY

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Introduction and Synthesis

WORKSHOP AND PARTICIPANTS

The International Mineral Processing Council met in Antalya, Turkey, October 13-14, 2005. The host, Professor Dr. Güven Önal of the Istanbul Technical University is President of the XXIII International Mineral Processing Congress, to be held in Istanbul in September, 2006. This Council meeting was to be the last prior to the Congress and it was decided that a Workshop should coincide with the meeting. Council member, Dr. Roberto Villas Bôas, of CETEM in Brazil and CYTED-XIII agreed to organize the Workshop and recommended that experts in minerals sustainability from various countries be invited to present different perspectives on the topic.

The title chosen for the Workshop was "Indicator of Sustainability for Mineral Extraction Industry: A Review." Authors, co-authors and presenters represented government (Brazil, China, the EU, Slovenia, the USA), academia (China, Germany, Russian, Turkey, the USA) and industry (Australia, Canada, South Africa, Turkey). The Workshop was organized into a series of sessions, each chaired by two eminent scientists in the field of mineral processing, with discussion following each presentation. IMPC Congress Secretaries, Prof. Dr. Ali Güney and Asst. Prof. Dr. A. Ekrem Yüce, handled the myriad of organizational details prior to and during the Workshop.

The Workshop was opened on the morning of October 13 by Dr. Önal, who welcomed the speakers and attendees. Participants were also welcomed by Professor Dr. Eric Forssberg (Sweden), President of the IMPC Council. Prof. Dr Villas Bôas made opening remarks as well, as referred to the purposes and objectives of the Workshop. The first presentation was made by Dr. Sami Demirbilek, Undersecretary, Ministry of Energy and Natural Resources. He expressed the view that the meeting was of timely importance for Turkey, as it prepares to join formal discussions with the European Union. Minerals management in Turkey will be expected to meet EU standards and international norms, including the implementation of sustainability indicators for the extractive sector. Dr. Demirbilek spoke of his country's desire to increase economic development in rural areas, of plans to double energy output by 2020 using Turkey's natural resources, and of the need to strengthen the contribution of non-agricultural sectors to the Turkish economy. He placed his thoughts in the context of the need to embrace sustainable development principles. Each of the issues Dr. Demirbilek raised was discussed and elaborated over the course of the Workshop.

The first technical speaker was Dr. Deborah Shields of the United States Forest Service. Her presentation, titled, "USA and UN Perspectives on Indicators of Sustainability for the Mineral Extraction Industry," provided historical background on how sustainability principles have been extended to minerals, particularly in international fora. She also described the open, collaborative, public/private process being used in the US to develop minerals indicators, i.e., the Sustainable Minerals Roundtable (SMR). She pointed out that while mining has sometimes created problems in the past, with mistakes being made and repeated, mining's contributions to society are both vast and essential. The US position is that managing mining within the principles of sustainability can help ensure that minerals' contribution to society is a net positive. The mineral indicators being developed through the SMR are a tool to track progress toward sustainable resource management. Discussion centered on the challenges of ensuring and responding to public participation in complex processes.

The second session was co-chaired by Prof. Dr. Erdoğan Yüzer and Dr. Selahattin Anaç. The first speaker was Mr. Paul Anciaux of the EU Commission, Enterprise Directorate. His presentation, "Sustainable Development Indicators for the EU Non-energy Extractive Industry," described the 2000 EU Communication on promoting sustainable development in the EU non-energy extractive industries. He identified issues deemed important to the EU, including among others the need: 1) for a secure, less polluting industry, 2) to maintain competitiveness, 3) for access to land for future exploration, and 4) for stakeholder dialogue. Mr. Anciaux discussed the EU Industrial Policy Framework, and then put the EU indicator process in the context of the need to assess the competitiveness of industry, stating that it will be essential to have a competitive industry in order to be sustainable. He also stressed that the EU process had incorporated extensive stakeholder consultation. Subsequent discussion focused on how these policies would be extended to new and proposed EU member states and on the need to convince industry that openness is in their best interests.

The second speaker in this session was Dr. Slavko Šolar, Geological Survey of Slovenia, whose presentation was titled, "Indicator of Sustainability for the Mineral Extraction Industry: case study Slovenia". Dr. Šolar began his presentation with an introduction to minerals sustainability and indicators. He described the characteristics of useful indicators and their basic functions. He then described the process by which a sustainability indicator had been created for the aggregates sector in Slovenia. He stressed, however, that one indicator alone cannot tell the complex story of sustainability, but rather that a suite of indicators is needed that covers the range of economic, social and environmental aspects of the minerals sector.

The first afternoon session on October 13 was co-chaired by Prof. Dr. Heinz Hoberg and Prof. Dr. Mehmet S. Çelik. The session began with a presentation by Prof. Dr. Roberto Villas Bôas, who has developed a theoretical model of minerals, deposits and mining in sustainable development. The model, which is couched in the language of logical symbology and set theory, is a formalization of sustainability principles. This additional rigor will be needed for the field to be credible and accepted by the broader scientific community. Core to the model is the fundamental and essential concept that sustainability represents an agreement among members of society regarding how to inter-relate and use resources. There are many possible agreements, each of which will lead to an alternative future. Which agreement is reached will depend upon the resource or deposit in question, the existing social, environmental and economic situation, and the desires of the public. In discussion it was noted that sustainability might seen as a modern extension of Lavoisier: nothing is lost; nothing is created; everything is transformed.

The next presentation was made by Mr. Rodney Elvish of B E Enterprises, for the authors, Dr. Robin Batterham and Meity Mandagie of Australia. Their paper, "Australian Perspective on Indicator of Sustainability for the Mineral Extraction Industry," proposed a hierarchical approach to measuring sustainable development performance and progress. These are, from most general to specific: Global Objectives, Industry Strategy, Enterprise Target, Specific Project, and Individual Actions/ Measured Outcomes. Next the Mine of the Future was described as having zero environmental footprint. The need for collaboration and innovation was stressed. Finally, the presenter pointed out that small mines have opportunities to be innovators that big mines do not because of their openness to new methods and their quick turn-around times. He pointed out that the use of new technologies brings with it huge responsibilities: to take risks, to be brave, and to be super responsible.

Prof. Dr. Neşet Acarkan and Orhan Yilmaz co-chaired the next session. Professor Dr. Zhang Licheng, Beijing General Research Institute of Mining and Metallurgy, presented a paper, "Chinese Perspective on Indicator of Sustainability for the Mineral Extraction Industry," co-authored with Prof. Dr. Dianzu Wang. First, the paper pointed out the contributions that mining and minerals have made to China's recent development. Challenges of fulfilling China's demand for mineral resources over the next 10-15 were next discussed. The authors pointed out that supplying necessary resources while improving environmental performance will be the most critical engineering challenge that China's mining and mineral industry will face. They argue that the traditional consumption models of developed countries will not work for China and recommend instead that the sector focus on ecology, sustainability and low per-capital consumption of minerals. They also see important roles for recycling and reuse; however a major challenge will be increasing the awareness of the public about sustainability issues.

The next paper of the session, written by Dr. Francis Petersen and S.E.T.Bullock of Anglo Platinum Ltd, and presented by the former, was titled "South African Perspective on Indicators of Sustainability for the Mineral Extraction Industry." The paper had two main themes. First, the authors point out how recent legislation in South Africa has linked the acquisition and retention of mining rights to the need for environmental, social, and labour plans that determine impacts, propose how they should be mitigated and include monitoring schemes. The second part of the paper shows how South Africa is using technological advances to further the cause of sustainable development by protecting and enhancing economic and natural capital stocks.

The first day closed with short presentations by two additional speakers who were not originally included in the programme. Their presence at the Workshop made it possible for attendees to hear their thoughts on minerals indicators and sustainability. The first was Prof. Dr. Hermann Wotruba of RWTH Aachen University. He spoke about the Las Cristinas project in Venezuela. Development was to be a joint effort between Place Dome and the small scale gold miners. The firm went to considerable effort to increase capacity among the local miners and to introduce less environmentally damaging methods to an area where mercury use had been common. Unfortunately, the right to develop the deposit was transferred to another industry group that had less interest in public participation. Placer Dome demonstrated that there is an effective way to work with small scale miners. Conversely, the project also demonstrated the difficulties all parties face when rights of tenure are not clear and are variably enforced.

The last speaker of the day was Dr R. Craig Ford of INMET. He spoke in his capacity as a representative of the Mining Association of Canada (MAC) and introduced MAC's Toward Sustainable Mining Initiative. He reported that the group had accomplished the following:

- ✓ finalized four sets of performance indicators: for tailings management; energy use and greenhouse gas emissions management; external outreach; and corporate crisis management planning
- ✓ oversaw, guided and refined company reporting on TSM performance indicators

- ✓ began work on other performance indicators to address community relations, environmental management systems and biodiversity
- ✓ developed a verification framework for TSM, including assessment protocols for the four finalized sets of indicators; work continues on the TSM external verification system
- ✓ helped with the public launch of TSM and implementation of a TSM communications strategy
- ✓ conducted early planning for future needs, including the need to train company staff in auditing and assessment.

Dr. Ford concluded that MAC intended to make participation in TSM a condition of membership and saw the work to date as a concrete step toward sustainable mining, one that could be emulated by industry in other countries if they so desired.

The morning of October 14 began with a session chaired by Prof. Dr. Suna Atak and Dr. Avni Yazan. The first speaker was Prof. Dr. James Hendrix of the U. of Nebraska, who presented "Perspective on Indicators of Sustainability for the Gold and Silver Extraction Industry." He started by noting that even 'conservative' newspapers run articles questioning the safety of cyanide use and drew the conclusion that waste disposal is a major concern of stakeholders and therefore must be one for industry as well. He pointed out that the goals for sustainable mining differ from region to region and as a result indicators tend to differ. He also noted that each type of precious metal mining has unique characteristics that necessitate relevant indicators. Regardless of circumstances, indicators are needed for four spheres: environmental, economic, social, and governance. He recommended that indicators be developed for accidents, health and safety of workers and neighbors, and value-added at the local and national scales.

The next speaker was Prof. Dr. Valentin Chanturiya, of Russia, who presented a paper titled "Russia Perspective of Sustainability Indicators in Mineral Extraction Industry." He discussed the relationship between mineral wealth and commodities produced. He pointed out that given current technologies, only a small portion of mineral mass extracted is actually put to use. The balance accumulates as waste. He recommended considering waste as new resources, which could be used to make underground voids safe and useful from the environmental and engineering standpoints. Prof. Dr. A Abramov, Moscow State Mining University, then presented a paper on an unit operation: "The Perspective on Indicator for Flotation of Minerals."

The final session of the Workshop, co-chaired by Prof. Dr. Işik Özpeker and Mehmet Üzer, consisted of one paper followed by closing remarks. The speaker was Dr. Caner Zanbak, of the Turkish Chemical Manufacturers Association, who with Sabri Karahan, of DAMA Engineering, authored a paper titled "Turkish Perspective on Indicators of Sustainability for the Mineral Extraction Industry." Dr Zanbak proposed a way to think about sustainable development in developing nations: "integrated social and economic development achieved while conducting agricultural, animal farming, fishing, mining and industrial production activities without wasting natural resources and in a manner with due respect to human health and the environmental values." He expressed concern that a combination of misinformation spread by anti-mining groups, heightened environmental awareness by the general public and the reluctance of governments to manage social concerns is leading to a reduction in mineral exploration and development. He also expressed the view that the three pillars of sustainable development (social, economic, and environmental) had not been in proper balance in recent years. Dr. Zanbak hypothesized that for Turkey to reach a per-capita income level of \$15,000/yr, per-capita CO_2 emissions would need to triple. He closed with the thought that local-politics oriented opposition to mining can undermine the investment environment in ways that contradict the sustainable development concept.

Final comments were given by Prof. Dr. Roberto Villas Bôas, Prof. Dr. M. Zeki Doğan, and Prof. Dr. Güven Önal. There was universal agreement that the Workshop had been intellectually stimulating, productive, and an appropriate precursor to the XXIII IMPC. A visit to the Ovacik Gold Mine was performed prior to the Workshop and a paper by Mr. Ismet Sivrioglu was provided to be included in this book.

SUSTAINABLE DEVELOPMENT AND SD INDICATORS FOR MINERALS

The Workshop presentations and subsequent discussion brought out a number of recurring themes. We will present these themes below, organized in terms of who needs to act sustainably, when, for whom and to achieve what ends, and how and with what methods and tools. Prior to doing so, we reprise a few basic ideas about sustainability as it is applied to minerals and mining.

First, it is important to understand that sustainability is not the same concept as sustainable development, although the terms are used interchangeably by many people. The former is a characteristic of healthy social and environmental systems and refers to the ability of those systems to withstand externally imposed shocks and return to normal functioning. Sustainability, defined in this way, is not a characteristic of minerals, which are nonrenewable. Conversely, sustainable development necessitates integration of environmental policies and development strategies so as to satisfy current and future human needs, improve the quality of life, and protect the environment upon which we depend for life support services. Minerals are clearly a part of sustainable development. A stream of material inputs is necessary if quality of life is to be improved, but at the same time protecting the environment while supplying those materials is essential.

Sustainable development has many definitions within and across societies because there is disagreement about how to balance the social, economic and environmental dimensions. Some individuals emphasize environmental aspects while others focus on the economic sphere. How each defines sustainable development is a function of their values, education, and life experiences. Moreover, sustainability is context-dependent. What is acceptable and appropriate behavior depends on location and the economic and cultural context.

Similarly, the choice of indicators to track progress towards sustainable development goals is to some degree situation specific. Indicators of sustainable development, often termed sustainability indicators, are holistic indexes that are agreed upon in a given societal context. Agreement on technical indicators, such as those that report emissions or production levels, is more easily reached than is agreement on indicators of system condition, for example of social equity and ecosystem health.

The scale at which an indicator is applicable needs to be determined, in part because the drivers of system condition vary across spatial scales. The scale of interest also varies. If mining is important to the Country's GDP, then national indicators are necessary. If, however, mining is only important locally, then local indictors are more appropriate. In the final analysis, there is no single, perfect, universally appropriate set of sustainability indicators.

Moreover, a single set of information, a set of sustainability indicators, can and will be interpreted in more than one way. While it is certainly possible for a government or business to create and publish an 'official' interpretation, doing so may be counter productive if it undermines trust among stakeholders. Transparency, public participation, and stakeholder dialogue are key tenets of sustainable development. One way to make progress toward these goals is to engage stakeholders in the indicator development and interpretation process.

There is widespread agreement that achieving sustainable outcomes with respect to the minerals sector requires: a stable economy that allows for real investment benefits; and a balance of social expectations (informed, not emotional), good two-way communication, and trust. It is also the case that sustainable development for developing countries is not basically different than that for developed countries. Only the framework within which sustainability choices are made is different: a) the social, political, and geographic background, b) the endowed mineral wealth, production capacity, and levels of efficiency, c) the legislative regimes, ability to implement regulations (capacity), and governance. Questions remain about who needs to take action, at what point in time, why, and how. Below we briefly describe each of these categories and then in bullets report the relevant messages and conclusions that came out of the Workshop.

Who

- Which parts of society have responsibilities with respect to achieving sustainable outcomes with respect to minerals? The clear message of the Workshop was that there are roles for all: governments at various scales, firms and industry sectors, local communities, non-governmental organizations, and also professionals. Cooperation, collaboration, and communication among all parties is essential. Key ideas included

Government

- Industrial policy is crucial to sustainable economic development. Moreover, nations need a subset of industrial policies that are specific to mining, that address waste management, chemicals management, and site rehabilitation.
- Government has the responsibility to ensure a stable business environment, with clearly allocated property rights, supportive economic policies, and consistent environmental regulation.

Firms

- Sustainable development is not just for big mines, major mining companies and developed nations. It is applicable to small mines and to developing nations. Small mines can be innovators, the ones free to try new technologies, but doing so brings with it huge responsibility to take risks, be brave, and be super-responsible.
- Responsible corporate behavior, consistent with SD principles, can change situations, moving them from animosity to harmonious partnership.
- Although governments have been active in creating sustainability indicators in the past, firms are now developing their own indicators and using them in public reporting.

Science and Professionals

- If we are to achieve the goals of sustainability as applied to mining there are open scientific and technical questions that will need to be answered. These include mass flows, processes energies, and environmental impacts.

- Professionals need to engage actively in the sustainability debate and share their expertise and knowledge with other stakeholders.

Non-governmental organizations and society as a whole

- There is a need to openness and honest communication by all stakeholders.
- Each person must accept responsibility for the consequences of their personal consumption and life style choices. Sustainable consumption will be an increasingly important topic, one that will be addressed by the UN CSD in 2010/2011 along with mining. The need to link consumption forecasts with the possible consequences of alternative levels of consumption was raised by several speakers.
- Similarly, each must be aware of and accept responsibility for the potential consequences of their positions vis a vis sustainable development.

When

- The time for action is now. All stakeholders need to act. Business as usual is no longer acceptable in the view of the wider community of nations.

Why and for whom

- Serious, complex, and interconnected problems of environmental degradation and poverty exist. These affect the world we live in today and the one that will be left for future generations. Action is necessary if the overarching goals of sustainable development, social equity, economic prosperity and a healthy environment, are to be achieved.

How and in which areas

- Communication is essential. Key aspects of sustainable development are transparency and public participation. The EU sees stakeholder dialogue as an important issue.
- Formalization of the concepts of sustainability and their application to mining and minerals will provide intellectual rigor and a structure upon which to build.

- Waste disposal in terms of 1) public concerns, 2) legacy problems, 3) best practices, and 4) accident prevention are all of great importance.
- What is obligatory versus voluntary behavior will depend upon where mining takes place. Zero emissions means zero above some agreed-upon level and that level is socially defined, not engineering-imposed.
- Indicator development processes are taking place in various countries, industry associations and firms.

Speakers at the Workshop on Indicator of Sustainability for Mineral Extraction Industry represented a variety of countries, each with its own culture, economy, and resource endowments. Some speakers represented government, others either industry or academia. Despite this diversity, there was a general consensus that sustainable development principles can and should be applied in the minerals sector. And as would be expected in a group of technical experts there was considerable debate about the role of science and engineering in the achievement of sustainability goals. Clearly governments need to support research and encourage the application of innovative tools and methods. Industry needs to embrace new ways of doing business, including educating their workers in and implementing both new technical approaches and stakeholder engagement processes. Finally, those in the academic community have the responsibility to both find solutions to the technical problems identified at the Workshop, equally importantly to train the next generation of scientists and engineers who will carry this work forward.

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INDICATORS: SOME FACTS, EXERCISES AND PROPOSALS

America

USA AND UN PERSPECTIVES ON INDICATORS OF SUSTAINABILITY FOR THE MINERAL EXTRACTION INDUSTRY

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Sustainable development is an evolving concept that focuses on the need to ensure economic prosperity, environmental health, and social equity for the benefit of current and future generations. Its main premise is that actions we take today must provide for our own needs without diminishing the assets, resources, and capabilities available to our descendants. Commitment to sustainable development principles necessitates integration of environmental policies and development strategies so as to satisfy current and future human needs, improve the quality of life, and protect resources.

There are many definitions of sustainable development because there is disagreement about how to balance the social, economic and environmental dimensions of sustainability. This disagreement stems from the fact that sustainability is not science, although science must be utilized to achieve its stated goals. Rather, it is a value-based concept, an ethical precept (Norton, 1992), and stated desires for simultaneous equity, prosperity, and environmental protection represent moral positions.

The moral and ethical precepts that underlie a desire for a sustainable way of life are embodied in held values. Held values comprise the morals, beliefs, conduct, qualities and states that individuals and groups consider desirable (Brown, 1984). A set of held values can be divided into two categories: terminal and instrumental. Terminal values are the generalized or ideal end-states one seeks in life, for example an equitable society, a healthy environment or a viable economy. Instrumental values relate to the alternative means of reaching those desired end-states, for example, promoting equal opportunity, minimizing emissions, or investing in infrastructure. Values exist within social systems, including a society's institutions, communities, and familial units, and these social factors affect terminal and instrumental held values (Beckley et al. 1999). The social context also affects how individuals order their values, i.e., give precedence or emphasis to certain values over others (Boulding and Lundstedt, 1988). Thus, people may hold different, though often similar or overlapping, value sets, and that fact explains why they have different opinions about what sustainability means and how it should be achieved. This is true both within countries and communities, as well as across nations (Shields et al. 2002).

The mainstream definition of sustainability comes from the Brundtland Commission report (WCED 1987), "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The United Nations Conference on Environment and Development (the Earth Summit), held in Rio de Janeiro, Brazil in 1992, introduced the concept of sustainability to the world. Since that time, sustainable development has become accepted as a foundation for public policy in many countries. The Earth Summit produced a document entitled Agenda 21, which documented issues and areas of concern vis à vis sustainable development (UN 1992). Subsequently, the United Nations created the Commission on Sustainable Development (CSD) within the Department of Economic and Social Affairs. The CSD meetings held annually thereafter provided a forum for debate and discussion of each of the issues raised in Agenda 21, with the goal of generating consensus text.

<u>Chapter 8</u> of Agenda 21 called on countries to adopt national strategies for sustainable development that "should build upon and harmonize the various sectoral economic, social and environmental policies and plans that are operating in the country." In the United States, then President William J. Clinton, created the President's Council on Sustainable Development. This group of social, business and religious leaders produced a report titled "Sustainable America" (PCSD, 1996). The 35 Council participants built on the Bruntland definition of sustainability. Their vision of a sustainable future for the United States was based on commitment to a dignified, peaceful and equitable existence for all Americans. A

sustainable America would have a growing economy, but also protect the environment, natural resources and natural systems.

Chapter 40 of Agenda 21 calls on countries and the international community to develop indicators of sustainable development. Such indicators are needed to increase the focus on sustainable development and to assist decision-makers at all levels in adopting sound national sustainable development policies. In response, the President’s Council recommended that a way be found to track progress toward a sustainable future, which led to the creation of the Interagency Working Group on Sustainable Development Indicators. This team of Federal government employees created a set of national scale indicators, which were published in 1998 (US IWGSDI).

One part of a sustainable future is sustainable management of resources. With that goal in mind, the United States participated in the Montreal Process, which sponsored discussions on sustainable forest management. The desire to measure and monitor the current situation and trends in key variables is a hallmark of sustainability. The Montreal Process resulted in a signatory document, the Santiago Declaration, which presented 7 criteria and 67 indicators of sustainable forest management. These criteria and indicators were endorsed by 12 nations, including the United States (Montreal Process Technical Advisory Committee, 1997). The U.S. Forest Service committed to implementing the criteria and indicators on all the lands they manage (more than 90 million hectares). They convened the Roundtable on Sustainable Forests as a forum for discussions on the Montreal Criteria and Indicators. All signatory nations agreed to report on the Montreal Criteria nd Indicators. The U.S. National Report on Sustainable Forests was released (USDA Forest Service, 2003).

The Forest Service soon realized that the set of Montreal Criteria and Indicators were inadequate for their needs because the agency manages not only forests, but also rangelands, water resources and minerals. It was determined that additional indicators and public input were needed. Therefore, the Sustainable Minerals Roundtable (SMR) was established in 1999 and charged with the task of developing a set of national level indicators to measure the contributions of mineral systems to sustainable development in the United States (Shields et al. 2003). Minerals here refer generically to mineral(s) and mineral-based material(s), plus energy resources. Roundtables for rangelands and water resources were also launched. Before addressing how the forest indicators, plus those from the latter three Roundtables will be integrated, the mineral indicators will be discussed in more detail.

The Forest Service has collaborated with many other Federal agencies, including the Bureau of Land Management, Department of Energy, Environmental Protection Agency, Minerals Management Service, Office of Surface Mining, and US Geological Survey, as well as state, local, and Tribal governments, NGO's, and industry, in an effort to develop indicators of sustainability for energy and mineral resources. A sustainable future for America will only be achievable with the contributions that these resources can make. The purposes of the mineral indicators are as follows:

- Encourage and support an informed national dialogue about the place of and need for nonrenewable resources in our society and economy, and how they can best contribute to a sustainable America;
- Identify the types of information that will be needed for such a dialogue;
- Highlight trends and priorities related to energy and mineral systems;
- Track progress toward the nation's sustainability goals; and Support sustainable mineral resource management.

The Minerals Roundtable is an open, collaborative process; any individual or organization was welcome to participate. Meetings were held in many parts of the nation to facilitate broad participation and to solicit a wide range of views and perspectives. During the meetings, participants discussed sustainability and indicator theory, reviewed indicator sets developed by others (including those from Canada, the UK and Australia), and proposed new indicators. Over 19 meetings, participants of the SMR determined that four of the seven criteria from the Montreal

Process were applicable to mineral resources, although in two cases some adaptation was required. The remaining 3 criteria were either deemed to fall outside the scope of the SMR and/or are being addressed by the other Roundtables. The four mineral criteria are:

- Maintenance of capacities to produce commodities.
- Maintenance of environmental quality.
- Maintenance and enhancement of long-term social, economic, and cultural benefits to
    - meet the needs of societies.
- Legal, institutional, and economic framework to support sustainable development.

The goal of the Productive Capacity Criterion is to assess the nation's energy and mineral resources and the capability to meet the needs of current and future generations. There are 5 Sub-criteria:

1. Resources.
2. Exploration capacity.
3. Production (extractive) capacity.
4. Processing capacity (smelting, refining, pipelines, and transportation).
5. Use of Energy/Minerals/Materials.

The Environmental Criterion covers the influences of the energy and mineral sectors on the environment, including air, surface water, groundwater, and land. There are 4 Sub-criteria:

1. Ambient environment
2. Management of extraction and processing
3. Reclamation – remediation-restoration of all extraction sites.
4. Environmental releases.

The objective of the Socio-economic Criterion is to provide information that can be used to assess the socio-economic impact associated with energy and mineral activities in the United States. The Criterion has 5 Sub-criteria:

1. Local economic benefits (and costs).
2. National economic benefits (and costs).
3. Cultural, social and spiritual needs.
4. Equity.
5. Recreation and Tourism.

The Legal and Institutional Criterion describes the overall policy framework within which energy and minerals activities take place. Sub-criteria are:

1. Legal framework.
2. Institutional framework.
3. Economic framework.
4. Capacity to measure and monitor indicators.
5. Ability to conduct and apply research and development.

The SMR initially identified more than 200 potential indicators and has narrowed the list to 61 indicators, 38 of which are deemed Phase I indicators, meaning efforts to populate them with data will precede efforts to populate Phase II indicators with data. Selection for Phase I or II depends on answers to the following questions:

1. The relevance of an indicator to sustainability and the issue it addresses;
2. What is to be measured and the scale at which it applies;
3. The data that are needed and the science basis for its collection and use;
4. Who is interested in this indicator;
5. Have the data been collected; and

6. Complexity, time, and resources necessary to populate the indicator.

The Roundtable has created a draft report on the criteria and indicators, which is now being reviewed. The SMR has faced several challenges (Shields et al. 2005). First, creating trust among participants has required continuous effort, given the differences in perspectives between some industry and NGO representatives. Second, the group selected what they believed would be an appropriate set of indicators regardless of the availability of data. As a result, data do not currently exist for every one of the indicators. The SMR has no authority to require reporting of additional data by industry and no funding to undertake new monitoring efforts, so some indicators may not have data for the foreseeable future.

Finally, interpretation will be controversial. The indicators are intended to be meaningful as a set. No single indicator can describe the full contribution of minerals to a sustainable future. Nonetheless, some stakeholders will undoubtedly use individual indicators to support their position regarding minerals management. Further, as noted previously, there is no single agreed upon definition of sustainability and hence no single, correct interpretation of the full indicator set. It is the intention of the Roundtable to share the indicators and associated data with a range of stakeholders and solicit their interpretations, all of which will be published together along with a discussion of points of agreement and disagreement. Clearly, it would be more expeditious to create an 'official' interpretation; however, two of the fundamental principles of sustainability are transparency and public participation. By conducting an open process and engaging the public in the interpretation, the minerals indicators gain a level of legitimacy with the public that they would not otherwise have. Further, the engagement process itself fosters the informed public debate about minerals that was one of the original goals of the Roundtable. This approach is also being followed by the Forest Roundtable, which has recently launched a website that reports multiple perspectives about the meaning and content of the

National Report on Sustainable Forests (USDA Forest Service 2003).

In addition, members of the SMR are also participating in an effort to develop a framework to house all resource indicators, including mineral indicators. This work is being undertaken by the Integration and Synthesis Group (ISG), which is comprised of leaders of the four Roundtables plus representatives from the US EPA and the Heinz Center, and under the sponsorship of the White House Council on Environmental Quality. The systems-based framework will be used to promote greater commonality in the C&I developed by the four roundtables, thus providing a mechanism for synthesis of national sustainability indicators for all lands and resources in the United States.

Indicators are organized into environmental and human subsystems (fig. 1) (ISG 2004). The organizing framework distinguishes between the states or conditions of interest, and the processes through which changes in those states occur (fig. 1). Within the states of both subsystems, the Framework distinguishes between current conditions and the enduring capacities that human's rely upon to satisfy their needs. The enduring capacities are called social capacity, economic capital and natural resource capital. A key feature of this approach is that the human and environmental subsystems are treated in an inclusive, even-handed and logically consistent manner.

The four resource indicator sets will also be used by the U.S. National Academy of Sciences' Key National Indicators Initiative.

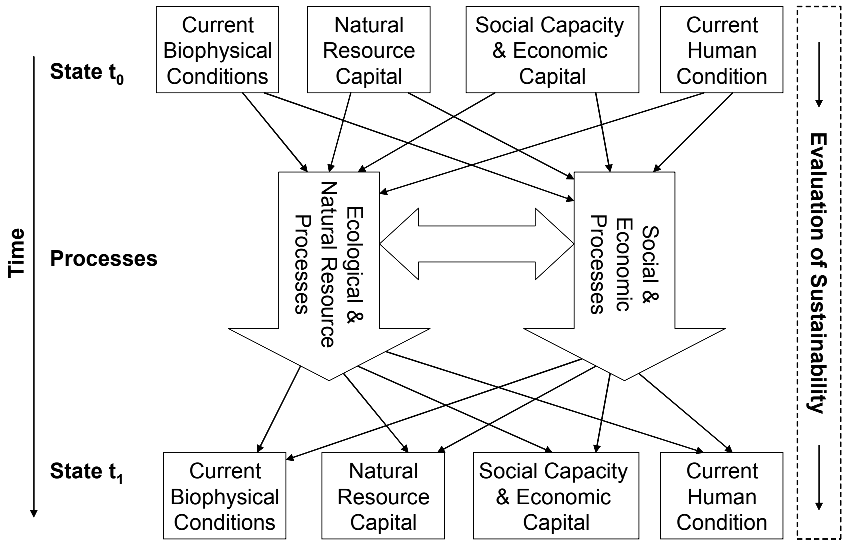

Figure 1 - Indicator Integration Framework

Returning briefly the United Nations process, the CSD spent the 9 years after 1992 preparing for a second international meeting. Heads of State and governments met in Johannesburg, South Africa, for the 2002 World Summit on Sustainable Development (UN 2003). Participants reaffirmed their commitment to the principles of sustainable development and endorsed a Plan of Implementation. Mineral resources were not addressed in Agenda 21, but were included in the Plan in Paragraph 46, which states in part, "Enhancing the contribution of mining, minerals and metals to sustainable development includes actions at all levels to: (a) support efforts to address the environmental, economic, health, and social impacts and benefits of mining, minerals and metals throughout their life cycle, including worker's health and safety, and use a range of partnerships…. to promote transparency and accountability for sustainable mining and minerals development."

The post-WSSD CSD cycle of new work has been organized in a somewhat different manner than was previously the case. The CSD will now address selected themes over 2 year cycles instead of

1 year cycles. The topics of mining and sustainable consumption will be considered during the 2010/2011 cycle. Moreover, the CSD will focus on results rather than on consensus text.

Mining has sometimes created problems in the past. Mistakes have been made repeatedly and many legacy sites are in need of remediation and reclamation. Nonetheless, mining's contributions to society are both vast and essential. Managing mining within the principles of sustainability can help ensure that minerals' contributions to society are net positive over the life cycle. The U.S. government is committed to the sustainable management of all our resources and is using indicators as a tool to track the contributions of minerals resources to a sustainable America.

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TOWARDS SUSTAINABLE MINING: THE CANADIAN MINING INDUSTRY SUSTAINABILITY INITIATIVE

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The Mining Association of Canada (MAC) began developing the Towards Sustainable Mining (TSM) initiative in 2000, to enhance the industry's reputation by improving its environmental, social and economic performance. TSM was launched publicly on May 10, 2004.

On November 24 2004, the MAC Board made TSM a condition of membership. The condition requires that MAC members endorse the TSM Guiding Principles, a set of commitments that address all areas of the industry's performance. It also commits all members to report on key performance areas within three years. In MAC's *Towards Sustainable Mining Progress Report*, member companies have begun to report on key performance areas such as tailings management, energy management, external outreach and corporate crisis management planning. The objective is to show Canadians the industry's current performance and ways of improving it.

TSM is spearheaded by the TSM Governance Team, a committee led by MAC's Board of Directors. Within each member company, TSM is supported by internal representatives called "initiative leaders." Committees of MAC members are leading the development of performance indicators and technical guidelines for implementing TSM.

As part of the TSM initiative, MAC's Board developed the Community of Interest (COI) Advisory Panel. This panel provides one way of strengthening engagement with mining communities of interest, and of helping to achieve TSM's objectives and guide its evolution.

Towards Sustainable Mining - Guiding Principles

As members of The Mining Association of Canada, our role is to responsibly meet society's needs for minerals, metals and energy products. To achieve this we engage in the exploration, discovery, development, production, distribution and recycling of these products. We believe that our opportunities to contribute to and thrive in the economies in which we operate must be earned through a demonstrated commitment to sustainable development.*

Accordingly, our actions must demonstrate a responsible approach to social, economic and environmental performance that is aligned with the evolving priorities of our communities of interest.** Our actions must reflect a broad spectrum of values that we share with our employees and communities of interest, including honesty, transparency and integrity. And they must underscore our ongoing efforts to protect our employees, communities, customers and the natural environment.

We will demonstrate leadership worldwide by:

- involving communities of interest in the design and implementation of our Towards Sustainable Mining initiative
- proactively seeking, engaging and supporting dialogue regarding our operations
- fostering leadership throughout our companies to achieve sustainable resource stewardship wherever we operate
- conducting all facets of our business with excellence, transparency and accountability

* We draw on the 1987 Brundtland Commission definition of sustainable development: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
** We use the term "communities of interest" to include all of the individuals and groups who have or believe they have an interest in the management of decisions about our operations that may affect them. This includes employees, contractors, Aboriginal or indigenous peoples, mining community members, suppliers, customers, environmental organizations, governments, the financial community and shareholders.

- protecting the health and safety of our employees, contractors and communities
- contributing to global initiatives to promote the production, use and recycling of metals and minerals in a safe and environmentally responsible manner
- seeking to minimize the impact of our operations on the environment and biodiversity, through all stages of development, from exploration to closure
- working with our communities of interest to address legacy issues, such as orphaned and abandoned mines
- practising continuous improvement through the application of new technology, innovation and best practices in all facets of our operations

In all aspects of our business and operations, we will:

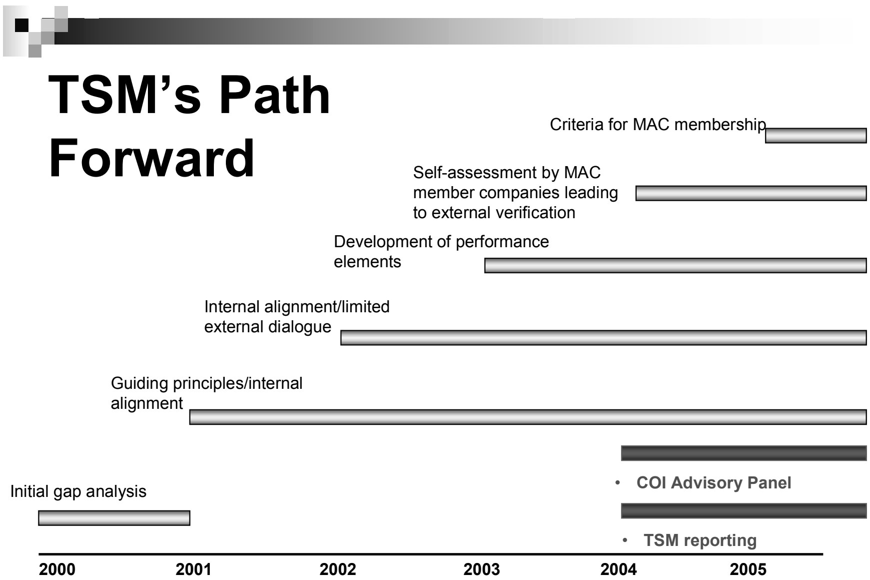
- respect human rights and treat those with whom we deal fairly and with dignity
- respect the cultures, customs and values of people with whom our operations interact
- recognize and respect the unique role, contribution and concerns of Aboriginal (First Nations, Inuit and Métis) and indigenous peoples worldwide
- obtain and maintain business through ethical conduct
- comply with all laws and regulations in each country where we operate and apply the standards reflecting our adherence to these guiding principles and our adherence to best international practices
- support the capability of communities to participate in opportunities provided by new mining projects and existing operations
- be responsive to community priorities, needs and interests through all stages of mining exploration, development, operations and closure
- provide lasting benefits to local communities through self-sustaining programs to enhance the economic, environmental, social, educational and health care standards they enjoy

The path forward

In 2002 MAC's Board of Directors adopted a three-year plan for TSM that included some ambitious tasks:

- developing performance indicators for tailings management, energy management, external outreach and crisis management planning
- developing indicators for three more performance areas by the end of 2004
- establishing the Community of Interest Advisory Panel
- designing a system to verify performance
- developing TSM-based criteria for membership in MAC

Ambitious as it is, the TSM plan is on track, though the development of new performance indicators is taking more time and work than anticipated. An important objective as the initiative moves forward is to encourage mining companies that do not belong to MAC to adopt TSM, its guiding principles and its obligations.



TSM performance indicators

From the outset, MAC members identified the need for performance indicators to provide a consistent framework for evaluating and reporting on industry performance against the guiding principles. Indicators help ensure that reporting is relevant to communities of interest and that it helps member companies improve their performance at both the operational and corporate levels.

TSM Performance Indicators

Tailings Management	**Energy Use and Greenhouse Gas (GHG) Emissions Management**	**External Outreach**	**Corporate Crisis Management Planning**
Tailings management policy and statement of commitments	Energy use and GHG emissions management systems	Community of interest (COI) identification process	Corporate crisis management preparedness
Tailings management system	Energy use and GHG emissions reporting system	Effective COI communications and engagement processes	Annual review
Responsibility for tailings management assigned to a senior official	Energy intensity performance	COI response mechanism	Training
Annual senior management review	GHG emissions intensity performance	Reporting performance	Adherence to best practices
Operation, Maintenance and Surveillance (OMS) manual			

How they work

In 2003 MAC developed performance indicators for four initial areas. In three of these areas - tailings management, energy use and greenhouse gas management, and external outreach - the indicators are supported by a ranking system and clear criteria for evaluating performance and monitoring progress.

For each indicator there are five levels of performance, with criteria for each level. In general, the levels represent the following degrees of activity:

Level 1 No action has been taken; activities purely reactive, no systems in place

Level 2 Some actions, but sporadic and not fully documented; systems/processes planned and being developed

Level 3 Systems/processes are developed and implemented

Level 4 Integration into management decisions and business functions

Level 5 Excellence and leadership

A reporting company selects the level that most clearly represents the company's or the facility's performance. Only one level can be chosen for each indicator, and it can be chosen only if all criteria for that level and all preceding levels have been met. If a company considers an element not relevant to the operation, it reports N/A (not applicable).

In the case of corporate crisis management planning, companies assess their performance against criteria by answering yes/no (met requirements/did not meet requirements).

The results

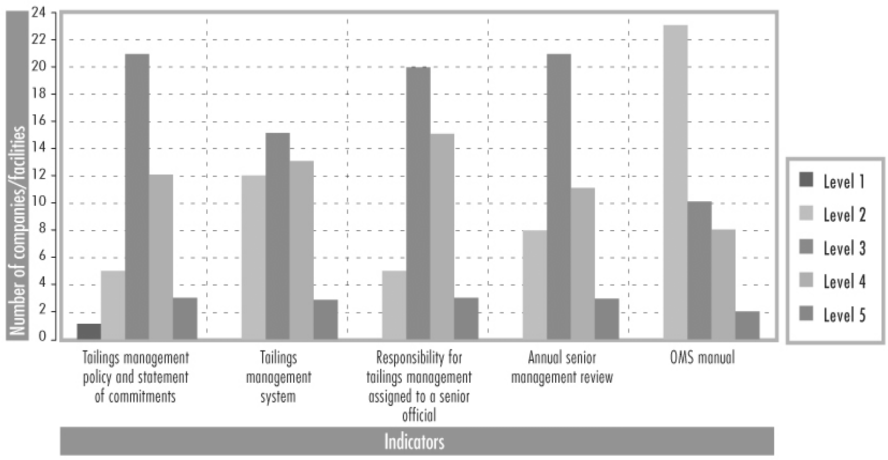
The graphs presented here show data submitted by 19 member companies, with 6 companies still to report. MAC considers such high participation an excellent outcome for TSM's first year, but expects full participation in future years.

The results show the overall performance across MAC's membership, on an aggregate basis. Several companies presented results for each of their facilities, while others submitted an overall corporate assessment. These results have been combined to produce the graphs below.

1. Tailings Management

MAC believes that the results for tailings management reflect several years of effort by members to improve performance in this critical area. With the publication of both *A Guide to the Management of Tailings Facilities* (1998) and *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities* (2003), MAC and its members are developing and working to implement best practice guidelines for the safe, responsible management of tailings facilities.

Tailings Management Assessments



Company-Level Reports: 5 companies
Facility-Level Reports: 38 facilities (37 for tailings management policy and statement of commitments) (13 companies)
Total Reports: 43 reports (18 companies)

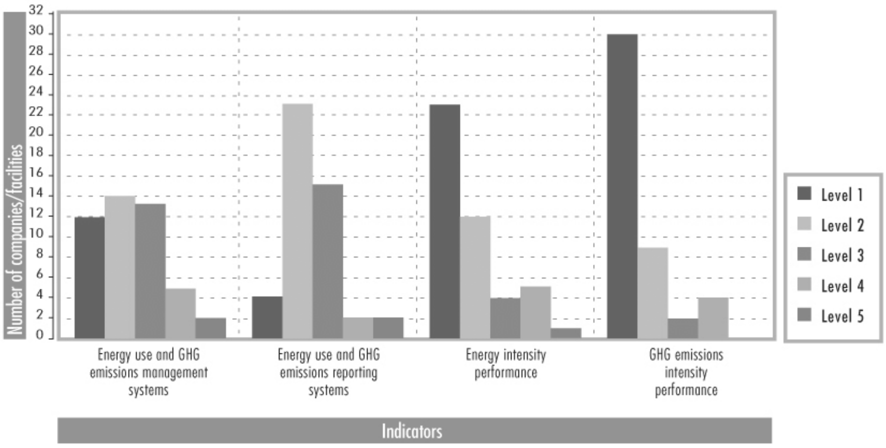
The results in this area--most MAC members report Level 3 or better--show the extent to which members have adopted and implemented best practices. (The exception is with the fifth indicator, regarding implementation of an OMS manual, which may reflect the fact that MAC's OMS guide was published only in 2003.) The fact that most companies are reporting a Level 3 assessment or higher for "annual senior management review," for example, means that each year there is a formal, documented senior management review of the adequacy of tailings management policies and objectives and the performance of the tailings management system.

However, given the serious impacts of a tailings failure, MAC members recognize that tailings facilities must be managed to the highest standards. Work remains to ensure that performance continues to improve in the future.

2. Energy Use and Greenhouse Gas Emissions Management

MAC has been working with member companies over the past several years to improve the energy efficiency and greenhouse gas (GHG) emissions intensity of their operations. In 1997 MAC published a guide to help members plan for better energy efficiency and GHG reduction. A more comprehensive guide to strategic action and planning on climate change followed in 2000.

Energy Use and Greenhouse Gas (GHG) Emissions Management Assessments



Company-Level Reports: 6 companies (5 for energy intensity performance and GHG emissions intensity performance)
Facility-Level Reports: 40 facilities (13 companies)
Total Reports: 46 reports (19 companies)

Since then, MAC has collected and published members' energy use and GHG release data. Thanks in part to MAC's efforts, in 2004 most companies and their facilities have or are developing formal systems and strategies for energy use and GHG management and reporting.

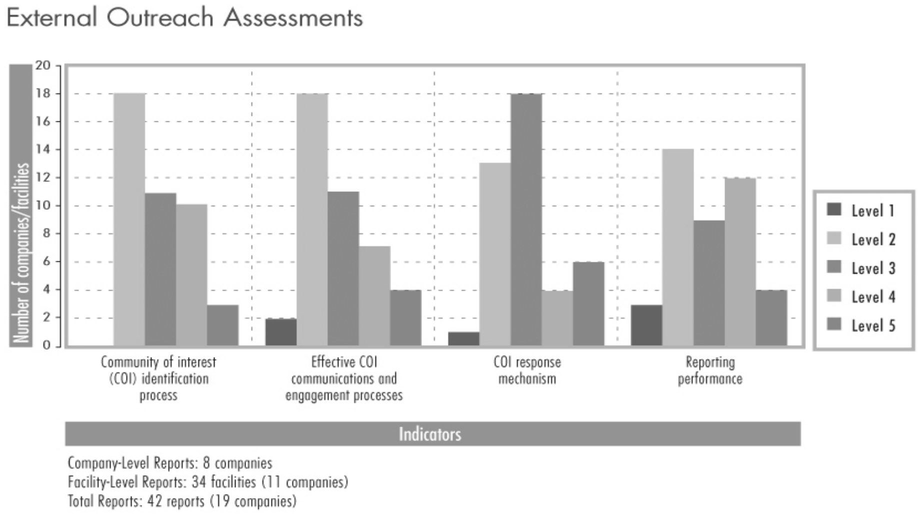
The criteria for the energy use and greenhouse gas management indicators reflect the expectations of Canada's Voluntary Challenge and Registry program[1] as well as those of the Greenhouse Gas Protocol, which operates under the umbrella of the World Business Council for Sustainable Development and the World Resources Institute.[2] More than half of the MAC members that reported indicate that they have established inventories and basic systems/strategies for energy use and GHG management that meet these expectations (Level 2 or higher for the first indicator above). In addition, a quarter report having voluntarily reduced energy intensity by at least 1 percent per year (Level 3 or higher for the energy intensity and GHG intensity indicators above).

Looking ahead, MAC will work with member companies to help them establish formal inventories and systems/strategies for managing energy use and greenhouse gas releases. We expect that members will continue to strengthen their systems and will demonstrate continuous improvement in this area throughout their operations.

3. External Outreach

When it comes to external outreach, MAC members follow a range of practices. Some embrace best practices, while others have no formal system for consulting with and engaging their communities of interest (COIs) in an ongoing, meaningful way.

[1] For details, visit the VCR's website: www.vcr-mvr.ca.
[2] The Greenhouse Gas Protocol can be found at www.ghgprotocol.org.



With almost all results at Level 2 or higher, the industry is clearly on the road to putting in place effective mechanisms for consultation. For example, a Level 2 assessment for "effective COI communication and engagement processes" means that companies or facilities have some informal engagement processes and conduct ad hoc consultations with COIs. It also means they have plans to use formal COI engagement processes, but those processes have not yet been implemented.

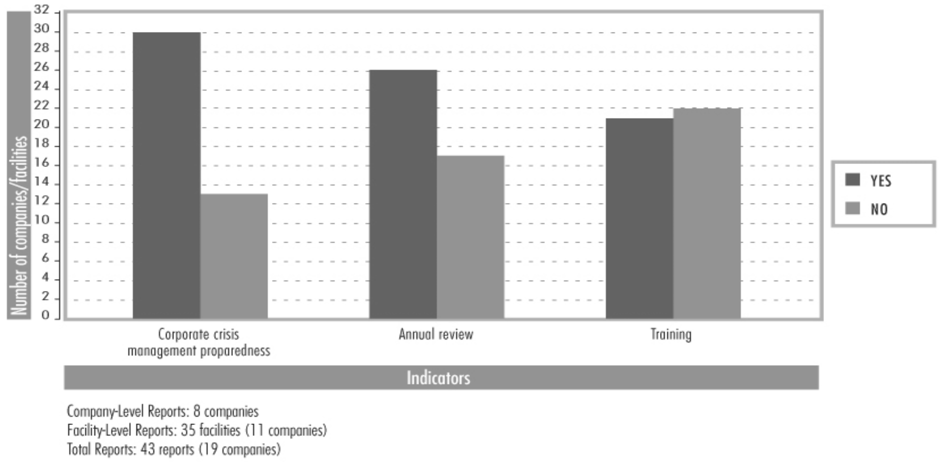
However, the high variability of the results suggests uneven application of external outreach systems among MAC members, and in some cases among facilities of individual companies. MAC expects that these results will spur members to share their experiences and practices in an effort to help all companies improve their future performance.

4. Corporate Crisis Management Planning

The results show that crisis management plans are in place in 70 percent of reported companies and facilities and that 60 percent review their plan annually. As well, just under 50 percent of those reporting ensure that key personnel receive training in this area every year.

Over the past three years, MAC members have invested considerable resources in improving their crisis management preparedness. They did so in response to early TSM research, which showed that neither the industry nor its communities of interest believed the industry responded effectively to major events--that the way such events were managed tended to make incidents worse.

Corporate Crisis Management Planning Assessments



In 2001 MAC published *Guidelines for Corporate Crisis Management Planning*, and over the next two years offered crisis management training to members and non-members alike. To fulfill a TSM performance requirement,[3] the MAC guide was reviewed and updated in 2004 so that it continues to promote best practices.

[3] This refers to the indicator "adherence to best practices," which applies to MAC itself and therefore does not appear in the graph below. **[*or other wording depending on layout]**

Despite this progress, MAC recognizes that the results in this area should be stronger. The goal of MAC's Board of Directors was that by June 2003 all MAC members would have crisis management plans in place. With this goal still unmet, more work is required.

As well, companies keep their crisis management plans effective through annual reviews and training. Without regular updates, crisis management plans quickly fall out of date as staff change and business activities evolve. And skills can lapse without ongoing training, which is also needed to prepare new staff for their responsibilities in the event of a crisis.

Moving towards external verification

Currently, performance indicator reporting is based on company self-assessments. The MAC Board felt that self-assessment was a necessary first step to familiarize companies with the TSM indicators and the reporting process. However, the Board also recognizes that it is crucial to assure MAC members and communities of interest that the reported results are consistent and accurate. The Board has thus endorsed a three-step approach to phasing in a TSM verification system:

- Year 1 (2004): Members self-assessed and submitted their performance data to MAC for reporting on an aggregate basis in the 2004 *TSM Progress Report*.
- Year 2 (2005): As above. MAC members will be asked to acknowledge TSM in their annual or sustainable development reports. Assessment protocols will be developed and tested.
- Year 3 (2006): Each company's CEO or authorized officer will submit a letter of assurance, to be posted on MAC's website, that the results reflect the company's performance and have been verified by an external party.

To implement the verification system and to make reporting more consistent across the membership, TSM initiative leaders from member companies are working together to develop assessment protocols for all performance indicators. The protocols should be ready for use by year-end 2005.

In 2006 MAC will assess the verification program and, with advice from the TSM Community of Interest Advisory Panel, will determine whether further steps are needed to meet TSM objectives. This process will include a review of the information being reported and an evaluation of both the letters of assurance and the effectiveness of external verifiers.

The COI Advisory Panel

TSM's 14-member Community of Interest Advisory Panel includes representatives from Aboriginal organizations, labour, communities where the industry is active, environmental and social NGOs and the investment community, along with senior mining industry representatives. The panel's purpose is to do the following:

- help MAC members and their communities of interest to improve the performance of the industry, in line with the TSM guiding principles
- provide a mechanism for two-way dialogue between MAC and its communities of interest and for MAC to respond to issues raised by them
- provide input into and build understanding of and support for TSM goals

TSM Community of Interest

Advisory Panel Members

Chief Jim Boucher	Fort McKay First Nation
Richard Briggs	Canadian Auto Workers
Ginger Gibson	Mining Engineering, University of British Columbia
Larry Haber	City of Kimberley, BC
Peter C. Jones	Inco Limited
Peter R. Jones	HudBay Minerals
Brenda Kelly	Canadian Environmental Network
Soha Kneen	Inuit Tapiriit Kanatami
Stefan Lopatka	Nunavut Tunngavik Incorporated
Christy Marinig	Timmins Economic Development Corporation
Elizabeth May	Sierra Club of Canada
Allan Morin	Métis National Council
George Nikitsas	United Steelworkers of America
Gordon Peeling	The Mining Association of Canada
Alan Penn	Cree Regional Authority
Chris Jones	Albion Sands
Richard Ross	Inmet Mining Corporation
David Scott	CIBC World Markets
Eira Thomas	Stornaway Diamond Corporation
Chief Darren Taylor (Tr'ondek Hwech'in First Nation)	Assembly of First Nations

The panel met for the first time from March 10 to 11, 2004. At this meeting, the panel finalized its terms of reference and operating procedures, and developed a work plan for 2004. It also addressed membership issues, including inviting the Métis National Council to appoint a representative. As well, the panel reviewed and recommended enhancing the TSM guiding principles by adding three principles: one concerning health and safety, one reflecting the industry’s commitment to addressing legacy issues (such as orphaned and abandoned mines) and one containing an explicit reference to Aboriginal peoples. These recommendations were accepted by MAC.

In subsequent meetings, the panel has focused on and generated advice about a number of substantive issues, including the following:

- results from the first year of reporting by MAC members

- new performance indicators and criteria, particularly for Aboriginal relations and community development
- the TSM verification framework

The panel also identified issues for future meetings. Among them are the development of consultation guidelines and the promotion of best practices in this area, orphaned and abandoned mines, and the need for membership criteria for MAC to strengthen adherence to TSM. For more information about the panel's meetings, see the meeting reports posted on MAC's website (www.mining.ca).

Next steps

MAC is working on new performance indicators in 2005:

- good neighbours (community development)
- biodiversity

Another TSM objective is to reach out to MAC's associate members--suppliers and consultants to the mining industry--to identify how they might participate in TSM and what their obligations would be. A workshop for associate members is planned for 2006.

It has been an exciting first year for TSM, and much progress has been made. The challenge for everyone at MAC is to maintain the momentum and the enthusiasm for TSM that are growing across the industry and beyond. Next year we hope to have the full participation of all MAC members, working with the COI Advisory Panel and others, to build a more complete performance system against which the industry will be measured and held accountable.

SUSTAINABLE INDICATORS FOR THE EXTRACTION MINERALS INDUSTRIES IN LATIN AMERICA

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ABSTRACT

In recent years, the concepts of sustainability and sustainable development have been successfully extended to mineral resources and, as a consequence, several exercises on the linkages amongst goals of sustainable development, mineral resources and societal needs have been proposed and developed. Also, a lack in formalization, in the logical sense, has led to some misunderstandings and misinterpretation of the concepts and their applicability. It is the purpose of this paper, besides reviewing present day status of the indicators of sustainability for the minerals extraction industries in LA,to stress and point out some necessary logical formulations for the sustainability ideas and indicators.

INTRODUCTION

In a recent paper (Shields,Solar,Anciaux and Villas-Bôas,2005)it was stressed that a commitment to sustainable development needs integration of policies and development strategies so as to satisfy current and future human needs, improve the quality of life, and protect the environment upon which we depend for life support services. Since Brundtland´s proposal of the concept, societies the world over have embraced the principles and goals of sustainable development. They are debating and selecting sustainability goals, setting policies consistent with those goals, and enacting related legislation. Initially there were serious questions on the degree to which mineral resources fit in sustainability, given that their sustainability does not follows the same pattern as the ecosystems or biological

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resources. However, people are coming to understand that mineral resources are an integral part of developed, modern societies and that a sustainable future is unachievable without the services they provide.

A thorough discussion regarding current issues on sustainable development, which impacts the minerals extraction industries was provided by myself on several occasions (Villas-Bôas, 1994, and Villas-Bôas & Beinhoff,2002)and does not need to be herein repeated. However, for the sake of clarity of the concepts to be explained and indicated, I strongly recommend their readings.

OLD AND NEW

It is my belief that some logical formalizations are needed regarding the concepts of sustainable development, sustainable development indicators, and even, sustainable ore body and sustainable mine, as referred to the minerals extraction industries.

If that is done, several misconceptions are prevented and all readers and involved parties would know what is been meant by such words. Thus, this proposed formal (logical-mathematical) framework for such themes and issues. I shall dwell upon then, latter in the article.

Also, it seems, the old Ricardo´s proposition on distinguishing between renewable and nonrenewable resources does not quite fit anymore, as such, in our actual, sustainable, development framework, for the sake of resource exploration and development, through its more recent paths and practices. Therefore, the suggestion of conceptualizing sustainable resources and no sustainable resources for that matter! These subjected to societal agreements, as proposed.

SUSTAINABLE INDICATORS

Indicators and indices package complex mineral information into understandable forms for stakeholders, decision makers and public use (Villas Boas & Beinhoff, 2002). These mineral indicators must be useful as analytical, explanatory, communication, planning and performance assessment tools. Indicators help people understand the complexities associated with mineral resource management policy decisions, such as the interconnectedness of physical and environmental systems and the inevitability of making tradeoffs among conflicting management policy objectives (Shields & Šolar, 2005). Thus, the information contained in indicators can contribute to public understanding of the state of the world and the potential consequences of fulfilling various objectives, i.e., they can facilitate social learning (ISG, 2004).

THE INDICATOR PROCESSES IN LATIN AMERICA

Background - In October 1999, CYTED (http://www.cyted.org), an official agreement between the Ministries of Science and Technology, or equivalent, in Iberoamerica, plus Portugal and Spain, launched via CYTED-XIII, one of its programs, a discussion on "Technological Challenges posed by Sustainable Development to the Mineral Extraction Industries", resulting in a publication under the auspices of CYTED, UNIDO, IMAAC and the Copper Study Group (Villas Boas & Fellows (eds.), 1999). Its aim was to prepare the mineral industries carrying on its operations in Iberoamerica to face the new challenges as well bringing government representatives into the new discussion.

Next year, 2000, enlarging the discussion, a "Mining Closure Experiences in Iberoamerica", document was presented and paved the road to present, in 2002, a publication titled Indicators of Sustainability for the Mineral Extraction Industry (Villas Boas & Beinhoff, 2002), which set forth some guidelines for starting the stakeholder process to conceptualize and build up such sustainable development indicators, taking into account:

- The particular branch of industry (metals, industrial minerals, energy minerals);
- The given physical environment in which the operations are conducted (rain forest, desert, temperate)
- The specificities of the country economy in which the operations are carried out;

- The existence, or not, of social pressure mechanisms in the particular region or country where the industry is located;
- The existence, or not, of R&D infrastructure in the region or country where the industry is located to measure some of the measurable effects.

Goals - Indicators are supposed to … indicate! However, what to measure and what, thus, to indicate? Formally, indicators are to be easily measurable and easily identifiable, when there is still time to act and propose solutions in a given set of risks/problems/performances. In reality, they measure the several, and eventually even contradictory, factors and events prevailing at a given predetermined time, in a given society or sub-sector of that society. Thus, creation of indicators brings together physical parameters, if identified and measurable, psychosocial parameters, whenever prevailing in the particular stakeholder group taking part in the creation process, inherently cultural parameters, "representative" of the region(s)/country(ies) where the action is taking place, etc. Indicators are a "mirror" of the anxieties of that set of stakeholders who established the indicator as a measure for the performance of industry and its commitments with sustainable development aims. They are dynamic in the sense of stochasticity, but can provide a minimum framework for decision-making and acceptance within a sufficient time.

Methods - Working Groups were established beginning in 1999 and continuing up to now, and are working under the aims and objectives of sustainable development on the following areas. The identified person and organization chair them:

- Land Use in Mining. (Luis Martins, INETI/IGM, Lisbon) 2003.
- Geomechanical Risks. (Roberto Blanco, ISMM, Moa, Cuba) 2001.
- Fertilizers in Iberoamerica. (Hugo Nielson, UNSAM, Buenos Aires, Argentina) 2000.
- Industrial Minerals and Building Materials. (Benjamin Calvo, E. de Minas Madrid, Spain) 1999.
- Mining Heritage. (Arsenio Gonzalez Martinez, UHU, Huelva, Spain) 2003.

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These working groups hold regular meetings and reports of their discussions are available at http://w3.cetem.gov.br/cyted-xiii. They are in the process of disseminating the methodology of the stakeholder-based approach for developing the indicators, and discussing some groups of indicators. As usual, at the beginning of the process, circa 2000, the environmental indicators prevailed over the balance of others, but the set is evolving to balance "social indicators", "community indicators", Amerindians rights, etc. The method of the working groups is not to develop or propose common indicators, since Iberoamerica, as such, is just a cultural background area, legislated through several different legal diplomas. Rather they encourage discussions and propositions within the existing legal framework and diverse social setting of a given region.

The sustainable development indicators are grouped into the following categories, following the four pillars of sustainability (Villas Boas & Fellows (eds.), 1999):

- Mass Flow Analysis: minimization of mass generation is a must for mining sustainability;
- Environmental Impacts: minimization of heavy metals into environment and wastes; open pit against underground operations;
- Process Energy: the Free Energy challenge;
- Social Satisfaction: maximization of social indicators (health, ecology, jobs, rent, social security, local environment).

Scale - This is a fundamental question, which has to be addressed at the very beginning of the process to establish a set of sustainable development indicators, so that time, efforts, money and energy are put at the right place, at the right amount. Normally, medium to large extraction companies do develop or are in the process of developing LCA type of procedures, such that some of the most obvious environmental indicators might be at hand; the large ones do have a set of social indicators at hand as well, which are quite helpful for some of their needs (company indicators). As a sector of an economy, as well, some indicators might be available, such as jobs, accidents, financing community events and festivals, total tonnage of extracted rock, federal, state and local tax payments, buying within a given municipality or region, etc. Sustainability, however, is an agreement that sets forward that your neighbor has to be as conscious as you are, otherwise there will be no major net gain. Thus, indicators have to focus on geopolitical areas. Realistically though, the process probably has to start from local or site scale and then expand.

Status - Since participation in the working groups are is voluntary, and they meet on average twice a year, and sometimes just once a year, their actions have been concentrated on disseminating propositions and results of discussions throughout their respective nets (industry, government and interested parties of their communities). It is envisaged that, by the end of 2005, some indicators might be available for reporting by several working groups.

Challenges and realities affecting the process - Geopolitical realities: In Iberoamerica, the geopolitical reality is a function of the geography of the region where the mineral development event is taking place: Andean, Amazonian, South Cone, Caribbean, Mezzo American. A given country could be made up of one, two or three regions, each having its particular interests and issues. Henceforth, sustainable development indicators must be set forth for this geographical reality, vis-à-vis the overall policies of the country towards that particular geographic region.

As an example of such, lets consider the following countries and their, eventual, outcomes in terms of SI. OIL and GAS not considered here, since they will tend to mask the overall process.

Chile and Peru: GNP deeply dependent on mining, possibly inducing to adopt a NATIONAL IS.

Argentina, Brazil, Mexico and Venezuela: important activity, however rather inexpressive in terms of global GNP, possibly inducing the adoption of LOCAL to REGIONAL IS.

Colombia, Ecuador, Bolivia: quite significant as ALTERNATIVE to other investments, possibly inducing REGIONAL to NATIONAL IS.

Mesoamerica: small but locally significant activity, inducing the adoption of REGIONAL, for the whole region, i.e., SUPRANATIONAL for that matter IS.

Caribbean: quite important for the whole of the region; adoption of NATIONAL IS. The island characteristics of this region do not induce the adoption of SUPRANATIONAL indicator, as the Mesoamerica case.

Difficulties in data collection: Some regions or countries have limited scientific resources, and therefore fewer capabilities to propose, test, monitor and validate data and data quality. Errs in data aggregation are also prevalent in some areas. Also, of importance, is the fact of the existence of SSM and garimpos in the whole region, which data is almost inexistent.

In Brazil, are very important, also, Profa.M.Amelia Rodrigues da Silva's – UFPa ,UNB - contributions on the discussions and propositions of SI. M.Amélia has been working on the IS of the mining industrial activity for the State of Pará, in the Oriental Amazon, and an example of such is given in her article in this book.

In Bolivia, Ms. Marthadina Mendizábal Rivera, from the Ministry for Sustainable Development, is conducting several discussions on the Rio+10 project: strategic alliances for Bolivia and her conclusions might lead to IS.

SOME (NECESSARY) FORMALIZATION REGARDING SUSTAINABILITY AND SUSTAINABILITY INDICATORS FOR THE MINERALS EXTRACTION INDUSTRIES

A) Sustainable development

A.1. Let

$$R \equiv \bigcup_{0}^{n} R_i$$

where

$R \equiv$ is the set of all <u>resources</u> as, for instance:

$R_1 \equiv$ natural resources

$R_2 \equiv$ environmental resources

$R_3 \equiv$ energy resources

$R_4 \equiv$ capital resources

$R_5 \equiv$ human resources

$\vdots \qquad \vdots$

$R_n \equiv$ any resource

and

$R_o \equiv \phi$, i.e., no resources at all

A.2. Let W be a <u>transform</u> such as

$$W : R \rightarrow D$$

where

$W \equiv$ is the transform <u>work</u>

$D \equiv$ is the set of <u>development stages</u>

and W a <u>surjective function</u>, i.e. it links at least one <u>argument</u> to every possible <u>image</u>.

A.3. Let:

$$S_i \equiv \bigcup_1^n \left\{ S_{i_1}, \cdots, S_{i_n} \right\}$$

be the set of development hypothesis where n is the number of subsidiary hypothesis which characterizes S_i respectively to D*

A.4. Now consider

$$S_d \equiv D \bigcup \left\{ S_{d_1} \bigcap S_{d_2} \bigcap S_{d_3} \bigcap S_{d_4} \bigcap S_{d_5} \right\}$$

where

S_{d_1} ≡ set of minimal use of natural resources

S_{d_2} ≡ set of optimal (or maximal) use of physical flow resources

S_{d_3} ≡set of minimal use of energy resources

S_{d_4} ≡ set of minimal use of environmental resources

S_{d_5} ≡ set of maximal social satisfaction states**

such as

$$s \in \bigcap S_d \leftrightarrow (\forall\, S_{d_i} \in S_d, s \in S_{d_i})$$

and S_d is a no empty set

$S_d \neq \phi$

* observe that $D \neq \bigcup_1^n S_i$, rather, S_i implies the acceptance of D !

** social satisfaction is the degree of societal acceptance of a given policy, or political agenda

A.5. Thus

S_d = set of sustainable development scenarios belonging to D and having as constraints

A.6. Then

$$\bigcap_{1}^{5} S_{d_i}$$

represents the goals and targets of a political agreement *, a political agenda, and setting for the agreed states of sustainable development **.

B) Sustainable development indicators

B.1. Having defined, formally, sustainable development, in order to measure it one needs an indicator or indicators.

B.2. Let define effort (T) as a function, or transform ,that attributes a positive number to every productive operation (P) or process.

B.3. Thus

$$T : P \rightarrow \mathbb{R}^+$$

defined by

T(p) = Γ

for every p $\in$ P and r $\in$ $\mathbb{R}^+$ and $\mathbb{R}^+$is the set of real numbers

B.4. Let define enhancement (E) as the benefit obtained by the person, or firm, x from y – also person, or firm – who performs or allows to perform the productive operation p

* In this regard sustainable development might be regarded as a ***Weltanschauung*** (meaning a "*look onto the world*" in German) rather than a full Khunian paradigm shift, i.e., that describes a process and result of a change in basic assumptions within the ruling theory of Science

** which, according Brundtland's report is the essence of *environmental sustainable development*

B.5. Let:

$E : X \cap Y \cap P \to \mathbb{R}^+$

such as :

E (x, y, p)– E (y, x, p) – T (p)

is the <u>measure of agreement</u>, (A), indicator of agreement, when the <u>enhancement</u> E (x, y, p) obtained by x from y through p, the disturbance T(p) which the <u>operation</u> p causes to x, and E (y, x p) the enhancement obtained by y as retribution to x to performs or allows to perform operation p .

Thus:

A (x, y, p)= E (x, y, p)– E (y, x, p) – T (p)

B.6. If

A (x, y, p) = 0

it implies a <u>mutual enhancement</u> or benefit for x and y

A (x, y, p) < 0

$x \in X$, loses

A (x, y, p) > 0

$y \in Y$, loses.

B.7. for a <u>community</u> or <u>nation</u> or any <u>social group</u> , G, where $X \subset G$ and $Y \subset G$:

$$A(x,y,p) = \sum_{x \in G} E(x,y,p) - \sum_{y \in G} E(y,x,p) - \sum_{1}^{n} T(p)$$

where n is the number of productive operations considered involving x and y .

B.8. If

A (x, y, p) is a <u>sustainable indicator</u> , As

Then

$$As = Sd \bigcup \{A_1, \cdots, A_n\}$$

where

A_i = is the set of agreements obtained under prevailing Sd conditions

C. Sustainable ore body

C.1. Let:

$$R_{S_i} = R \bigcup_{1}^{5} \{ Sd_1, Sd_2, Sd_3, Sd_4, Sd_5 \}$$

be the set of sustainable resources

C.2. a sustainable are body (Os) is such that

$$O_{S_i} = R_{S_i} \bigcup A_{S_i}$$

$$m \in \bigcap O_{S_i} \leftrightarrow (\forall A_{S_i} \in O_{S_i}, m \in A_{S_i})$$

where m is ore mineral reserve.

D. Sustainable mine

D.1. applying the transform W :

W: Os $\rightarrow$ M

where

M = Sustainable Mine Development

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Europe

SUSTAINABLE DEVELOPMENT INDICATORS FOR THE EU NON-ENERGY EXTRACTIVE INDUSTRY

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The Directorate-General (DG) Enterprise and Industry of the European Commission has policy responsibility for the non-energy extractive industry, which covers metallic ores, industrial minerals and construction minerals. Energy minerals, such as coal, oil and gas are covered by DG Energy. These paper therefore only deals with the non-energy extractive industry in the EU.

THE IMPORTANCE OF MINERALS FOR EUROPE

Minerals are essential raw materials for modern society, contributing significantly to its social and technological progress. Each person in Europe consumes on average almost 400 tonnes of minerals during his or her lifetime. Many uses are well known to a large public, such as sand & gravel for construction or gold for jewellery. But many applications are lesser known: the use of borates in the treatment of cancer, calcium carbonate in pharmaceuticals, or the use of silica in the glass of telescopes used in space.

The mining and quarrying industry which extracts these minerals therefore plays an important role in the industrial development of the European Union (EU), providing both jobs and value added to its economy. It has been estimated that collectively, the non-energy extractive industry within the EU25 generates approximately €36 billion of turnover and provides in the region of 270,000 jobs.

Taking value added in 2001 as an example economic indicator, it is possible to consider the three traditional sub-sectors – 'construction materials', 'industrial minerals' and 'metals', separately. Construction materials, which include ornamental and building stone, limestone, gypsum, chalk, slate, sand and gravel account for over 70% of the total value added for the sector - at approximately 10 billion €. Industrial minerals generated a further 2.1 billion € and the metals sector approximately 1.4 billion €. In passing, it is worth reflecting that these classifications are somewhat false, as some minerals are used for both construction and industrial purposes.

If these figures are compared with the value added generated by selected downstream industrial sectors which are dependent on the raw materials produced by the extractive industry - such as construction (almost 400 Billion €); metal products 190 billion €; or chemicals 160 billion € - it can be concluded that it is relatively small in comparison. The importance of the extractive industry therefore far exceeds its direct contribution to the EU economy.

EU SUSTAINABLE DEVELOPMENT FRAMEWORK

The classic Brundtland definition of Sustainable Development has been incorporated in the EU Strategy for Sustainable Development1, which was adopted at the Gothenburg European Council in 2001. This strategy requires that all policies should be judged by how they contribute to sustainable development, in other words, all major legislative proposals should include an assessment of the potential economic, environmental and social benefits and costs.

Even before that, in 2000 the Commission launched a Communication on promoting the sustainable development in the EU non-energy extractive industry2. It sought to reconcile the need for more secure and less polluting extractive activities while maintaining the competitiveness of the industry. A number of priority issues for sustainable development were identified. Many of these focussed on means of improving the environmental performance of the industry following the accidents at tailings management facilities at Aznalcóllar (Spain) and Baia Mare (Romania). Consideration was also given to other important

1 Communication of the Commission (2001) 264 "A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development"

2 Communication of the Commission (2000) 265 "Promoting Sustainable Development in the EU non-energy extractive industry"

issues, such as the availability of new land for future exploitation, the enlargement of the EU, Health & Safety performance, Research & Technological Development and stakeholder dialogue.

Currently work is being undertaken to evaluate this Communication. A key aim is to consider the extent to which the broad policy lines set out in the Communication have been taken forward. The study will also provide an assessment of the success or otherwise of actions taken, and help to identify if the key challenges which were identified earlier remain the same. This work is expected to be finalised by early 2006.

EU INDUSTRIAL POLICY FRAMEWORK

The Lisbon European Spring Council of 2000 set the policy objectives of making the EU the most competitive and dynamic knowledge -based economy in the world by 2010 – the so called 'Lisbon Strategy'. The Gothenburg Council in 2001 developed this further to ensure that the concept of sustainable development remained at the centre of European policy by requiring that economic growth, social inclusion and environmental protection should go hand in hand. Industrial policy3, and its key focus on the competitiveness of EU industries, is now recognised as being crucial if we are to pursue a balanced and coherent approach to sustainable development.

Many assessments have been made of the state of competitiveness of the EU and its component Member States against its global competitors, for example the annual reports from the Commission, and analyses are being produced for selected sectors of industry –including for the chemical, automotive and pharmaceutical sectors.

Unfortunately, these analyses have concluded that the goals set at Lisbon are unlikely to be achieved by 2010, and that they are threatened by weak sectoral specialisation within industry, a slow take up of Information Communication and Technology (ICT), skills shortage, and a regulatory environment

3 Communication of the Commission (2002) 714 "Industrial policy in an enlarged Europe"

which is not perceived as being business-friendly. In fact, the competitiveness of EU industries appears to be declining relative to that of our main competitors, such as the USA and Japan.

Last year the so called "Kok" Report4 concluded that the Lisbon Strategy was not on track to deliver the desired results. In response, the Commission adopted new policy recommendations at the last Spring Council. These policy recommendations, known as the Growth and Jobs strategy, stress the need to strengthen further the economic pillar of sustainable development, and set out an action programme for the EU and its Member States to generate sustained economic growth and more and better jobs. The objectives include reaching a target of 3% of GDP for R&D expenditure. It also seeks to improve European and national legislation to reduce the burden of administrative costs.

However, whereas industrial policy is horizontal by nature, it also pays particular attention to the sectoral dimension. Already in its Communication of 2003, entitled "Some key issues in Europe's competitiveness – towards an integrated approach", the Commission recommended the need for the systematic monitoring of developments and a review of the state of competitiveness of individual industrial sectors.

This need was further stressed in the new Communication on industrial policy5, which was launched in October 2005. This Communication aims at deepening and supplementing the framework for industrial policy by focussing on its practical application to individual sectors. The Communication is based on the screening of the competitiveness of 27 sectors of manufacturing industry6 . It sets out the main policy challenges that have been identified. The Communication presents a set of

4 European Communities, High Level Group, chaired by Wim Kok: *Facing the challenge: the Lisbon strategy for growth and employment*. November 2004.

5 Communication from the Commission on « Implementing the Community Lisbon Programme: A policy framework to strengthen the policy framework for EU manufacturing: towards a more integrated approach for industrial policy », COM(2005)474

6 Commission Staff Working Document « European industry : A sectoral overview », SEC(2005)1216

cross-sectoral policy initiatives and also highlights a number of sector-specific initiatives. For the extractive industry it mentions in particular the ongoing work on the in depth analysis of the competitiveness of this industry.

ASSESSING THE COMPETITIVENESS OF THE EXTRACTIVE INDUSTRY

Work on the assessment of the competitiveness of the non-energy extractive started already in 2004. One of the first tasks was to identify a number of indicators to characterise the industry. Economic indicators such as turnover, value added and production value, for individual Member States and the EU25 as a whole are available from Eurostat while data on the tonnage of different minerals which are extracted, imported and exported from each Member State are available from a number of national geological surveys.

Work is now being undertaken to further evaluate data from different sources, identify gaps and try to fill them. Another aspect of the work is to consider the factors that affect the industry. Different factors have been identified as important: access to land, levels of investment in exploration and production facilities, the legal framework in which industry operates, human resources, access to markets, research and development and globalisation. These factors do no stand alone, but are clearly interlinked.

Listening to representatives of the industry suggests that a key determinant for the future success of the extractive industry is its ability to gain access to new resources. It is an unavoidable characteristic of the sector, that unlike almost all other forms of industry, the choice of location is largely set by geology. Minerals can only be worked where they are found, and this can bring the industry into conflict with the other uses of land, such as urban development, agriculture, forestry and biodiversity.

An assessment of the land use and mineral planning policies of the EU25 Member States was completed recently by the University of Leoben in Austria. This examined the different legal frameworks within which the industry operates and determined the extent to which provision is made for the long term availability of minerals in the different countries. It is clear that there are different attitudes towards mineral extraction in different Member States, and indeed, within different regions within Member States. While some have clear policies for securing supplies in the long term, it is less clear in others. Obviously, if the industry and investors are to have the confidence to invest into the development of a site, it is important that there is some certainty that the investment will pay off.

This brings us to another driver of competitiveness, namely the fact that significant upfront investment is required to find viable resources and to start a site running. This can be in the order of millions of Euros, while the time to recoup the initial investment and make a profit, can be many years. This reinforces the need for a policy framework which is transparent and, as far as possible, predictable.

Regulation can bring with it added costs and administrative burdens. For the extractive industry, this relates in particular to regulations dealing with environmental protection and health and safety. There have been reports on difficulties experienced by extractive industry enterprises due to constraints imposed by the NATURA 2000 framework, which will require further analysis.

However, while there are costs to the industry of meeting the requirements of such legislation, it also has to be recognised that much of this legislation also directly benefits the industry. For example, it helps to provide the public and public authorities with confidence that site operations can be properly controlled and safe and that the land will be rehabilitated to a beneficial use once extraction has ceased. All this helps to reduce the scale of opposition to proposals to open new sites or to extend existing ones.

Health and safety regulation is also essential to minimise the risk of injury or death – both to the workforce and to those living in the vicinity of sites. It is not possible to prevent all accidents, and the industry remains one of the more hazardous industrial sectors. However, one has only to compare the number of fatalities now with those of a few decades ago, or to look at the continuing situation in some non-EU countries, to clearly understand the importance of the regulatory framework.

SUSTAINABLE DEVELOPMENT INDICATORS

It is increasingly recognised that if the industry is to achieve public acceptance it needs not only to operate in a sustainable manner, but also in a way that is transparent. An important initiative to achieve this was the publication in February 2004, for the first time, of a set of Sustainable Development Indicators for this sector.

The initiative was taken by the Raw Materials Supply Group (RMSG). This is a stakeholder group, chaired by DG Enterprise and Industry, which comprises representatives from Member States, candidate countries, industry federations and other stakeholders.

At the end of 2000, the RMSG created a specific Working Group in order to develop a set of indicators for the non-energy extractive industry. The participants were experts from industry, the Commission, and other stakeholders such as an environmental NGO and a university.

Objectives and target audiences

The primary purposes of the set of indicators developed by the Working Group are:

- to encourage dialogue at European and Member States level about how the non-energy extractive industry can best contribute to a sustainable Europe
- to widen the range of information that will be needed for an informed public dialogue
- to highlight trends and priorities related to metal and mineral systems, and

The outcomes of the initiative, the indicator sets, are likely to be of interest to a number of audiences:

- industry itself can use the indicators to better demonstrate their economic and social welfare benefits as well as their environmental efforts
- the national, regional or local administrations who have to examine the performance of industry and to grant access to land for mineral extraction
- the general public including NGOs and the media which are concerned with mining activities, in order to better understand the industry's needs and constraints

The stakeholder process

The Working Group was set-up in 2000 and met eleven times, with extensive consultation occurring between meetings. It was agreed at the outset that the indicators should report neutral, science-based information and not imply by their wording a preconceived conclusion about the contributions of non-energy minerals to sustainability. A first list of 31 indicators was subjected to a pilot test at the end of 2001, which involved 152 sites. As a result of this exercise, the list was shortened to provide 13 priority indicators covering the activity of the industry (company level indicators) and 7 Member State level indicators. They were not developed with a specific regulatory or policy application in mind, but instead were chosen because they provide a useful picture of the sustainability of the industry, while the data collection requirements are considered to be achievable.

Representatives of the Member States, however, identified that the data required to construct the Member State level indicators was problematic due to the lack of a legal base for this exercise. In the mean time some progress has been made on some indicators through our contacts with Eurostat, the statistical body of the European Commission.

However, the Working Group did not await the final outcome of this process, but proceeded with the data collection on the indicators at company level. A questionnaire and guidance document explaining how to complete it was developed for the company level indicators. This was then circulated to individual companies via their trade associations by the end of 2002. It is stressed that the exercise was voluntary, and companies were invited to participate. The responses from companies were sent to their associations which collated the data received, before forwarding the aggregated data to the Commission.

The first report[7]

Results were obtained for the metals and industrial minerals sub-sectors. The data for the metalliferous sub-sector are estimated to represent 60% of the companies in the EU (based on the numbers of employees rather than turnover or other indices). For the industrial minerals sub-sector it is about 40%. Unfortunately, because of the large number of small companies supplying construction minerals, it did not prove to be possible to obtain a meaningful set of data for this sub-sector for 2001, so their results are not presented in the first report.

In the first report the figures are presented without any "official" interpretation of the data. Instead, they are presented to encourage individuals and groups to make their own assessments, combining and interpreting the indicators as they deem appropriate. The members of the Working Group anticipate that most stakeholder groups would agree on some points of interpretation but disagree on others. This diversity of thought should play a major part in the public debate about the role of non-renewable resources in a sustainable Europe.

The way forward

A second report is currently under preparation, which will present data for the period 2001 till 2003. It is hoped that by continuing this exercise it will be possible to identify trends and to help identify where action is required. Nevertheless, there are still some big challenges to be faced: further integrate the new Member States in the reporting scheme and continue to increase the participation by SMEs. The reporting on these indicators

7 Available at: http://europa.eu.int/comm/enterprise/steel/non-energy-extractive-industry/sd-indicators.htm

remains a process of continuous improvement. The feedback given by the companies that fill in the questionnaires is taken into account when improving questionnaire and guidance document.

The use of voluntary initiatives, such as the development of the sustainable development indicators and related work on Corporate Social Responsibility can in some cases provide an effective alternative to regulation. Industry is encouraged to continue its efforts and look for further opportunities.

CONCLUSIONS

So in conclusion, industrial policy is at the heart of European politics. It is in fact considered essential to have a competitive industry in order to be sustainable. The EU extractive industry is an important provider of raw materials which are vital to the European economy and to the quality of life of European citizens. It is important that it is able to remain competitive in an ever increasing global market. It is recognised that industry as a whole needs a more supportive policy framework to help it compete on a global scale.

The Commission is working closely with the industry and Member States to achieve the Lisbon objectives and the competitive success of the EU non-energy extractive industry.

The European Commission will continue its work to improve the framework conditions under which the minerals industries operate. But it is up to industry to face the issues, use the opportunities available, and improve its image wherever possible. In this respect, it is very important to develop pro-active approaches, of which the development of indicators for this industry is an excellent example. The Commission will continue to facilitate the efforts undertaken in this field.

INDICATOR OF SUSTAINABILITY FOR THE MINERAL EXTRACTION INDUSTRY: CASE STUDY SLOVENIA

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Abstract: The indicators of sustainability that monitor all spheres of human living are being applied to the mineral sector. This is an opportunity to gain information for balanced solutions that fit the specific conditions of each particular mineral operation or activity, as well as the unique situation in each country. Presented case study from Slovenia on indicator for aggregates points out the extension of the opportunity.

Key words: sustainable development, principles, mineral resources, exploitation

INTRODUCTION

Humans affect their environment in many ways. They transform forests into agricultural lands, convert that farmland into cities, and build transportation networks to connect the cities together. They also affect the environment directly and indirectly through daily activities such as driving to work or buying consumer goods. Vehicles emit pollutants, make noise and cause vibrations. Manufacturing and disposal of the products impact the environment.

Of interest to us here is the fact that there is a mineral component to most human behaviors, whether land altering or personal. Quarried materials are needed to construct buildings and roads, and metals are used in many consumer goods. Mineral resources are part of human well being throughout history. Mineral resources are fundamental to human wellbeing; they are essential to virtually every sector of the economy, are the basis for the human-built environment, and provide desired services.

In the recent past, mankind has also raised questions about the negative impacts of mineral extraction and use. The provision of minerals alters the landscape and can cause significant environmental impacts. Public concern about environmental degradation, including that related to mining, has increased as it has become more widely understood that human societies exist within and are ultimately dependent upon the services provided by the earth's physical, chemical and biological systems.

Mining is one of the most significant human effects on environment. Because in past there has been a lot of damage, now there is lots of opposition to minerals exploitation. A way to overcome this situation is to apply sustainability principles that would put negative impacts and benefits of mining into socially acceptable balance. Maximizing benefits and reducing costs are the main goals of sustainable minerals management.

MINERALS SUSTIANBILITY & INDICATORS

Mineral resources, as an integral part of country's overall sustainability considerations, are to be managed in a manner consistent to sustainable development principles. Sustainability can be thought of as a hierarchy. At the top is the goal of sustainability, the strategic objective. This is a broad, over-arching, vision statement that provides the rationale for policies, practice, and initiatives related to sustainable development. Next come principles, which are fundamental truths or laws that form the basis of reasoning or action. Principles are general, but can also have spatial, temporal and other limitations in order to make their definition more operational.

Principles are in turn supported by criteria. Criteria describe what it means to be sustainable; they describe the characteristics of a sustainable system and so are comparable to fundamental end-state objectives. Criteria serve as basis for evaluation, comparison or assessment. Achievement of objectives is judged against relevant indicator(s), which describe, display, or predict the status or trend of some aspect of sustainable development.

Indicators serve three basic functions: simplification, quantification, and communication. They are parameters (properties that are measured or observed), or measures derived from parameters, which provide information about the state of a phenomenon, environment, or area, with a significance extending beyond that directly associated with a parameter value. An index is a set of aggregated or weighted parameters or indicators.

Indicators of sustainable development are tools for knowledge, information transfer. The most comprehensive way to monitor and review the managerial practices is by using the indicators. Hence, indicators are used to monitor the implementation of the policy, laws, acts, regulations, programs, plans etc. They are also used in the so-called policy path of policy cycle, which needs more information than does the more straight-forward regulatory path. Data or databases for monitoring policy and regulatory paths are in many cases the same, because there is no need to have a double data collecting, storing or analyzing. Collected data should be consistent, accurate for the purpose.

Transformation from raw or analyzed data to indicators and/or information is sometimes influenced by à priori assumptions, biases, or interpretations. To the degree that the neutrality of the information is compromised, this can make an indicator irrelevant to some stakeholders. Finding the balance, or the point at which indicator becomes accepted by consensus by the stakeholders, is one of the most important tasks in the process of defining an indicator. Within this process several other issues are also significant: a) the relationship among individual indicators or groups of indicators of the indicator set, b) the relationship to "neighboring" sets of indicators on the same scale and, c) the relationship to indicators at different scales. Indicator organization within the information pyramid can provide many of the answers. Differences between ideal, theory-driven indicators, and real-life, data-driven, indicators need to be considered. Spatial scale and different classifications (mineral resource, production size, etc.) give opportunities for aggregation or dis-aggregation.

Exploration, exploitation, processing, use and disposal of minerals (cycle) are regarded as one complex issue that needs a huge amount of science-based information if it is to be addressed effectively. Geoscientists in particular produce information on the exploration stage of this cycle. Information on mineral assessment is dependent on the investor's interests. Some information has business or political restrictions, and so access to those data may be limited. In may cases, mineral assessments garner lots of public attention regardless of scale. How broadly the results are used is a variable of an enlightened research investor and how important the research issue is to current public interest.

Useful mineral information should be provided at each stage of political debate (detailed policy cycle). In addition, mineral information should satisfy multi-stakeholder needs by facilitating multi-scenario solutions within the frame of what is called sustainable mineral resource management (SMRM). The goal of SMRM is not to sustain a single deposit or mine, but rather to sustain the flow of benefits and services from those resources in such a way that their contribution to society over the life cycle is net positive.

Three characteristics of SMRM related to data and information manipulation are that: (a) the boundary between the public's right to be informed and the right of investor not to share information must be carefully defined; (b) information should be evaluated in terms of planned assessment goals and also in terms of general or more detailed applicability in other fields of uses; and (c) study results need to be translated into information that is meaningful to the broader public, not just experts of discipline. Information should influence information receiver's values and objectives in a positive manner.

The objectives of an SMRM plan and the form it takes differ between regions and countries due to the interplay of differing value sets, goals and objectives. Because the goals and objectives are slightly different in each country or region, different indicators have emerged. European cases studies with similarities and differences were compared, where there are similar open issues, but different geology, and history. Sets of indicators were described and comparison among them was made from two regions, one in United Kingdom, and the other from Italy, while Slovenian case was observed on the national scale (SDIMI 2003 paper). The latter will be described in detail in next section.

SLOVENIA CASE STUDY

As noted previously, mineral resources, including construction materials, are integral to every country's sustainable development. Large infrastructure or building projects require substantial material inputs, and their provision should be handled in a manner that is consistent with sustainability principles. Development of a SMRM plan, and creation of related indicators, will increase the likelihood of this occurring.

The 1999 Slovenian Mining Act (partly revised in 2004) mandated the development of a mineral resource programme, the current draft of which is based on sustainability principles. The Mining Act states that, "The National Mineral Resource Management Programme … shall provide the goals, policies and conditions for the coordinated exploration and exploitation of mineral resources in Slovenia …". An effort has been made to incorporate the basic sustainability principles in the National Mineral Resource Management Programme into two main themes: (1) ensure that a reliable supply of mineral resources is provided to society in a manner that appropriately balances social, economic and environmental concerns, and (2) ensure that future generations have access to the mineral resources they will need.

Slightly fewer that 2 million people live on the Slovenian territory of about 20.000 km2. In the last few years the annual growth rate of the economy has been approximately 4 %, the unemployment rate 7 %, inflation around 5 %, and per capita income 18.000 USD. In 1991, the country attained the independence from ex-Yugoslavia, changed the social and economic system, and started the process of integration into the European Union.

Geology controls the location and quality of mineral resources. Lithologically, Slovenia is mostly composed of sedimentary rocks (over 90 %). Carbonate rocks prevail slightly over clastic rocks, with only a small percentage of metamorphic and igneous rocks. Identified resources of aggregates in Slovenia are virtually infinite, although not all geological resources are extractable.

In recent years mineral development in Slovenia has been significantly reduced so that, by the turn of the century, quarrying was the prevailing form of resource extraction in Slovenia. The aggregate industry has survived, in part, because domestic demand is being met with in-country production. In fact, aggregate demand has increased considerably in recent years due to a state highway construction program. Theoretically, mining is allowed only in designated exploitation areas, and is to be conducted under strict environmental oversight. In reality, landscape superintendence has been weak and enforcement of environmental regulations has been lax. At a time when permitting of new quarries is extremely difficult and time consuming, informal miners have faced few legal consequences for their actions.

Although many aggregate quarries remain open, the sector faces two kinds of challenges. First there is growing pressure to restrict extraction. This is occurring for a combination of reasons: (1) public mistrust of the industry and decisions associated therewith; and (2) demands for compliance with costly environmental regulations. Second or economic pressures: (1) increases in the cost of land, which has become enormously expensive as people have begun to incorporate the value of mineral resources in the sale price; and (2) the hindrances and extra demands (mostly in monetary terms) being placed on the mining industry by local communities. An effective policy on aggregates is needed to correct this contradictory situation.

AGGREGATE INDICATOR

The first step in utilizing the SMRM approach to develop a Resource Management Plan is to identify stakeholders and their values and objectives regarding quarries and aggregates. Public objectives and preferences range from total rejection to welcoming acceptance depending upon the individual’s proximity to a quarry, type of interest (economic, environmental, nature conservation, etc.), and decision making power or influence. Consider for example the objectives of three different stakeholders. These objectives were expressed to the author during various discussions, meetings, and roundtables held between 1998 and

2002. Participants included government, industry, local community, and NGO's (non-governmental organizations).

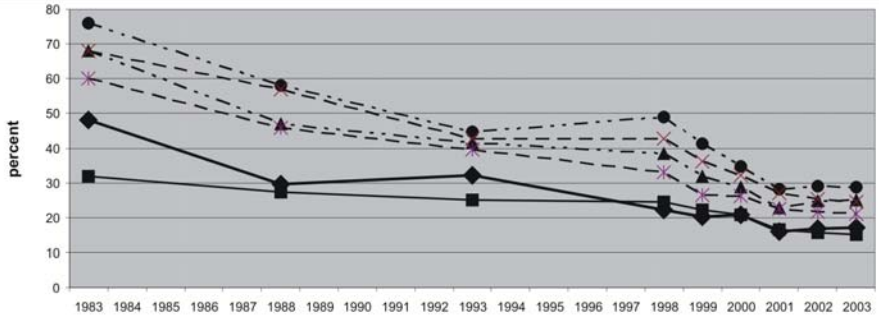
Industry: Their objective is a stable operating environment, including sufficient sales, production to support sales, and adequate reserves and resources.

Government (Spatial Planning Department): Their objectives include reduction of environmental degradation (to be accomplished through a reduction in the number of quarry sites), regional supply of aggregates, and zoning areas of aggregate resources.

Local Community: Their objectives include minimizing negative effects, such as visual intrusions, and ensuring that quarry operations deal with environmental impacts, site closure, and reclamation.

The foregoing objectives can be summarized as: (a) maintain access to adequate reserves and receive permission to mine in acceptable locations; (b) eliminate small, unregulated quarries; (c) disallow super-quarries that cause significant disruption; and (d) close or disallow quarries that are so distant from their markets that commodity transport becomes disruptive to communities.

Having identified objectives, the next step is to develop management alternatives that respond to those objectives and then describe the alternatives using available information. Aggregates can be supplied in numerous different ways. Assuming that some supply alternatives are feasible and sustainable, the next stage in the process would be public debate, negotiation and selection of an alternative to be implemented. Final selection requires some level of stakeholder consensus. Public preference among alternatives will be predicated upon each stakeholder's weighting of different objectives, e.g., minimizing the number of quarries versus minimizing transportation impacts. Tradeoffs will inevitably have to take place because it is not possible to optimize everything, everywhere simultaneously. The desired outcome included in mineral resource programme draft is for a high percentage of legal quarry sites to have what are termed acceptable production and enough reserves/resources. For Slovenia, a "proper" quarry would have (acceptable) production annually between 50.000 and 500.000 tons, and (enough) reserves for between 10 and 50 years of average production. These levels were chosen so as to address the competing objectives of the stakeholders listed above.



	1983	1988	1993	1998	1999	2000	2001	2002	2003
A	**48**	**29,6**	**32,3**	**22,3**	**20,2**	**20,7**	**15,9**	**16,9**	**17**
A (v)	32	27,2	25	24,5	22,3	20,7	16,5	15,7	15,2
B	68	46,9	41,7	38,3	31,9	28,7	22,9	24,7	25,1
B (v)	76	58	44,8	48,9	41,4	34,8	28,2	28,9	28,7
C	60	45,7	39,6	33	26,6	26,2	22,4	21,7	21,1
C (v)	68	56,8	42,7	42,6	36,2	32,3	27,1	25,3	24,6

Figure 1 - Indicators for Aggregates for Years 1983–2003

Legend:

A: Percentage of legal quarry sites that have (acceptable) production annually between 50.000 and 500.000 tons, and (enough) reserves for between 10 and 50 years of average production (based on last 5 years).

A(v): Percentage of legal quarry sites that have (acceptable) production annually between 50.000 and 500.000 tons, and (enough) reserves and resources for between 10 and 50 years of average production (based on last 5 years).

B: Percentage of legal quarry sites that have (acceptable) production annually above 50.000 tons, and (enough) reserves for more than 10 years of average production (based on last 5 years).

B(v): Percentage of legal quarry sites that have (acceptable) production annually above 50.000 tons, and (enough) reserves and resources for more than 10 years of average production (based on last 5 years).

C: Percentage of legal quarry sites that have (acceptable) production annually between 50.000 and 500.000 tons, and (enough) reserves for more than 10 years of average production (based on last 5 years).

C(v): Percentage of legal quarry sites that have (acceptable) production annually between 50.000 and 500.000 tons, and (enough) reserves and resources for more than 10 years of average (based on last 5 years).

Figure 1 presents the main indicator plus a series of auxiliary indicators. The main indicator incorporates an upper limit on production that has been set in response to the significant negative environmental and social impacts of larger operations. An upper limit on reserves (resources) reflects the fact that for large reserves (resources) stock, larger areas need to be exclusively reserved for extraction. That may increase the possibility for potential land use conflict. The lower limit on production and low reserves/resources was included because small and short term operations are not desired by the public, in part because they may not earn profits adequate to ensure environmental protection..

These limits are arbitrary to some degree, especially upper limits. For that reason, the conditions were altered in the auxiliary indicators. Some of the auxiliary indicators remove the upper limit of production and reserves, or use only reserve estimates. Other auxiliary indicators use both reserves and resources (probable stock of mineral resources). The main indicator is more easily interpreted when contrasted with the auxiliary indicators.

The main and auxiliary indicators are national in scale. The main indicator’s trend is negative; the number of improper quarry sites increased in the period 1983–2001. Two major discontinuities occur because data became more accurate in 1998, and then the revised mining act was passed in 1999. From 1999 on, control over operation licenses transferred from local to national control. Starting in 2001, all operations were obligated to pay a mandatory royalty.

In year 2001 the number of sites with insufficient production and reserves (& resources) was higher than that desired by stakeholders and the government, based on stakeholder input and government statements. Conversely, there are only a very few locations having production above the upper limit. This can be seen clearly by examining the auxiliary indicators that do not have an upper limit on either production or reserves (& resources) or use only reserves (& resources). Approximately 5 % of all locations are larger than desired, but over 70 % of locations have insufficient production and reserves (& resources).

ADDITIONAL INFORMATION

The indicator (together with auxiliary indicators) resides at the top of an information pyramid that provides a wide range of spatially dispersed information. While useful and informative, the indicator we present here cannot alone tell the complex story of sustainability. Rather it is intended as one of a set of indicators that, when taken together, describe how implementation of the national mineral resource management programme is affecting the sustainability of Slovenia.

By looking lower on the information pyramid second order indicators for aggregates can be found. These indicators address information on different scale (country divided into three regions and into twelve regions. The latter can be aggregated into three regions and three regions can be aggregated on country scale. There can also be indicators on lower scale, such as administrative units or even lower – municipalities. In this exercise indicators on administrative and municipality level were not observed.

Further more aggregates can be classified into several types. For the purpose of the case study with regard to geological settings of the country, aggregates were classified into two major groups: crushed stone and gravel (with sand). Crushed stone was separated into three classes: limestone, dolomite and silicate rocks.

More detailed information was obtained with regard to the production classification that was consistent with main indicator interval into three classes: (a) below 50.000 t of annual production, (b) between 50.000 and 500.000 t of annual production, and (c) above 500.000 t of annual production. To get even more detailed picture production size distribution was divided into seven classes that could be aggregated into three, described above, classes. The detailed information was also obtained with regard to (1) reserves and (2) reserves and resources. There is separation into three and seven classes. Three class size distribution is also consistent with the main indicator intervals.

This huge amount of information can be displayed in many different ways to support the national mineral resource management programme. Ways of displaying the data and information that were used are following: (a) in intervals so as to present trends, (b) comparison within the data with average and aggregated average (regional data versus national data/ information), and (c) comparison to desired state of the world.

Gathered indicators are useful for many stakeholders on national, regional, and even municipality levels. Stakeholders are representatives of public authorities, industry (investors, mining companies) or non-governmental organizations. This information has an educational aspect, beyond being strictly informational. Communication of data, information and indicators is an important segment of indicator message, because the way that indicator is presented can influence the information user's perspective.

OPEN ISSUES – INDICATOR DISCUSSION

Inevitably, many practical problems have to be solved during the process of indicator creation. In the Slovenian case, the indicator selection process had to deal with unrealistically high stakeholder expectations that complete information would be incorporated into a single indicator, when in reality only a limited amount of information was actually incorporated in the selected indicator. That indicator was based on available data that had been collected over a long period of time. During the reporting period, data accuracy was inconsistent; in the 1980's data on location, production and reserves were collected only from what at that time was termed large aggregate sites. Data accuracy is also questionable, due to the fact that many quarry operators were not filling out the annual questionnaires in the same manner. There were particular problems related to reporting on reserves and production in cubic meters. No clear distinction was made between cubic meters of intact mineral resources (in site) and dispersed cubic meters of mineral resources on tracks (of production). As a result, data were calculated into tons under the assumption that all cubic meters were dispersed.

The question of the adequacy of existing data needs to be addressed. Will existing data provide enough information to enable decision makers and stakeholders to compare and discuss the full range of costs and benefits associated with alternative resource management plans? In the case of Slovenian supply of aggregates, the answer is clearly no. Only a portion of the needed information is available. Historic demand and predictions of future demand were not utilized and the implications of significantly higher or lower demand were not considered. Second, it is impossible to devise management strategies that reflect public objectives without full information on what objectives stakeholders have. The objectives discussed above represent the positions of only three stakeholder groups, not the full range of opinion.

CONCLUSIONS

SMRM is about what to do (content) and how to do it (process). It occurs at the intersection of the public's values and objectives, science and information, and government policy. Important thoughts on using SMRM as a tool to achieve sustainable development are: (a) think in scenarios, (b) share useful information, and (c) link mining (mineral resources) to other land use activities. Sharing information through indicators is one of many ways that experts can engage in the policy and management debate. A selected set of mineral indicators should express a need for balance: (a) among stakeholders; (b) between the process of defining indicators and the set of chosen indicators; and (c) among dimensions of sustainability. Mineral indicators of sustainability should be used: (a) as tools for knowledge, information transfer; (b) integral parts of other initiatives and sets of indicators; and (c) as a solid base for decision making.

The case study addresses the sustainable supply of aggregates indicator for Slovenia that is based on policy goals of industry, government and civil society. The indicator is intended as one of a set of indicators that would tell about the trends of implementation of the part of the national mineral resource management programme. The sustainable supply of aggregates indicator is on the top of information pyramid that provides a wide range information that is spatially dispersed information and useful on different levels and to different stakeholders. The information pyramid includes auxiliary indicators, i.e., indicators of lower order. All information is stored in suitably organized databases that provide an easy access.

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TURKISH PERSPECTIVE ON INDICATORS OF SUSTAINABILITY FOR THE MINERAL EXTRACTION INDUSTRY

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ABSTRACT

Mining, along with agriculture, is a major activity of humans that has been providing the necessary resources for survival and development of the communities throughout the history. Use of mining products has shaped the civilizations and even named the eras in pre-history with its progressive products, as "Stone, Copper, Bronze and the Iron Ages". Combined use of mining products, fossil fuels and petroleum have accelerated development rate of the communities in the last 200 years.

Survival, let alone development, of the countries is not possible without use of their natural resources. Providing subsistence, shelter and basic daily needs for more than 6 billion people is a heavy burden on the natural resources worldwide. Some geographical localities are inherently lucky in availability of agricultural land, fuel and mineral resources. Under the premise of resource conservation and pollution prevention while utilizing their resources without compromising the needs of the future generations, assessing sustainability of social and economic development requires that the countries had reached "*a level of development*". However, on the other hand, it should be kept in mind that development without due respect to environmental values is also not sustainable. In this context, main task of the current generations in the developing countries is to benefit from their natural resources in an environment-friendly manner in order to provide their future generations a better quality of living conditions to further their developments.

Nowadays, mining and chemical manufacturing have a perceived negative image in the communities in general. The reasons why the mining and chemical industries have this image lie in the heightened environmental awareness of the general public based on some justifiable reasons and some misinformation on what a mining activity is about. Unfortunately, the mineral explorations and new investments in mining have lost its momentum especially in the developing countries due to the deliberate spread of misinformation by oppositional environmental movement campaigns and reluctance of the governments to manage such social concerns adequately. As a result of the decelerating exploration expenditures and mining investments, a shortage in metallic ore supply is anticipated in the near future for a world population reaching 6.5 billion. Impact of such a shortage will definitely be a concern for Sustainable Development.

SUSTAINABLE *(SUSTAINABILITY OF)* DEVELOPMENT

Communities are in a continous struggle to provide food and shelter and improve their quality of living for their current and future generations. However, ever-increasing world population and growing environmental concerns draw a bleak picture on sustainability of the current development level.

The term "Sustainable Development" is used for all occasions in every day language, mostly to make reference to an uncertain future. Even though this concept has "integrated social, economic and environmental" dimensions, the *environmental protection* aspect has been receiving more attention to the extent as if it is "the only" component in Sustainable Development.

Sustainable development is defined as "the development, which meets the needs of the present without compromising the ability of future generations to meet their own needs" in the 1987 Bruntland Report, where the emphasis is on "meeting the needs" of the communities with due respect to the future generations [1].

It should be realized that the primary concern for sustainability of development lies in *rapid increase in population*, which induces increase in basic needs for "food and shelter" and a social need to "improve living quality". It is also a fact that industrial growth to address such community needs apparently endangers the resources of the future generations due to excessive use of natural raw materials and environmental pollution caused by improper management of generated waste. Within this context, Sustainable Development can be rephrased as: "*integrated social and economic development achieved while conducting agricultural, animal farming, fishing, mining and industrial production activities without wasting natural resources and in a manner with due respect to human health and the environmental values*". Therefore, from the management point of view, the fundamental factors in Sustainability of Development are:

- Control of population increase - *reduction in needs*
- Natural resource conservation
- Waste management } - *optimization in production*
- Pollution abatement and remediation - *past damage reduction*

Sustainability of Development can only be achieved if an adequate balance is kept between its three pillars; namely, social, economic and environment. An absence of such a balance in the last twenty years was evident both in outcome of the 1992 Rio and 2002 Johannesburg Sustainable Development Conventions that revealed not enough efforts had been spent towards sustainability at a global level, specifically in the field of environmental protection.

Improvements in the social and economical well-being of the communities is an apparent indicator of development. Application of global Sustainable Development criteria on an undeveloped country with natural resources has limited validity, if any. Development requires generation of basic goods and services needed by the communities. In as much as incresead added value generated during production of goods boosts the social and economic development, resultant environmental problems may eradicate the economic benefits in the long run. While greater emphasis is placed on meeting the demand of basic needs of the community, the process of development in social and economic areas should also take into account "resource conservation and waste minimization" and "pollution prevention" principles.

Beneficiation efficiency of natural resources and effetiveness in environmental protection has a direct relationship with the current level of development of the countries. In utilization of natural resources, undeveloped and developing countries have an apparent handicap to implement "resource conservation, waste minimization and environmental protection" due to lack of meeting the basicneeds, training, environmental awareness, know-how and financial means.

ENVIRONMENTAL AWARENESS

The growth of environmental awareness in developed countries started about four decades ago as a public reaction to apparent industrial and urban air pollution. It is worth noting that this awareness came only after growth of per capita Gross National Product ecceeded levels to meet the basic needs of the communities in the developed countries. Curbing of environmental degragadation is the end result of regulatory enforcement of the state and municipal governments and implemention of appropriate environmental protection measures by the developed industry.

Growth of environmental awareness in the developed countries has been instrumental in:

- making the concept of environmental protection part of the daily life for three generations, making it part of culture,
- gradual establishment and improvement of appropriate and adequate infrastructure and environmental mitigation measures, *even though they may be considered "not fully satisfactory" for all the members of the public,*
- establishment of a legal environment where all parties are aware of their responsibilities and liabilities on environmental matters,
- continuous economic growth with adequate expenditures allocated for environmental protection.

The concept of environmental awareness had reached the developing countries in early 1980s. As a consequence of the globalization of environmental movements and developments in global communication means, awareness level of public in the developing countries on environmental issues has reached the level of the developed countries in a very fast pace. Even though the perception of environmental awareness today *(or people's wishes)* is as high as the developed countries, there are major differences for the developing countries in achieving the level of environmental quality and efforts spent towards environmental protection. The case for the developing countries is likely the following:

- The current generation is under an imposed *(not necessarily digested)* environmental awareness to implement modern concepts of environmental protection without adequate funds, where younger generation lacks adequate guidance in education and training on environmental issues. Whole community complains of inadequate environmental protection efforts and environmental quality,
- Environmental protection infrastructure is inadequate or non-existing and sufficient funds are not available for appropriate new infrastructure and proper operation of the existing facilities,
- Globally applied environmental legislation is in place, sometimes with stricter permitted discharge/emission criteria; however, not enforced adequately. Environmental responsibilities are assigned and recognized by the public management authorities and the industry; but performances are questionable and noncompliance cases are penalized randomly.

People, driven by fear rather then educated response, are over-sensitive to any investment that may have impact on health and environmental conditions; and likely oppose to any new industrial activity due to ambiguities in the regulatory environment and/or political reasons.

The depiction above for the developing countries fits fairly for Turkey. The last point above is specifically valid for the mining industry in Turkey.

ENVIRONMENTAL QUALITY VERSUS ECONOMIC WEALTH

Per capita Gross Domestic Product (GDP), generally used as an indicator of economic wealth, is a measure of economic activity of the countries defined as the value of all goods and services produced less the value of any goods or services used in their creation. Following the 1987 Bruntland Report, application of Kuznets curve to environmental values has been a popular tool for numerous studies to assess possible relations between the state of pollution (or environmental quality) and GDP. The Environmental Kuznets Curve (EKC), being an empirical tool, hypotesizes that environmental quality in low per capita GDP countries could be as good as the developed countries but degrades in the developing countries and later improves with further economic development following an inverted U-shaped trend. An example of EKC for SO_2 emmissions versus per capita GDP is presented in Figure 1a.

(a) For Sulphur Emissions *(b) Alternative Views*

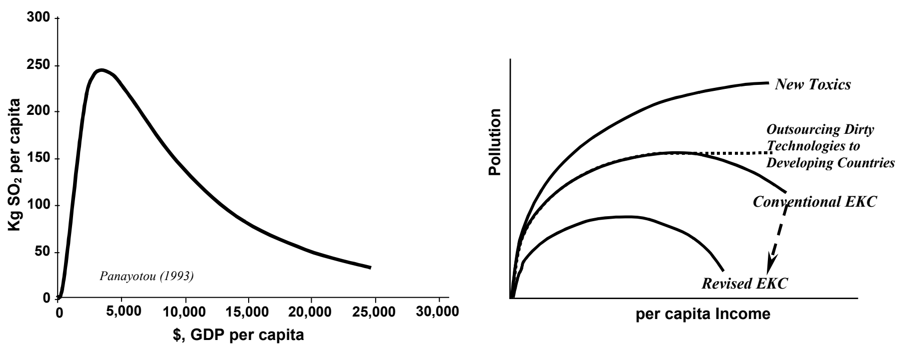

Figure 1 – Kuznet's Curve Approach to Environmental Quality versus Economic Wealth [2,3]

EKC approach may have reasonable grounds based on past observations of pollution increase in the countries that were on the way to industrialization. However, numerous empirical testing of this hypotesis reveal that EKC has inherent limitations and cannot be generalized for all pollution indicators. In as much as the inverted U-shaped trend is still applicable, recent reviews of the EKC concept suggests that the magnitude of pollution levels may be higher for releases of newly developed (or monitored) chemical releases whereas the conventional pollutants in the environment are at much reduced levels, as schematized in Figure 1b [2,3].

Developed countries of today are indebted their economic wealth to rapid growth in their industrial activities in the last three decades. Industrial activities heavily rely on utilization of natural resources; namely, energy *(oil, gas and coal)*, metallic and non-metallic minerals resulting CO_2 emissions. It is a common perception that the environmental quality is relatively better in the developed countries than in the developing countries. Currently, there is no globally accepted performance criteria to characterize the environmental quality at country level. However, there is a direct relationship between the economic growth and CO_2 emmission rates, where per capita CO_2 emmission rates are significantly higher in the developed countries, making "sustainable development" a real concern.

At macro level, time-series data for CO_2 emissions is a relatively good gross indicator of past industrial activity of the countries. A graphical presentation of the annual per capita CO_2 emmissions versus per capita GDP time-series data of select mining countries for the 1980-2000 period reveals the relationship between industrialization and economic growth, reminiscing the rising segment of a Kuznet's Curve (Figure 2).

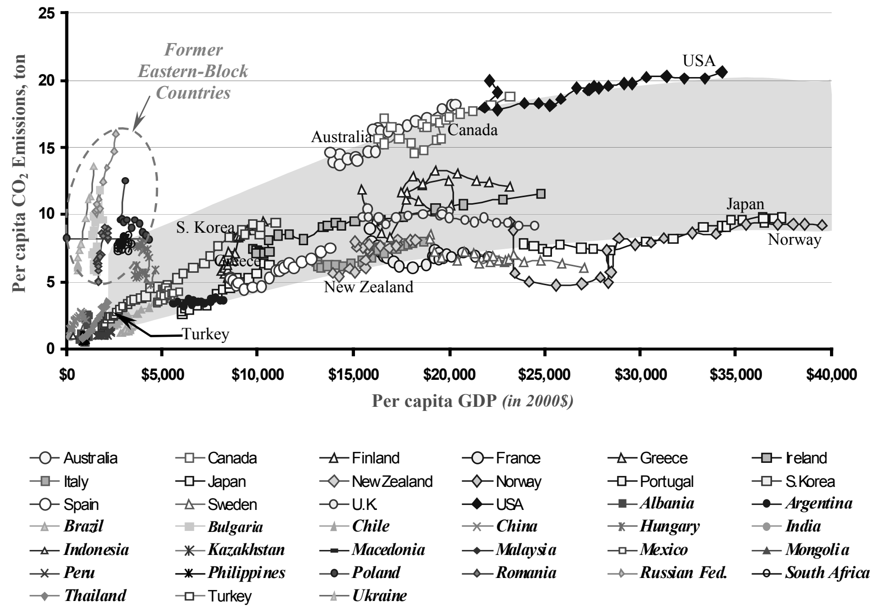

Figure 2 - Per capita CO2 Emissions of Select Mining Countries for the 1980-2000 period, (*UNFCC data)* [4]

In recognition of global climate change potential of greenhouse gases, countries are spending great efforts to minimize CO_2 emissions. It is interesting to note that only some developed countries are successful in reduction of CO_2 emissions, while most of the countries (*especially the ones with mineral resources*) are having great difficulty to achive CO_2 reduction goals of the Kyoto Protocol. The only significant decreases in CO_2 emissions observed in the 1990-2000 period belongs to the former Eastern-Block Countries due to collapse of their industrial activities, as seen on Figure 2.

Figure 3 shows the relationship between energy use *(per capita CO_2 emmissions)* and economic *(and indirectly, social)* wealth for 41 select mining countries. Considering that per capita CO_2 emission value is a gross indicator of needed natural resources, it is apparent that development future of the countries will rely on extractive industries. Realizing that exploitation of natural resources has a potential to cause environmental concerns, efforts will have to be spent towards minimization and mitigation of the resulting environmental impacts. It has to be recognized that apparent dependence of economical and social development on natural resources is a dicotomy towards Sustainability of global-level Development.

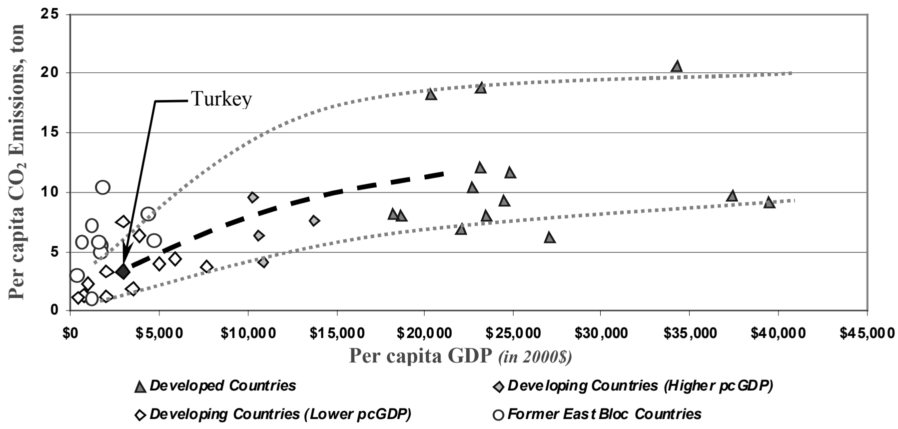

Figure 3 - Per capita CO_2 Emissions of 41 Mining Countries in year 2000, (*UNFCC data*) [4]

As seen on Figures 2 and 3, per capita income of Turkey during 1980-2000 period remained below $3,000, while per capita CO_2 emissions were below 3 tons per person. An anticipated development path for Turkey is likely to be the dashed curve shown in Figure 4. This extrapolation suggests that for Turkey to reach a $15,000 percapita income, the per capita CO_2 emissions need to triple up to 9-10 tons/person, requiring a significant increase in natural resource usage. Realizing the global efforts to limit the greenhouse gas emissions, an unability to generate necessary CO_2 for industrial development will likely hamper development of Turkey, unless more environent-friendly energy sources are developed and made available in the next decade. Otherwise, like other developing countries, Turkey will have to put more emphasis on further use of its natural resources to sustain its development, despite global efforts to limit CO_2 emissions.

MINING IN GENERAL

Industry produces goods to fulfill the needs of the communities. Mining sector plays a vital role in this activity as the provider of fundamental raw materials, namely fossil fuels and minerals.

Mining, as the oldests production sector of the history alongside of agriculture, carries the highest capital risk. In general, mining is economically dependent on technological developments and international market fluctuations, clearly affected by the national and international interventions and prone to regression if continuous exploration and investments are not realized.

Economical, technical and administrative factors are the primary parameters in decision making process in mining. Of these parameters, investment incentives, tax allowances, taxation and mining rights security issues dominate the investment decisions. In recent years, environmental reasonings have become the source of difficulties in obtaining exploration and operation permits, becoming a major barrier in mining investments, globally.

Developments in the last three decades revealed that success in mining mainly relies on private enterprises (domestic or foreign capital) with sufficient investment power, expertise and global marketing capabilities. On the other hand, foreign investment incentives, national mining legislations, national environmental policy issues and local political environment are the primary factors in decison-making process in international mining investments. Countries with consistent national environmental and mining policies generally attract international mining investments.

SUSTAINABLE DEVELOPMENT and MINING

Sustainability of mining industry is very sensitive to numerous factors such as operational techniques and equipment utilized, global market fluctuations and governmental policy changes. Contrary to common belief, a mining operation is not a "treasure find" but a fruit of an expensive and very long-term systematic exploration, financing, design/construction and an arduous permitting process.

Fundamental principle of Sustainable Development Concept is "*Development*" of communities in economics and social areas while conserving the environmental values. Within the context of this principle, economic and social outputs of an industrial activity with potentially impacted environmental values are questioned. Factors in assessment of sustainability for mining activities are presented in the diagram below (Figure 4).

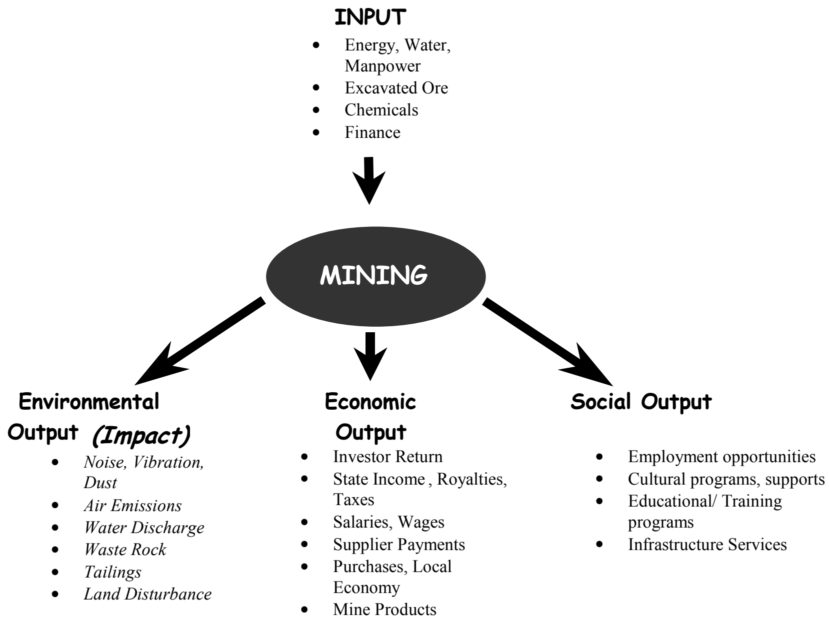

Figure 4 - Sustainable Development Model for Mining Activities [6]

Mining, as a supplier of vital fuel and raw materials, is an industrial activity that provides direct contribution to the economic and social developmental needs of communities. It is unconceivable to sustain the current quality of life for the world communities without mining. Ultimate benefit from natural resources can be achieved by conversion of mined ores to value-added final product through on-site ore beneficiation and integrated production units. In this regard, gold mines that process ore all the way to pouring "dore bars" (*like the Ovacik Gold Mine in Turk*ey) or copper mines with integrated smelters to obtain metallic copper *(like the Chelopech Mine in Bulgaria)* are prime examples of integrated mines providing the utmost benefits to the local communities and the country economy.

In developed countries, like USA, Canada and Australia that are geologically fortunate to have ore deposits, mining is a major industrial activity providing significant input to the national economies. A macro-level look at the numbers in the figure below reveals the role of only non-fuel mineral extraction industry in the overall USA economy. In an 11 trillion dollar 2004 USA economy, 38 billion dollars of mined mineral raw materials generates a 370 billion dollar processed mineral goods, which in turn contributes generation of 1,700 billion dollars of value-added products. This means that $1 worth of mineral mined generates a $10 worth of intermediate goods in making a $50 final product for the country. Looking at the $1.7 billion output of the major US industries consuming processed minerals, one can see that about 15 % of the US national income relies on mining of non-fuel minerals. In realization of the importance of mining in economical and social development, mining industry in USA, Canada and Australia receives significant incentives from the governments.

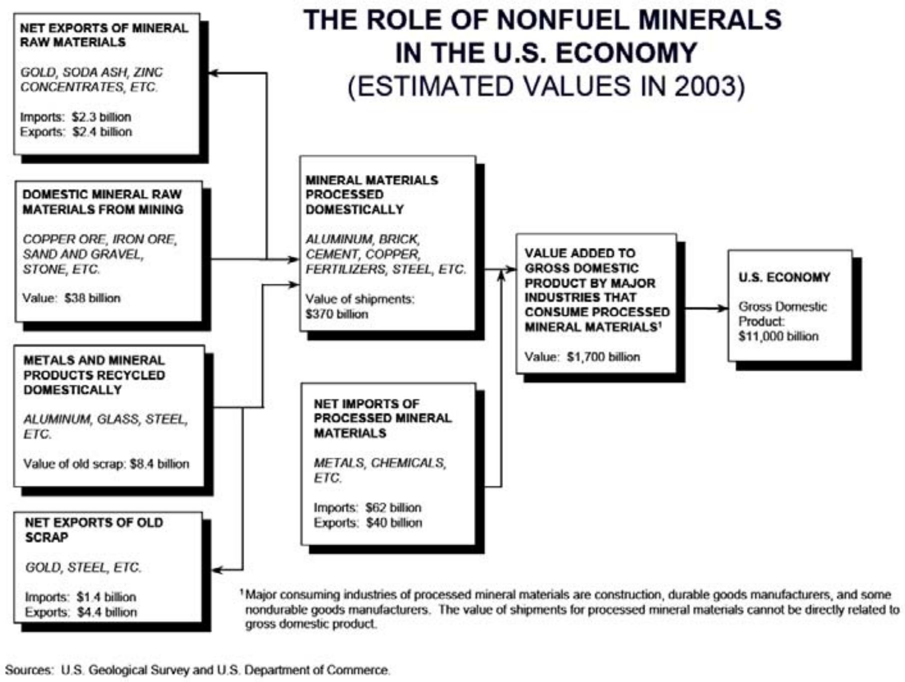

Figure 5 - Role of Non-fuel Minerals in the U.S. Economy [5]

SUSTAINABILITY CONCERNS FOR EXTRACTIVE INDUSTRIES

The communities are in a dichotomy regarding accepting or rejecting the mining and chemical industries in terms of "*Sustainability of Development*" in fear of their common future. We all realize that we need these industries for development; however, we are also worried of the long-term environmental problems that could accompany them.

In the last decade, mining industry has become a prime target of the environmental movements, especially in the developing countries for apparent environmental concerns as a result of improper past mining practices. However, like in other industry sectors, environmental awareness was heightened also in the mining industry. International mining companies have upgraded their practices to meet or exceed the regulatory requirements in all mines operated at different countries. In this regard, the currently operating Ovacik Gold Mine in Turkey has fulfilled the fundamental criteria of Sustainable Development by:

- Using of modern technology, as demonstrated by inclusion in the EU's Best Available Techniques (BAT) reference document for extractive industries,
- Demonstration of an excellent *environmental protection* performance,
- Providing *economical benefits* (taxes, cash inflow) to the country and local economy,
- Providing *social benefits* to the local communities through cultural, educational and infrastructure support.

However, the judicial struggle by the local "Environmental Opposition Movement" on the Ovacik Gold Mine has continued for the last 12 years. Such local politics-oriented oppositions definitely undermine investment environment for the extractive industries, especially in the developing countries, and clearly contradicts the concept of Sustainability of Development.

Unfortunately, the mineral explorations and new investments in mining have lost its momentum especially in the developing countries due to the deliberate spread of misinformation by oppositional environmental movement campaigns and reluctance of the governments to manage such social concerns adequately. As a result of the decelerating exploration expenditures and mining investments, a shortage in metallic ore supply is anticipated in the near future for a world population reaching 6.5 billion [5]. This situation also contradicts the "Sustainable Development" concept.

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Asia

PERSPECTIVES ON CHINA'S MINING AND MINERAL INDUSTRY

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Introduction

Mineral resources are basic materials for human civilization. During the last century, the world GDP increased 18 times, and the speed and amount of global resource consumption grew rapidly. The consumption of crude oil increased 177 fold, from 20.43 million tons to 3.5 billion tons; steel consumption increased 30 fold, from 27.80 million tons to 847 million tons; aluminum consumption increased 3,600 fold, from 6,800 tons to 24.54 million tons; and copper consumption increased 28 fold, from 495 thousand tons to 14 million tons. Social development and people's living standards have improved significantly. However, mineral resources are nonrenewable, and they will be depleted some day. Moreover, mining activities inevitably have an impact on the environment. The world has been paying increasing attention to resources and the environment. The concept of sustainable development has become widely accepted by most countries around the world.

China's rapid economic growth has brought great challenges concerning resource shortages and environmental degradation in recent years. How to ensure an adequate supply of resources, improve the environment and achieve sustainable economic and social development has become a top priority we face today.

1. Rapid development of China's mining and minerals industry has made great contributions to both the economic growth and improvement of people's living standards

Relying on infrastructure construction and the development of heavy and chemical industries, China's economic growth began to accelerate. The GDP increased from 1.85 trillion RMB in 1990 to 11.67 trillion in 2003. The annual GDP growth rate averaged 9.7

percent. The production and consumption of mineral resources and the related products has increased sharply. The mining and mineral industry provided great support for these developments. The consumption of major mineral raw materials in 2003 was: Coal, 1.59 billion tons; crude steel, 240 million tons; copper, 3.21 million tons; aluminum, 5.48 million tons; cement, 800 million tons; and potassium fertilizer (K_2O): 4.82 million tons.

It can be seen from Fig.1 that consumption of all the major mineral products increased by more than 4 times from 1990 to 2003.

According to the preliminary statistics collected last year (2004) the consumption of major mineral products in China was: Coal, 1.87 Bt; Crude steel, 270 Mt; Aluminum, 6.19 Mt; Copper, 3.12 Mt; Ten common nonferrous metals, ~14 Mt(production) ; Cement: 900Mt.

The mining and mineral industry has made important contributions to the development of China's economy, and it contributes to over 20% of China's present GDP. China has become a major consumer and trader of the world's mineral products.

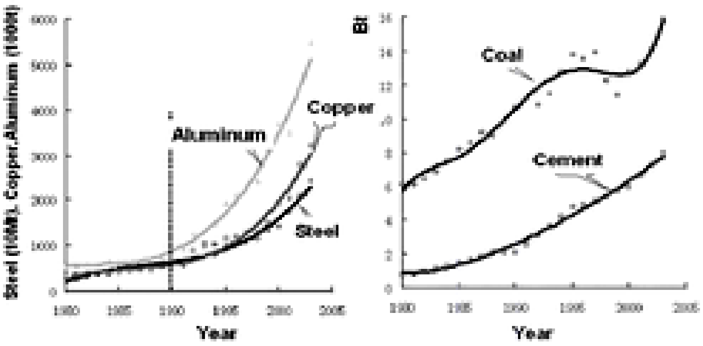

Fig. 1 The consumption of mineral products from 1980 to 2003 in China

2. China's mining and mineral industry faces great challenges in the new century

China's mining and mineral industry faces great challenges in the new century. First, the growing demand for raw materials results in a shortage of major minerals resources, such as oil, copper, iron, chromium and manganese ore. The domestic productions of these minerals can only meet one third to one half of the demand, and the rest must be imported from abroad. Second, China's energy and resource efficiency are relatively low. Compared with the developed countries, China's overall energy efficiency is lower by more than ten percent. Currently, the efforts in optimizing its economic structure, SMEs reform and technology upgrading are under way to improve this situation. Third, the mineral and mining industry puts a tremendous pressure on the environment. Although the Chinese government has adopted many measures to improve efficiency and issued strict laws and regulations to protect the environment, the environmental problems arising from the mining and mineral industry has improved very little, overall. Fourth, most Chinese enterprises in the mining sector, small and of low productivity, are not internationally competitive. In 2002, medium and small firms account for more than 94% of the 14,000 firms in the mining industry. They lack technology and money and have no innovation capability, resulting in low productivity, low resource efficiency, heavy environmental pollution and high energy consumption.

Some experts estimate that, by 2020, the population of China will have reached about 1.5 billion, and the people will expect to have had a better standard of living. So, ensuring that the supply of energy and resources meets the growing needs of a sustainable economic development over the next 10-15 years while improving environmental performance is the most critical engineering challenge that China's mining and mineral industry faces today.

3. General relation between economic growth and mineral products consumption

The developed countries have already made the transformation from an agricultural society to an industrial society. Their experience can give us a lot of help.

Let's cite data on GDP of, and mineral products consumption by, some industrialized countries during the last century. Fig. 2 shows that the pattern of GDP (per capita) vs. steel consumption looks like an S-shaped curve.

It indicates that in the early days of their industrialization, steel consumption increased rapidly with economic growth;

When they approached full industrialization, the consumption growth began to slow down;

During the period of post-industrialization, the consumption stayed relatively stable or began to decrease.

Fig.3 shows per capita steel consumption of developed countries in different years. For different counties, the growth or reduction rate is different. So is the peak of per capita consumption. This depends on the economic structure, resource efficiency, science and technology, and consumption styles of different countries. This phenomenon is particularly true for counties with large populations and territories.

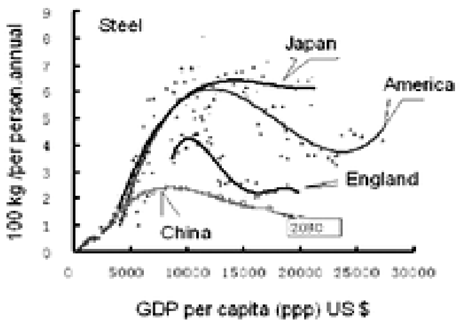

Fig. 2 GDP vs. steel consumption

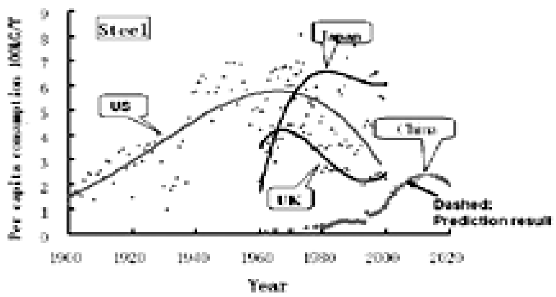

Fig. 3 Per capita consumption of steel of developed countries in different years

According to Economist H. B. Chenery, the industrialization process measured by per capita GDP can be divided into six stages: \$140—\$280, \$281—\$560, \$561—\$1120, \$1121—\$2100, \$2101—\$3360, and \$3361—\$5040. The per capita GDP of China in 2002 was US\$1000; China has entered the middle stage of industrialization, namely the fourth stage. During this period, the demand for energy and resources, arising form economic growth, will be more than ever. The experience of the developed countries has proved this point.

4. During the next 20 years, China's mining and mineral industry will still be vital to its economy

In the past, China's mining and mineral industry sustained the fast growth of its economy and, in the future, will still be vital to its economy.

Tab. 1 Steel Consumption of USA and Japan in the 20th century

During the 20th century (100 years)	USA	Japan*	China (up to 2003)
Total consumption of steel (Btons)	7.3	2.9	2.8
Peak annual consumption (Mtons)	146	93	240
Peak annual consumption per capita (tons)	0.70	0.76	0.18

* from 1945 to 2000

During the last century, the USA consumed 7.3 billion tons of steel; the peak of steel consumption was 146 million tons per year, and the peak per capita steel consumption was 0.70 tons per year. In Japan, the accumulated steel consumption from 1945 to 2000 was 2.9 billion tons; the peak of steel consumption was 93 million tons per year, and the peak per capita steel consumption was 0.76 tons per year.

Compared with the USA, we find that in both the total consumption of steel and annual consumption per capita, China still has tremendous gaps. From 1949 to 2003, the accumulative total steel consumption in China was 2.80 billion tons. The steel consumption in 2003 was 240 million tons, and the per capita steel consumption was only 0.18 tons per year. As a developing country with a vast territory and large population, China will need a large amount of steel in its infrastructure construction, including railways, highways, bridges and buildings; we estimate that China's total consumption of steel, while it is achieving industrialization, will be equal almost to that of the USA. So, China's mining and mineral industry still has a long way to go. According to a CAE report, the tendency of high-speed, large-scale development will continue for 15-20 years or more. The argument that the mining industry is a setting sun industry is absolutely not correct, especially in developing countries like China.

5. China's mining industry must concentrate on ecology, low per capita consumption and sustainability

China's mining and mineral industry cannot copy the model of developed countries. For example, the peak per capita steel consumption in the U.S.A. was 0.7 tons per year; if China reaches that level of consumption, its total steel consumption per year will surpass one billion tons, which will put an unbearable burden on world resources and the environment. The same holds for the consumption of other major minerals.

To ensure that the economic growth is sustainable and to mitigate pressure on resources and the environment, China's mining and mineral industry must take a new approach and concentrate on ecology, low per-capita use and sustainability. The strategic goal for the year 2020 is that the economy will be quadrupled, though the consumption of major minerals increases only 2 times or a little more. In recent decades, the Chinese government has focused considerable attention on the issue of resources and the environment. Currently, a resource-efficient and environment-friendly society is the goal that China is moving toward. A resource-efficient society satisfies two conditions. One is the development of a resource-conserving national economy; the other is for the whole society to completely change its conception on consumption. The changes should arise from a sound public policy, public awareness and a commitment to research and development.

6. New technologies

New developments in technology may provide great support for progress in the mining and mineral industry. High efficiency mining and mineral processing technology can significantly improve the recovery rate of mineral resources and mining productivity. We should invest more in this area. For example, the flotation desilicate-tube digestion process was developed to utilize disapore-type bauxite, whose Al/Si ratio is less than 8. Compared with sinter process, the new process will reduce operating costs by 15 percent, and energy consumption of alumina production by 50 percent. We adopted new high efficiency technologies in the iron and steel industry, including continuous casting and rolling technologies, PCI blast furnace technology, and slag splashing of BOFs. From the year 1990-2001, the production of steel doubled, while energy use increased only 33 percent. As a potential technology, the bioleaching process can recover low-grade copper ore and economically marginal resources, and further reduce pollutants. With regard to the processing technology of sulfide minerals, research in lab and milling shows that the redox potential of pulp is an important factor on sulfide mineral flotation behavior. A novel technology, called electro-potential control flotation technology, has already been developed to improve the flotation process and applied in practice. In the area of iron ore processing technology, China is considerably advanced in the beneficiation technology of low-grade iron ore. Once the price of iron concentrate in the world market goes too high, many concentrators in China can start operation economically.

The energy used in cement production in China is 50% higher than the world average. By adopting advanced dry processing, the average energy used per ton will be reduced from 170 kg to 107 kg coal equivalent. In the electricity sector, we are developing new technologies, such as clean coal technology and high efficiency combustion turbine technology, to increase the efficiency of power generation and reduce the emission of pollutants. Right now the average fleet efficiency for coal-fired power generation is 33 percent. By 2020, coal plants shall have achieved efficiencies of 37%. The country is also moving toward requiring all fossil-fuel plants to install NOx and SO_2 pollution-control equipment.

The recycling and reuse of primary metals, such as aluminum, steel and copper, will play an important role in saving mineral resources and energy use. It also can significantly reduce the environmental impact. Now, 30 % of the global steel and 50 %

of the global copper come from recycling secondary resources. For China, the proportion is only 10 percent. It is urged that the recycling proportion should be increased to 20% -30% by 2020. To develop the recycling industry, incentives through appropriate regulations and policies should be provided. The awareness of the public is also important.

RUSSIA PERSPECTIVE OF SUSTAINABILITY INDICATORS IN MINERAL EXTRACTION INDUSTRY

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Consistency of development of national mineral processing industry generally depends oп the volume of ore mass production, quantity of raw minerals being processed, number and range of valuable minerals being extracted, environmental safety of the process, actual mineral reserves and social demand for raw minerals.

With this set of factors in mind, let us have a look at the present-day status of Russia as a mining (raw minerals producer) country. In general, when assessing the mineral potential of a country, it is reasonable to focus upon the number of mineral commodities being produced (that is, the number of valuable minerals being mined and extracted) (Figure 1) [1]. Although there are as many as 166 mining countries in the world, the leading group includes only ten countries, where Russia ranks first according to the criterion just mentioned. The histograms in Figures 2 to 4 [1] display the number of countries producing different mineral commodities from ferrous, non-ferrous and precious metal ores. As is seen from the diagrams, some metallics, like iron, copper, zinc, aluminum, lead and gold, are mined in 40 countries and more, whereas less common species, like tantalum, vanadium, germanium, rare earth elements and platinum group metals, are produced in not more than ten countries.

Another important parameter characterizing the mineral potential of a mining country is its current volume of mining and mineral processing (Figures 5 to 9) [1]. According to this criterion, USA, People's Republic of China and Russia rank first, second and third, respectively, contributing altogether as much as 41 % to total world mining volume (Figure 5). In general, the contribution of the top ten of mining countries to total world mining and mineral processing is as large as 63.7 %. In particular, this group of countries yields 87.1% of the world ferrous metal production

Figure 6), Brazil leading here with 28.9 % of the total production volume. The same group of countries contributes 61.1 % to world production of non-ferrous metal commodities (Figure 7), Australia ranking first with 31 % of the overall production amount. In addition, the same ten countries contribute 43.7% to world production of precious metal commodities, where Australia also leads with 11% of the total production volume (Figure 8). Lastly, the contribution of this group of countries to world diamond production is as large as 95 %, Botswana and Russia leading here with 27% and 20 %, respectively (Figure 9).

The actual total amount of ore being admitted to dressing plants and the number of these plants are given in Table 1. In all, there are more than 100 mining-and-dressing plants and mining-metallurgical facilities processing ferrous and non-ferrous metal ores in Russia.

Table 1. Prognostic requirements and production of main raw mineral resources

Kind of resource	2000	2005	
	Production	Production (forecast)	Domestic requirement (forecast)
Oil and condensate, million t	305,7	320,0	130,0
Gas, milliard m^3	600,0	650,0	430,0
Fe documentary ore, million t	81,3	104,0	85,1-88,9
Cr documentary ore, million t	397,2	487,2	1740
Mn documentary ore, thousand t	124,7	197,8	430,0
Al raw, thousand t	630,0	595,0	850,0
Cu refined, thousand t	662,0	670,0	300,0
Ni metallic, thousand t	320,5	325,0	80,0
Pb metallic, thousand t	55,0	94,5	135,0
Zn metallic, thousand t	266,0	280,0	150,0
Sn metallic, thousand t	5,0	6,0	4,0
W concentrate, thousand t	6,8	15,6	17,0
Mo in a concentrate, thousand t	3,0	4,0	12,0

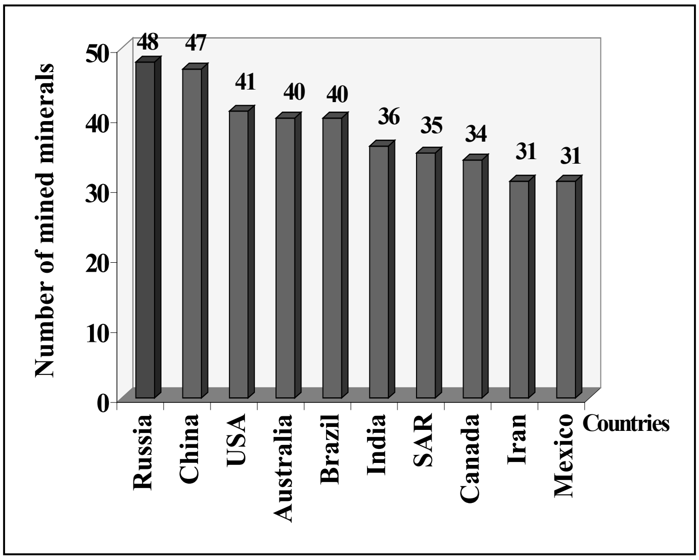


Figure 1 - Number of mineral commodities produced in different countries

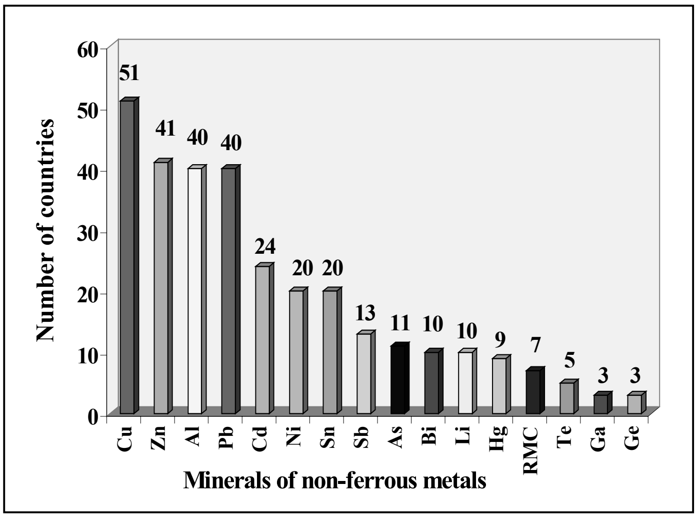


Figure 2 - Number of countries producing non-ferrous metal ores

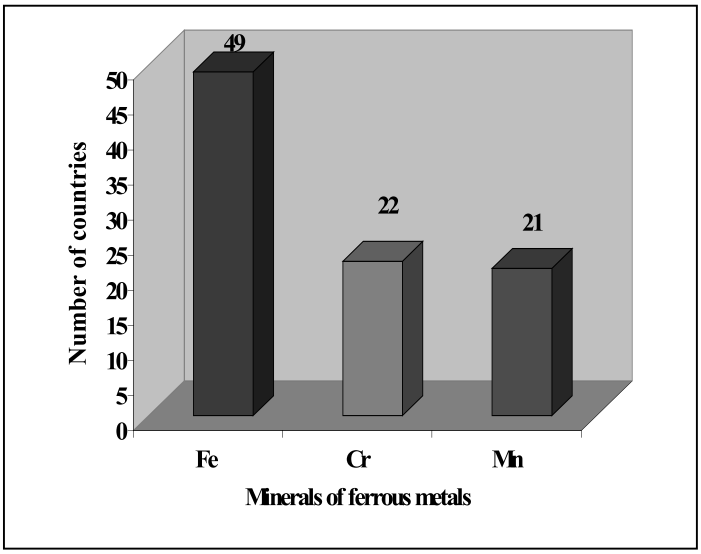


Figure 3 - Number of countries producing ferrous metal ores

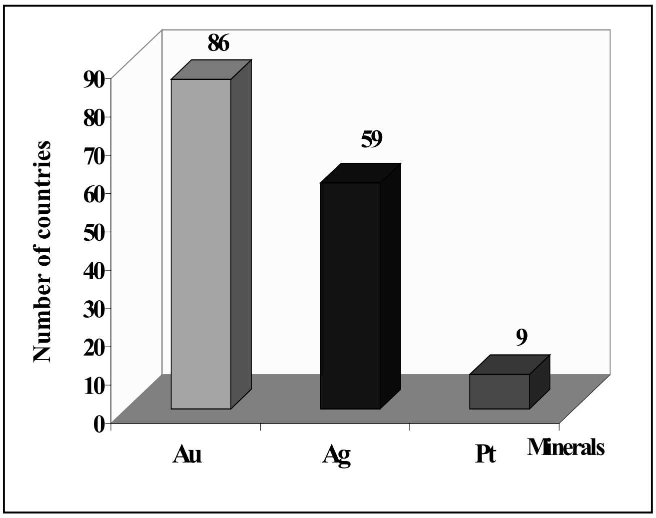


Figure 4 - Number of countries producing noble metal ores

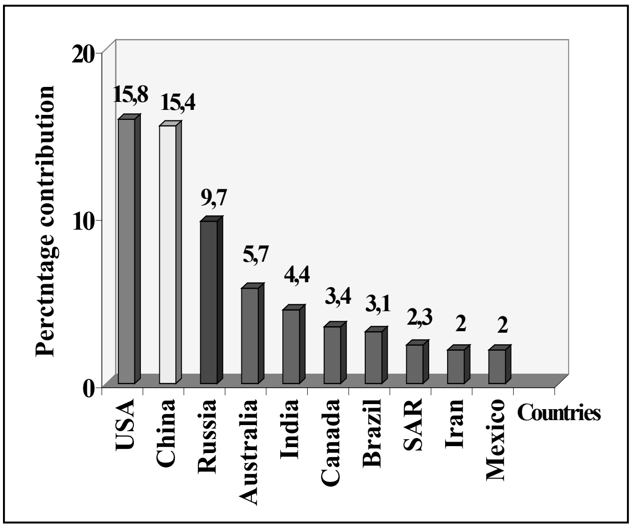


Figure 5 - Contribution to world production of raw minerals

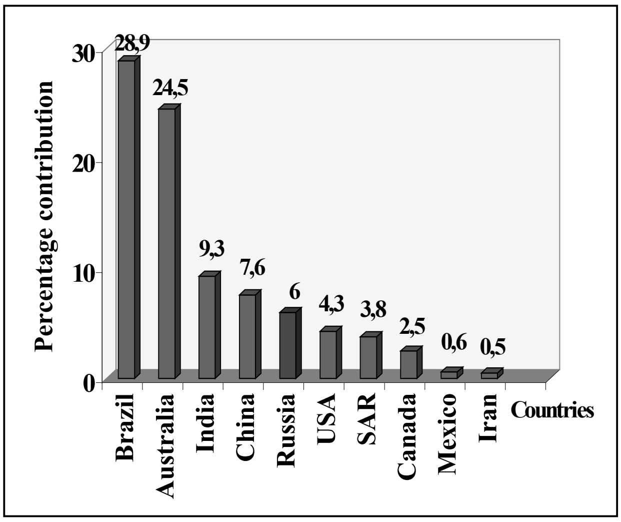


Figure 6 - Contribution to world production of ferrous metal ores

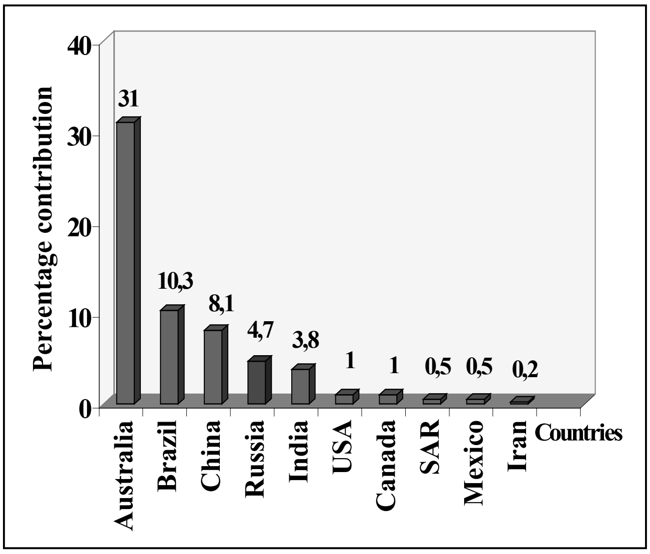


Figure 7 - Contribution to world production of non-ferrous metal ores

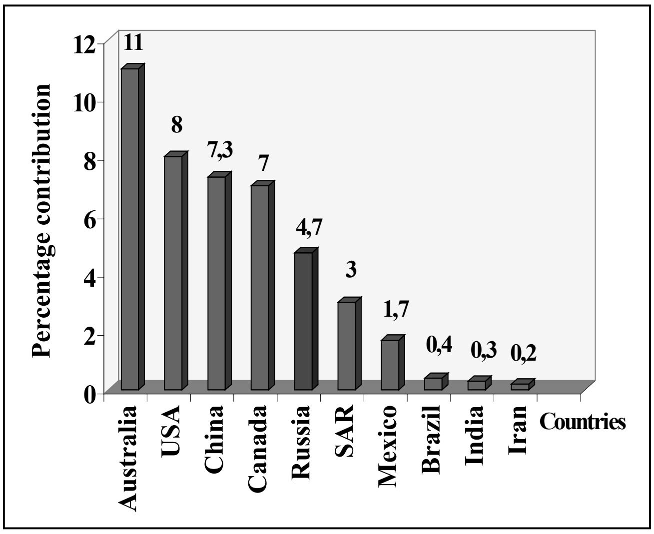


Figure 8 - Contribution to world production of noble metal ores

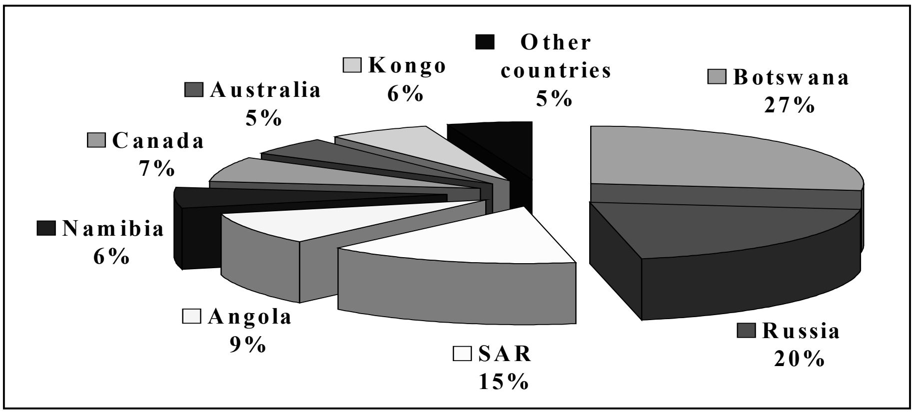


Figure 9 - Frame of world diamond mining

These enterprises incorporate 60 large open pits, 75 mines and 90 dressing plants. In 2004, the volume of coal mining in Russia ranged up to 283 mln tons, including 101.7 mln tons from 104 collieries and 181.3 mln tons from 134 openpit mines. A total of 120 mln tons of coal is being processed at 42 dressing plants. It is proposed that by 2015 about 80 % of as-mined coal will be subject to beneficiation.

From the aforesaid, it may be seen that Russia is really a big mining country with a sound mineral base. Of the 20 thousand mineral deposits discovered to date in our country, 40 % are now under commercial development. The raw minerals sector of Russian national economy provides for more than 30% of our gross domestic product and about 70 % of currency receipts of the state budget.

The contribution of Russia to total world mineral reserves is generally sizable, in particular, accounting for as much as 12-13 % of world reserves as regards crude oil, 32 % for natural gas, 11 % for coal, 26 % for iron, 10 % for lead, 15 % for zinc, 31 % for potassic salts and 21 % for cobalt. In addition, Russia ranks first to third in the world in nickel, gold, silver, platinum group metals and diamond known reserves. However, copper-zinc, rare metal, stannic, wolfram, bauxite and other ores coming from Russian mining facilities rank quite far below respective foreign ore products in processing characteristics. To process our refractory and complex ores, Russian specialists usually resort to integrated procedures involving a combination of concentration, pyro- and hydrometallurgical techniques, which inevitably increases the final product cost. Much consideration to this problem was given in the paper (Chanturiya V.A. "Modern problems of mineral processing in Russia" // The European Journal of Mineral Processing and Environmental Protection. 2001. №.1. P. 25-41).

In general, in order just to keep the raw minerals potential of a mining country at the present-day level, it is necessary to provide for consistent mineral base reproduction based on intense geological prospecting and exploration. Unfortunately, over more than ten years (since 1992 ti11 2003) the volume of geological prospecting works in Russia constantly decreased, which resulted in certain decrease in domestic mineral reserves. It is good that, as of now, Russian government has sharply intensified the financing of geological prospecting programs.

Data on social demand for raw minerals and volume of mining over the period since 2000 till 2005 are presented in Table 2.

Table 2. Number of plants and total output of ore treated by mineral processing methods (2004)

Kind of ore	Annual output, million t	Number of plants
Fe ores	255,2	30
Non-ferrous ores, including	62,8	52
Cu ores	34	19
Ni ores	23	8
K ores	29	7
P_2O_5 ores	59	5
Au-containing ores	250	37
Diamond-containing ores	26	12
Coal	120	42
Total:	802	185

As is evident from these data, mineral reserves of Russia cover the domestic demand for most of the metallic commodities, except for manganese, chromium, molybdenum, tin and 1ead. Data on increment of coal, iron ore, copper and precious metals known reserves in different regions of Russia are presented in Figures 10 to 13.

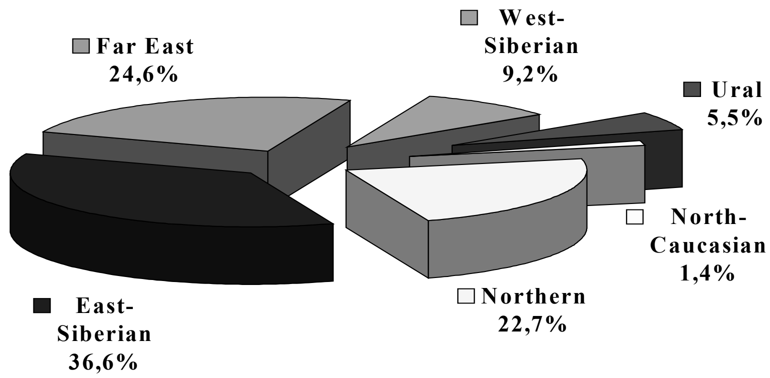


Figure 10 - Frame of increment of known coal reserves in different regions of the Russian Federation

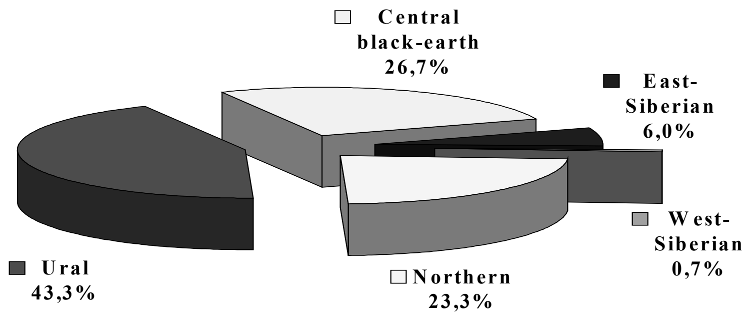


Figure 11 - Frame of increment of known Fe ores reserves in different regions of the Russian Federation

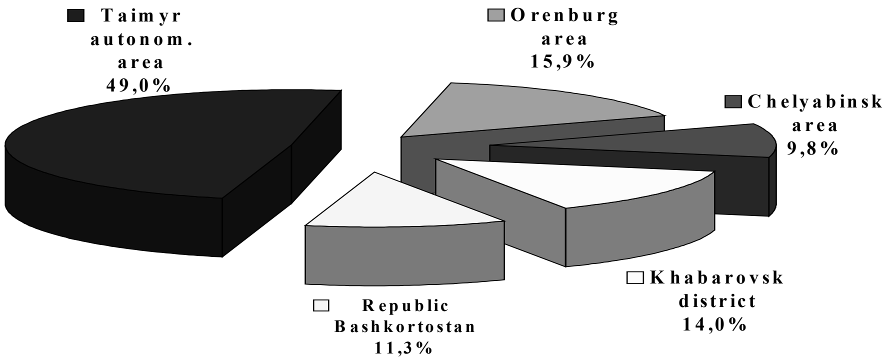


Figure 12 - Frame of increment of known Cu ores reserves in different areas of the Russian Federation

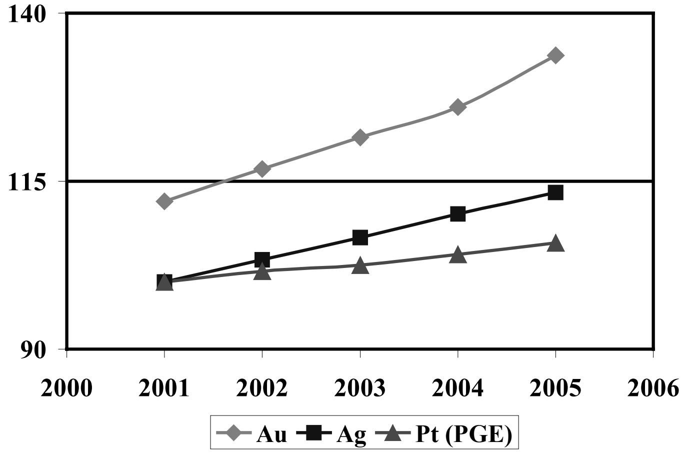


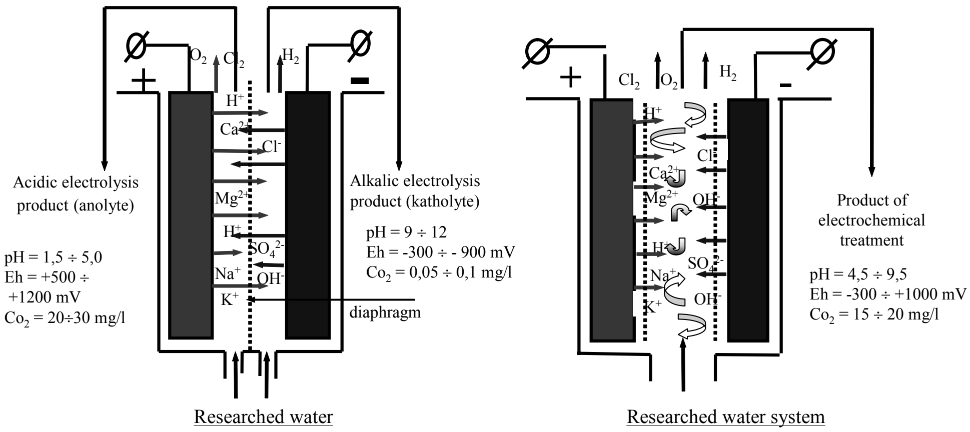
Figure 13 - Change in increment of known Au, Ag and Pt (PGE) reserves since 2001 till 2005 (per cent against 1998)

Russia's contribution to world export of oil, natural gas, non-ferrous and ferrous metals varies from 7 % to 20 %. However, Russia falls behind the major industrial countries, showing a per capita metal consumption 1.5 to 2 times lower than that typica1 of advanced nations. Generally speaking, the recent decades are characterized by a world tendency of decrease in per capita raw minerals production, from 2.038 tons of different mineral commodities per Earth inhabitant in 1985 to only 1.873 tons in 2002.

With presently existing mining and mineral processing techniques, only a minor portion of valuable mineral mass extracted from mineral deposits can be really put to use, whereas the remaining portion is treated as waste, which, as it is progressively accumulated and stored, tends to become a crucial anthropogenic factor affecting the environment. Of the total amount of waste accumulated by now in Russia, about three quarters, which is more than 12 bln tons, is due to mining industry. As regards ferrous and non-ferrous metallurgy, only mining alone yields more than 210 mln m^3 of solid rock waste and 140 mln m^3 of dressing tailings a year. Coal industry yields more than 650 mln m^3 of overburden rock and dressing waste and 730 mln m^3 of wastewaters a year. The total vo1ume of annually accumulated waste from all mining industry branches ranges up to several billion cubic metres. This is why the problems related to mining industry waste treatment have become a key factor for national environmental safety. Realizing this challenge, Russian Academy of Sciences, in cooperation with a number of applied research institutes and geological, mining and metallurgical enterprises, performs a set of research programs and implements the obtained results so as to solve the problems of reduction, recycling (recovery) and reprocessing of mining waste and eliminate its negative environmental consequences.

As of now, the basic idea in tackling the above discussed problem as a fundamental one consists in considering the waste derived from mining and mineral processing facilities as new resources, which can be used to maintain the mineral-producing potential of the subsurface and to restore this latter through goal filling, blocking various underground voids, creating artificial (technogenic) depleted mineral resources, and controlling the filtration, compression and other properties of rocks in local zones of the lithosphere with an aim to make these zones safe and even useful from the environmental and engineering standpoint.

The most efficient way to reduce the amount of waste and to reutilize waste materials appears to consist in developing new techniques for deep and all-round processing of as-mined raw minerals and organizing closed water recycling circuits at mining and mineral processing facilities. In particular, the researchers affiliated in IPCON RAS have developed an electrochemical water preparation technique, which, having been implemented at a number of concentration plants of the Alrosa JSC, provides there creation of a liquid phase, special for each particular process, with preset physicochemical pulp properties (pH, Eh, ionic composition and concentration of suspended species), designed optimal for different diamond-bearing kimberlite separation processes (Figures 14, 15).



Electrochemical conditioner of diaphragm type

The electrolysis reaction:

at cathode: $2\,H_2O + 2e \rightarrow H_2\uparrow + 2\,OH^-$

$2\,H^+ + 2e \rightarrow H_2\uparrow$

at anode: $2\,Cl^- - 2e \rightarrow Cl_2\uparrow$

$2\,H_2O - 4e \rightarrow 4\,H^+ + O_2\uparrow$

$4\,OH^- - 4e \rightarrow 2H_2O + O_2\uparrow$

Electrochemical conditioner of diaphragmless type

The electrolysis reaction:

at cathode: $2\,H_2O + 2e \rightarrow H_2\uparrow + 2\,OH^-$

$2\,H^+ + 2e \rightarrow H_2\uparrow$

at anode: $2\,Cl^- - 2e \rightarrow Cl_2\uparrow$

$2\,H_2O - 4e \rightarrow 4\,H^+ + O_2\uparrow$

$4\,OH^- - 4e \rightarrow 2H_2O + O_2\uparrow$

$Fe^0 - 2e \rightarrow Fe^{2+}$; $Al^0 - 3e \rightarrow Al^{3+}$;

$C + O_2 \rightarrow CO_2\uparrow$

Figure 14 - The scheme of electrochemical water treatment

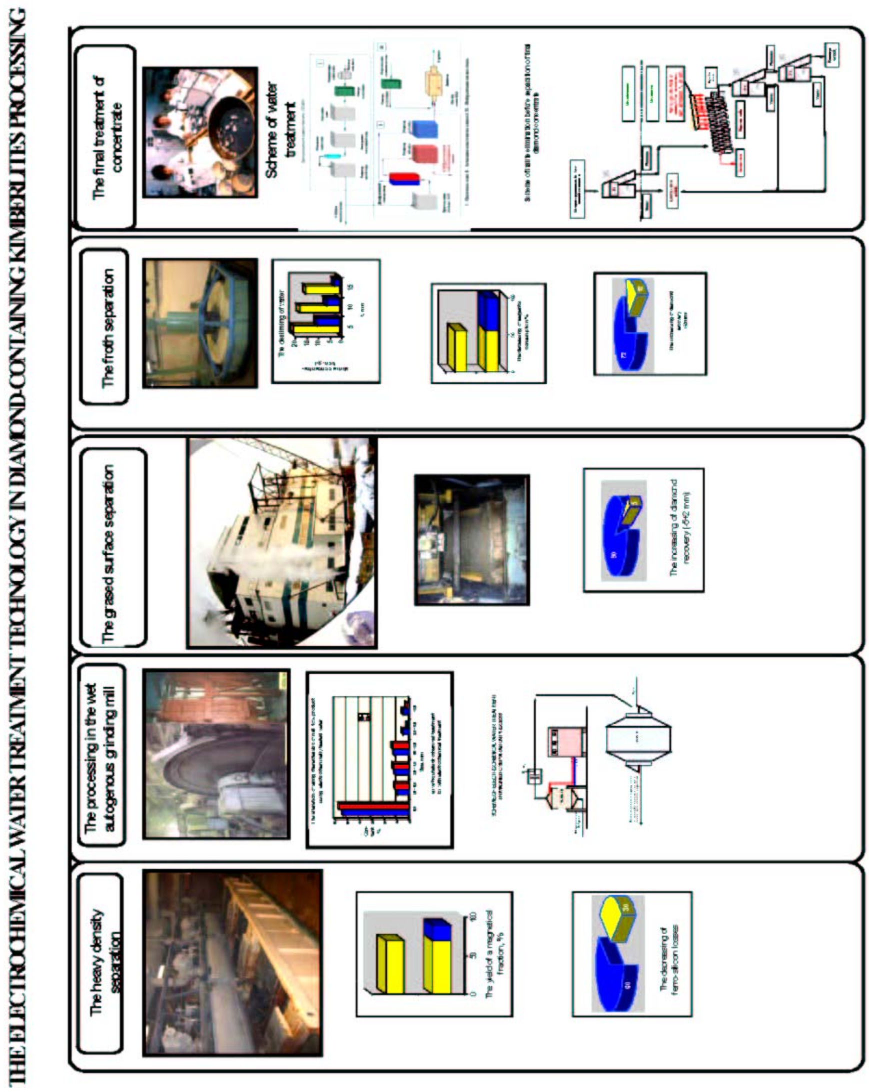


Figure 15 - The electrochemical water treatment technology in diamond-containing kimberlite processing

To summarize, it may be concluded that Russia possesses sizable natural resources providing a sound foundation for long-term and consistent development of domestic mineral processing and national industry as a whole, which, evolving in a mode of extended reproduction, promises to be attractive for international cooperation.

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Oceania

AN AUSTRALIAN PERSPECTIVE ON INDICATORS OF SUSTAINABILITY FOR THE MINERAL EXTRACTION INDUSTRY

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INTRODUCTION

There is a growing expectation that companies must conduct their activities with a view to sustainability. Corporate responsibility now runs well past health, safety and environment and includes social impact, product life cycle and the wider issues of sustainability. More and more companies have included their performance on sustainability in their annual reports and reviews. The Global Reporting Initiative (GRI), an official collaboration centre of the United Nations Environment Programme (UNEP), reported that more than 700 companies around the world are using the UNEP voluntary guidelines[1].

The mining industry has been a particular leader in taking the issue of sustainability seriously; examples include their contribution to the World Summit in Rio de Janeiro and more recently in Johannesburg.

There is a common saying in management that 'what gets measured gets done'. This paper therefore starts by looking at the systems that are available for measuring performance in sustainability, but then goes on to describe the characteristics of sustainable mining in the future, and in particular what the mine of the future might look like. We also report on a novel approach to sustainability undertaken by Rio Tinto through the formation of the Rio Tinto Foundation for a Sustainable Minerals Industry.

1 http://www.gobalreporting.org accessed on 19 September 2005

SUSTAINABLE DEVELOPMENT FRAMEWORK

Perhaps the most quoted definition of sustainability is that of the Brundtland Committee: "Sustainable development means the advance of human prosperity in a way that does not compromise the potential prosperity and the quality of future generations"[2]. Whilst the Brundtland definition has broad acceptance, it does not leave us an easy task in terms of defining our current performance or on how we can improve on it. For that we need hard measures. We have to be able to resolve such issues as to whether more or less production of primary aluminium is desirable. On the one hand we can see that the high energy demands of aluminium smelting are undesirable but on the other hand, the product life cycle of aluminium is such that it can result in significant energy savings, for example its use in lightweight cars. [3]

There is a growing awareness of the impact of greenhouse gas emissions on climate change. Whilst this issue is specifically about our patterns of energy production and consumption, it is also the key driver forcing us to rethink our position on sustainability. It is likely to be one of the most powerful drivers as the world takes the challenge of greenhouse emissions ever more seriously. Indeed, the UK Chief Science adviser has stated that global warming presents a more serious threat than terrorism. [4]

There is broad agreement that there are three essential considerations of sustainability namely, the economic, the community and environment as depicted in Figure 1. The three elements are, of course, interrelated. It is rare that one can change performance in one particular area without some impact on the other two. Often one finds that a desirable change in one of the three targets results in a less than desirable change in the others. We could commonly cite improvement in environmental

2 Our Common Future: World Commission on Environment and Development, G Brundtland, ed., Oxford University Press 1987.

3 Batterham, R J (2004), "The Contribution of Research to Sustainability (with a minerals industry perspective)", Green Processing Conference 2004

4 Fiksel, J (2003), "Designing Resilient, Sustainable Systems", Environmental Science and Technology, Dec 2003

impact where costs can occasionally be to the benefit of a company's performance but are often just the opposite. Finding an underlying optimum level is the key to sustainability and more often than not this is going to require totally different approaches rather than end of pipe solutions.

There is also the consideration of the rate of change in any one element. Our ability to change economic performance, environmental performance or community impacts are rather limited. Communities can and do change but if the rate of change is too drastic we have revolution or instability of governments. Anarchy follows and this is hardly sustainable! Similarly if the rate of change of the broad economics of a process or a region are too great, again our ability to behave in a sustainable way is diminished. Recessions do not lead to significant improvement in environmental performance.

Likewise with the environment; there is only a finite rate that the environment can adapt to changes imposed on it. Our measures of sustainability therefore must not just take into account the three primary areas of focus and their interaction but also the finite rates of change that can be tolerated.

History has shown that companies practising sustainability must achieve financial stability if they are to attend to health and safety issues and the environment and the concerns of the community in which they operate. A solid base of economic performance has to be the precursor of overall performance in sustainability.

Measuring our performance in sustainable development is a complex exercise and needs to be approached from different levels. We have previously proposed using a hierarchical method to take a systematic view in evaluating sustainable development[5]. There are a variety of presently available metrics and systems

5 Batterham, R J, "The Link between Chemical Engineering, Enterprises and Sustainable Development: Setting Direction, Wisdom from Action, Systems and Measurement", Hong Kong University of Science & Technology 10th Anniversary Symposium on "Chemical Engineering in Asia: Education, Research and Development", Hong Kong, 28 August 2004

aiming to measure sustainable development performance and progress. They can be roughly grouped into five levels in a hierarchy which ranges from global through to individual activities. The levels are:

Level 1: Global Objectives

Level 2: Industry Strategy

Level 3: Enterprise Target

Level 4: Specific Project

Level 5: Individual Actions/ Measured Outcomes

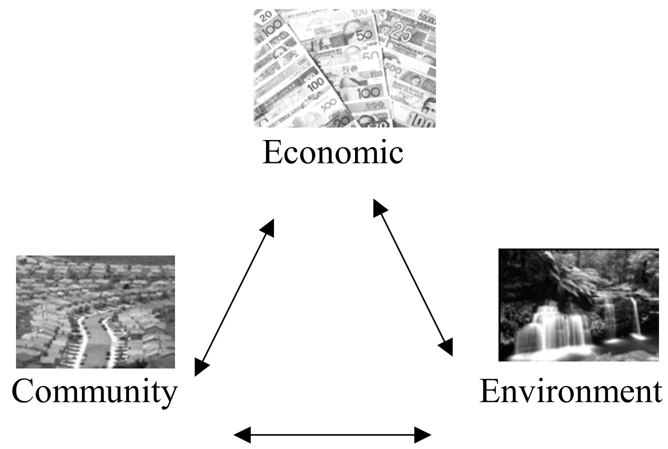

Figure 1 - Three main elements of Sustainable Development

Global Objectives (Level 1)

Some issues are innately global. An obvious example is the effect of greenhouse gases. Undoubtedly the production of greenhouse gases will have a global impact regardless of where they were produced.

Such global matters can be considered using the principles of the Natural Step[6]. This approach sees the world as a closed system, the sustainable resource for all life. It says that in a truly sustainable world, nature will not be impacted by increasing concentrations of substances extracted from the earth's crust; by substances produced by people or by degradation of the environment by physical means and yet, in that world the needs of all people will be met.

Industry Strategy (Level 2)

There are some specific issues that affect companies in the same industry. For instance, the issue of acid mine drainage, an issue that challenges the mining industry as a whole. As these types of issues are faced by all of the companies in an industry, there is a greater willingness for companies to collaborate together to address common issues. These issues have the potential to destroy an industry through removal by the community of the licence to operate. It is hardly surprising that acid mine drainage has had such a focus around the world but it has taken many years before a truly collaborative approach has been adopted. INAP (International Network for Acid Prevention) is such a collaboration between seven mining companies and exist to address the management of acid mine drainage[7].

Enterprise Target (Level 3)

An individual enterprise has significantly more ownership of sustainability activities. It has control of its activities and can therefore choose its own directions, re-engineering its activities, educate its people and interact with its local community. Individual enterprises are capable of developing better technologies and new processing routes to accomplish sustainable

6 Gips, T, 'The Natural Step Framework's Four Conditions for Sustainability or System Conditions', www.mtnorg/iasa/tnssestemconditions.html, accessed 30-10-04.

7 The International Network for Acid Prevention, http://www.inap.com.au, accessed on 4-11-04

development objectives. This enterprise level is therefore a key target for sustainability metrics.

Specific Projects (Level 4)

This level describes opportunities to increase sustainability by the execution of particular projects within a specific enterprise. Such activities of course can encourage a whole industry or even further a field.

Individual Actions/ Measured Outcomes (Level 5)

This level deals with the practical, tangible every day activities that individuals can choose to undertake, whether as individuals or within an enterprise or wider a field.

Overall, there are considerable advantages in this hierarchical approach. It allows us to resolve the issue of measurement into smaller sections and to come up with practical, detailed measurements. There are however disadvantages in targeting one particular level in our pursuit of sustainable development. As an example, concentrating too much on the sustainability aspects of a specific project (Level 4) may lead an enterprise into neglecting opportunities for collaboration with other enterprises (Level 2).

The INAP example already mentioned is a classic case here where an industry as a whole can move towards a more sustainable position by individual companies pooling their resources and modifying their individual projects to fit in with more global targets.

The challenge at any individual level is how well individual measurements cover the aspirations for sustainability, how they can be compared between different projects or players, how achievable targets are and how these might vary from one level to another.

Figure 2 describes several of the available systems and metrics and suggests which level they are capable of covering.

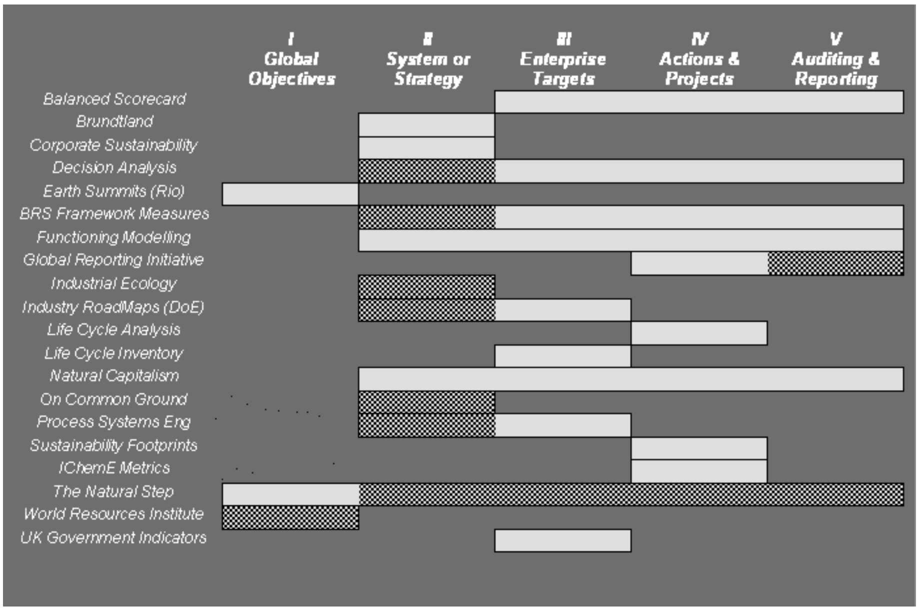

Figure 2 - Some available measurement methods for Sustainable Development

Analysis of Figure 2 suggests that no single system or metric is capable of covering all of the levels in our hierarchy of sustainable development. This is not to argue that the systems listed above are not useful within their areas of applicability. From the practical viewpoint we recommend several of these systems:

- The Natural Step (TNS) to provide some understanding of the global issues
- BRS is functional at industry level and beyond[8]
- PSE (Process System Engineering) is handy as a practical toolkit[9]

8 Chesson, J, "An Evaluation Framework for Sustainable Development", Bureau of Rural Sciences, Canberra (2004).

- Lifecycle Inventory and WRI (World Resources Institute) as practical tools for global targets
- IChemE (Institution of Chemical Engineers) as a minimum checklist[10]

MINE OF THE FUTURE

Figure 3 illustrates the increasing trend of the world demand for minerals. Both from the economic and the sustainability points of view the trends are encouraging as, while the market demand is increasing, the intensity of usage per unit of GDP is in fact decreasing.

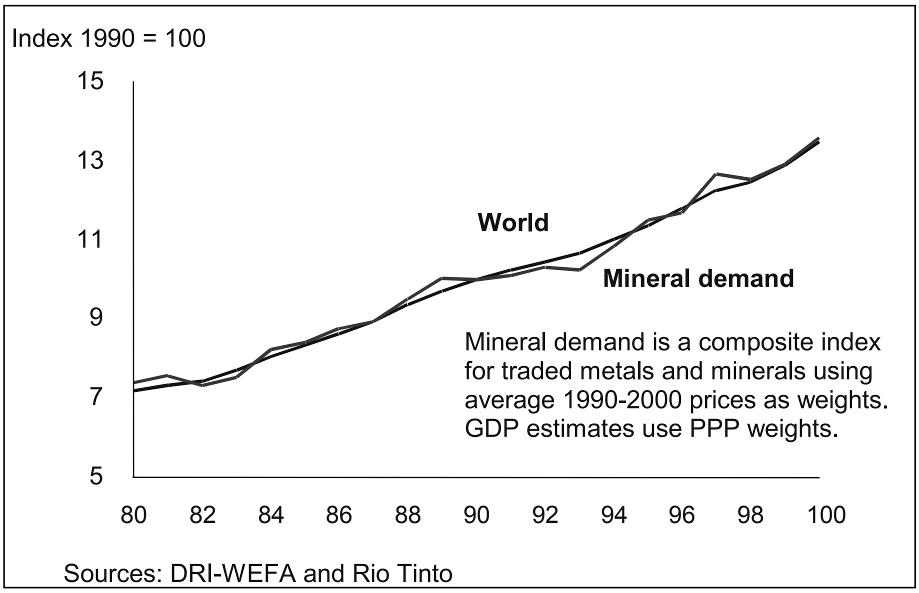

Figure 3 - World Demand for Minerals

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9 Bakshi, B R and Fiksel, J, "The Quest for Sustainability: Challenges for Process System Engineering", AIChE Journal, June 2003, Vol 49, No 6, p1350

10 Institution of Chemical Engineers, 2002, "Sustainable Development Progress Metrics Recommended for Use in the Process Industries", (IChemE, Rugby, UK)

Despite the demand and its impact on recent prices, there are significant long terms challenges being demanded by the market. The rise of so called responsible investment funds and societal pressures, particularly in developed countries, demand that improved returns must go hand in hand with better environmental performance and greater social responsibility.

These new market forces put pressure onto mining companies to change the way they plan and carry out their activities. It is not too difficult to imagine that the mine of the future may well have a significantly reduced environmental footprint, even to the point of virtually no long term environmental footprint.

Some of the characteristics of the mine of the future could be:

- Limited surface disturbance during mining as the mineralisations will be deep underground.
- Undisturbed land use as there will be no pit, no subsidence, no tailings, no waste and no fill.
- Automated, in place extraction techniques such as solution mining and hence much safer operations.
- Considerably more cost effective with significant reductions in mine development, ore transport, comminution and beneficiation.

It is clear to see that such a drastic change in the way we approach the sustainable mine of the future will need much innovation and, no doubt, collaboration. Innovations in barrier technology, leaching technology, direct electrowinning and transport of metal modules to the surface will all take time

A NOVEL APPROACH OF SUSTAINABLE DEVELOPMENT

Rio Tinto has undertaken a significant amount of work in sustainable development and targets sustainability in all of its operations. It is built into the structural role of operations. Over and above this, Rio Tinto has also set up the Rio Tinto Foundation for a Sustainable Minerals Industry (RTFSMI). The Foundation was established in 2002 as an alliance between government and business. The Foundation was funded by the loan of A$35 million from the Australian Government and a similar amount from Rio Tinto[11]

The foundation's objective is to endorse research and technical development that will assist the minerals industry to meet the challenges of sustainability. Its projects cover all aspects of sustainability, the technical and economic, the social and cultural and the environmental challenges. The Foundation is governed by an Advisory Board of six members that includes representatives from the Australian Government, from academia, from industry and three representatives from Rio Tinto.

The Foundation has Working Groups which consist of Rio Tinto employees and government representatives to support the Advisory Board. The Working Groups submit projects coming from Rio Tinto Business Units for approval by the Advisory Board. Given the origin of the projects within Business Units, they pass as a precondition the test of business practicability and meeting expectations of shareholder returns. Such an approach is fundamental to any sustainability project.

At the end of 2004, the Foundation had approved 46 projects with A$48 million allocated and A$32 million of expenditure. Encouraging early successes have been reported on energy and water management technologies. The Foundation activities are leveraged through industry bodies and include collaboration with more than 70 external research institutions and technology providers.

Projects range over:

- Advance Energy Efficient Smelting Technologies
- Sustainable Energy Futures
- Water Management and Control

11 The Rio Tinto Foundation for a Sustainable Minerals Industry, 2004 Annual Report

- Regional Synergies/ Regional Sustainability
- Mine Life and Site Remediation
- Communication and Networking

These categories are in line with the key themes of the Minerals Council of Australia (MCA) initiatives on sustainability[12].

Many of the projects tackle energy and energy efficiency as their primary objectives. As an example, Circofer®[13] is a project which investigates the possibility of using wider types of coal and renewable fuels in pre-heating and pre-reduction in the HIsmelt® iron making technology. The project was piloted in 2004 and has already demonstrated some success at the pilot stage. It has the potential to significantly reduce the net amount of carbon dioxide produced in the production of metallic iron and in the long run, via renewable sources, to see iron produced with zero greenhouse emissions.

Within Rio Tinto Aluminium, Comalco is conducting extensive research in the use of coated cells that target improving the energy efficiency of the conventional production cell. The benefits from these projects include lower greenhouse gas emissions and improved energy efficiencies and lower smelting costs. Figure 4 illustrates the schematic of the coated cell technology and the gradual progression from conventional cells through to fully drained cathode cells.

12 http://www.minerals.org.au/corporate/events/2005_sustainable_development_conference; accessed on 21-09-2005

13 http://www.outokumputechnology.com/pages/Page____7250.aspx, accessed on 22-09-2005

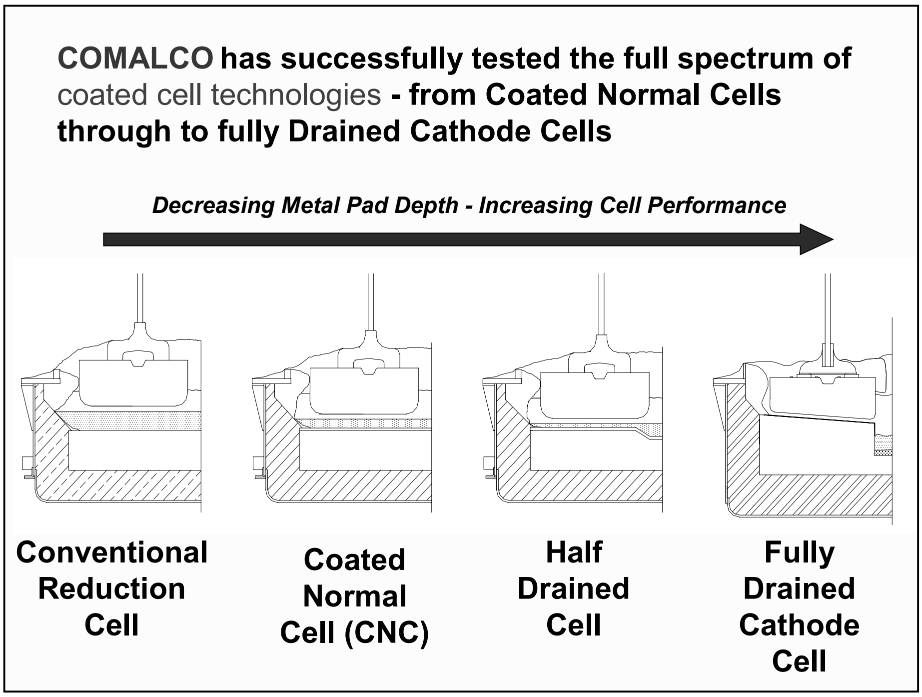

Figure 4 - Rio Tinto Aluminium coated cell technologies

There are several projects in water management that have already shown some success. As an example, the Excellence in Water Management project has reported that in four demonstrations within Rio Tinto's Business Units, the potential for reduction in fresh water consumption is of the order of 25% compared with conventional processing technologies.

In Regional Sustainability projects, Argyle Diamonds have undertaken a study on the extended stakeholder impact of a possible underground operation. Their proposed underground operation is being evaluated for the impact it will have on the company and the community at every stage of the international diamond value chain.

The Foundation also supports projects in remediation technologies. Bioremediation using sulphate reducing bacteria to remove metals from ground water has been demonstrated. Equally the development of geographical information systems to manage the monitoring of heavy metal contaminations and the risks associated with such contamination is a key project. We give particular emphasis to natural attenuation as a sustainable path.

CONCLUSION

It is clear that sustainable development is increasingly important in the operation of mining companies. For the mineral industry, one of the biggest challenges is the lack of agreed metrics to measure sustainability. For now, it is convenient to use metrics that focus on one particular level of activity.

In the future, we can envisage mining with zero environmental footprint. The steps towards this will, however, require considerable development and many years of activity.

On a practical level, mining companies such as Rio Tinto are engaging in a wide range of development projects which target improving our performance in sustainability.

ACKNOWLEDGEMENTS

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Africa

SUSTAINABLE DEVELOPMENT INDICATORS – SOME TECHNOLOGICAL CHANGES MADE IN THE SOUTH AFRICAN MINING AND RESOURCES SECTOR TO MEET THE CHALLENGE

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ABSTRACT

South Africa has vast mineral wealth in the form of, amongst others, world-class platinum, gold, coal and diamond deposits. These finite resources need to be exploited in an optimal and wise manner for the benefit of both the current and future generations so as not to create an economic dependency in South Africa on mining and to avoid the phenomenon of the so-called "resources curse". The South African government, business sector and society have recognized this fact about mining from past experience and through their participation in international bodies and studies, such as the United Nation's Global Compact, the Minerals, Mining and Sustainable Development Projects (MMSD), Internal Council on Metals and Mining (ICMM), Global Reporting Initiative (GRI) and the World Bank's Extractive Industries Review. As a result the South African government, business sector and society have fully embraced the principles of sustainable development in legislation, such as the National Environmental Management Act and the Minerals and Petroleum Resources Development Act, in the way mines are operated and in terms of how companies report performance.

This legislation is transforming the mining sector in South Africa and it has become a prerequisite that a mining company has environmental, social and labour plans over and above the usual financial plans in order to obtain and retain a mining right. These plans require*, inter alia*, that the environmental and social impacts be determined, mitigated and monitored for all stages of a mining operations life, and in particular at mine closure.

In order to determine the effectiveness of these plans and to report on performance, the government and business have

developed and adopted a number of sustainable development indicators in the economic, social and environmental spheres that are driving delivery and performance.

Five South African case studies are discussed to show how technology changes have been, and are being, made to meet the global sustainable development challenges. These case studies include how South African Government bodies and companies are investing in fuel cell research; reducing greenhouse gas emissions through projects such as the Mondi Biomass Project and Amandebult Mine Low Energy Lighting Project; maximizing the reuse of water through water treatment using the DesEl Process and reducing sulphur dioxide emissions through technology changes at the Waterval Smelter.

1. INTRODUCTION

South Africa is located on the southern most tip of the African continent and has tremendous mineral wealth in the form of large-scale gold, platinum, diamond and coal deposits (Figure 1). To ensure a stable South African society in future, it is imperative that this mineral wealth be harnessed for the benefit of all South Africans in a responsible and sustainable manner. To this end it is essential that government and business work in partnership to unlock the full potential and intrinsic wealth from the Country's mineral deposits.

This paper gives a general background to the concept of sustainable development before analyzing the principles of the National Environmental Management Act and the Minerals and Petroleum Resources Development Act thereby providing a more detailed overview of sustainable development in the South African legislative and business context. It is this legislation, and the global sustainable development agenda, that is driving the formulation of sustainable development indicators against which business and government are measuring their performance.

Figure 1 - Locality map of South Africa

Mining and resources companies have changed the way they operate and have implemented new technologies to ensure compliance with the sustainable development indictors and these will be discussed in more detail via five case studies. These case studies are discussed to show how technology changes have been and are being made to meet the global sustainable development challenges. They include how South African government bodies and companies are investing in fuel cell research; reducing greenhouse gas emissions through projects such as the Mondi Biomass Project and Amandebult Mine Low Energy Lighting Project; maximizing the reuse of water through water treatment using the DesEl process and reducing sulphur dioxide emissions through technology changes at the Waterval Smelter.

2. SUSTAINABLE DEVELOPMENT

According to Dresner, S. 2002 the starting point for the concept of sustainable development was the aim to integrate environmental considerations into economic policy, it was to be the ground on which the mainstream policy makers and economists were to consider the environmentalists case. It was deliberately conceived as being something more palatable than the hard-line environmentalists message. Rather than challenge the idea of growth directly, it sought to modify the kind of growth strategies that were pursued (Dresner, S. 2002).

Sustainable development was first defined in the Brundtland Report in 1987, which was a report compiled by the then World Commission on Environment and Development, chaired by Gro Harlem Brundtland. The report is well known for coining the phrase "sustainable development" which it defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

The activities of the Commission served as the basis for the UN Conference on Environment and Development1, held in Rio de Janeiro in June 1992. This Summit was instrumental in raising the awareness of the concept of sustainable development and in emphasizing the need to integrate environmental and developmental issues2.

Although the "Brundtland" definition is widely used, there is still much confusion about what sustainable development really means. It has been recognized that the sources of conceptual confusion surrounding the expression are linked closely to the lack of agreement regarding exactly what is to be sustained, for whom, and by what means (Redclift, 1992; Frazier, 1997). Jacobs, M. 1999 describes this conceptual confusion as "fault-lines" that represent internal tensions within the concept of sustainable development itself. On each one of these fault lines, two principally opposing and competing conceptions of sustainable development can be found, with a continuum of possible positions between the two polar extremes (Jacobus, M. 1999). In terms of

1 More commonly known as the "Earth Summit"

2 The outcome of the Earth Summit was: Three general documents: the Rio Declaration, Agenda 21 and the Forest Principles; A new institution: the UN Commission on Sustainable Development; and Two new environmental conventions: on climate change and bio-diversity.

Jacobs' analysis these fault lines have to do with, the degree of environmental protection that is envisioned to attain sustainable development; the emphasis placed on equity as a prerequisite for sustainable development; the measures and nature of participation required to attain sustainable development; and the scope of the subject area covered by the concept of sustainable development (Hattingh, J. 2002). Based on Jacobs' analysis, Hattingh, J. 2002 distinguishes between 5 conceptions of sustainable development, all of these representing internal tensions. These are weak or strong interpretation of sustainable development; a minimalist or a robust interpretation, a non-egalitarian or an egalitarian interpretation; a top-down or a bottom-up interpretation and a narrow versus a broad interpretation.

Despite this conceptual confusion it is the "5 Capitals" model has become a widely used model for sustainable development within organizations and is depicted in Figure 2 and is discussed in more detail. Natural capital encompasses the other capitals as natural resources and ecological systems form the basis of life, on which all organizations and wider society depend. Social, human and manufactured capitals are critical components of an organization and its activities. High values of these capitals deliver value to both organizations and society, not to mention improving the quality of life of stakeholders. Financial capital is crucial to the ongoing survival of an organization and is simply derived from the value that the other four capitals provide. All of the capitals are interlinked and there is some overlap between them. The whole system is encircled by the principle of accountability, representing the relationship that an organization has with the outside world – with its stakeholders and for its stewardship of the five capitals.

The capitals need to be managed for the long term, not just the immediate return, building up stocks of capital and living off the interest that this creates. They also need to be recognized as interdependent, where changes in one are likely to cause an impact on another. Likewise, one form of capital cannot simply be traded against another. The 5 capitals are discussed in more detail below.

Figure 2 - The " 5 Capitals Model" for sustainable development (***from the Sigma guidelines*****)**

"Natural capital" means the natural resources (energy and matter) and processes needed by organizations to produced their products and deliver their services. They include:

- sinks that absorb, neutralize or recycle wastes;
- resources, some of which are renewable (e.g. timber, grain, fish water), whilst others are not (e.g. fossil fuels); and
- processes, such as climate regulation and the carbon cycle, which enable life to continue in a balanced and healthy way.

"Human capital" incorporates the health, knowledge, skills, intellectual outputs, motivation and capacity for relationships of the individual. In an organizational context it includes the elements needed for people to engage in productive work and the creation of wealth, thereby achieving a better quality of life. Human capital is also about dignity, joy, passion, empathy and spirituality.

"Social capital" is any value added to the economic outputs of an organization by human relationships, partnerships and co-operation. Social capital includes, for example, networks, communication channels, families, communities, businesses, trade unions, schools and voluntary organizations as well as cultural and social norms, values and trust.

"Manufactured capital" refers to material goods and infrastructure owned, leased or controlled by an organization that contribute to production or service provision, but do not become embodied in its output. Examples include: tools, technology, machines, buildings and all forms of infrastructure.

'Financial capital' reflects the productive power and value of the other four types of capital and covers those assets of an organization that exist in a form of currency that can be owned or traded, including (but not limited to) shares, bonds and banknotes.

'Accountability' consists of three elements:

- Transparency means the duty of an organization to account to its stakeholders.
- Responsiveness means the need to respond to stakeholders.
- Compliance means the duty to comply with standards to which an organization is voluntarily committed, and rules and regulations that it must comply with for statutory reasons.

An organization's accountability is fulfilled by being transparent, being responsive and by its compliance with appropriate rules; and by engaging with and accounting to stakeholders for its performance in these respects. Organizational accountability is based on effective engagement with stakeholders. An organization's stakeholders are those groups who affect and/or are affected by the organization and its activities. Stakeholders may include, but are not limited to owners, trustees, employees and trade unions, customers, members, business partners, suppliers, competitors, government and regulators, the electorate, non-governmental organizations (NGOs), not-for-profit organizations, pressure groups, and local and international communities. Engagement builds relationships with stakeholders to determine what is important or material to all involved, in order to improve overall performance (Sigma Guidelines, 2004).

The 5 Capitals model is used in this paper to categories the sustainability indicators used by mining companies in South Africa to measure sustainability performance.

3. SUSTAINABILITY INDICATORS – GLOBAL DRIVERS

Clearly, the South African mining companies do not operate in isolation from the rest of the world and there are numerous global issues and considerations that influence and impact on the local sustainability indicators used by South African mining companies. The more significant considerations are discussed in this section.

In 1992 the United Nations Conference on Environment and Development (the Earth Summit) was held in Rio de Janeiro and the Nations of the World agreed on a human and environmental action plan for the next century, entitled Agenda 21. The Commission on Sustainable Development was then developed to supervise national and international implementation of the Earth Summits commitments, especially Agenda 21. In 1997, and as a result of a growing concern about global warming, the Kyoto Protocol was formulated. The Protocol commits 38 industrialized countries to cut their greenhouse gas emissions, between 2008 and 2012, to levels that are 5.2% below 1990 levels. In 2000 the United Nations Global Compact was launched to address some of the world's more intractable problems by challenging business leaders to adopt and apply nine operating principles across human rights, labour and environmental practices. The Millennium Summit was also held in 2000 at which over 150 Heads of State agreed on the Millennium Development Goals, an ambitious agenda to reduce poverty, improve lives and protect environmental resources. The Dow Jones Sustainability Index and FTSE4 good indices were launched in the USA and UK respectively in 1999 and 2001. Both these indices require companies wishing to qualify to report on economic, social and environmental performance against acceptable indicators. In 2002 the World Summit on Sustainable Development convened in Johannesburg and brought together Heads of State from around the world and the Johannesburg Declaration was adopted that included plans to, *inter alia*, reduce poverty, increase access to health care and medicines, reduce environmental degradation and improve the quality of life for the poor (Freemantle, A & Rockey, N, 2005).

Many of these protocols, declarations and agreements require business, including mineral recourse companies, to report on their economic, social and environmental performance against various sustainability indicators. In 1997 the Global Reporting Initiative (GRI) was launched as a joint initiative of the coalition for Environmentally Responsioible Economics (CERES) and the United National Environmental Programme (UNEP) to enhance the quality, rigour and utility of sustainable development around the world. The GRI released its first set of Sustainability Reporting Guidelines in June 2000. A continual process of international review of the guidelines culminated in the second release in 2002. To complement the 2002 guidelines, the GRI has also released six sector supplements that address industry specific sustainability issues. One such supplement is the Mining and Metals Sector Supplement that was released in February 2005 (Freemantle, A & Rockey, N, 2005).

South Africa's major mining companies including operations of, *inter alia*, Anglo American, Anglo Platinum, BHP Billiton, Gold Fields, Impala and Lonmin Platinum all report in accordance with the GRI and use the sustainability indicators recommended by the GRI as indicators of performance. Table 1 is a list of the South African companies per sector that are using GRI indicators as a measure against which to report performance.

Table 1 - South African Companies per sector that are using the Global Reporting Initiative's indicators as a measure of performance (*modified from www.global reporting.org*)

South African Company	Sector	In Full Accordance with GRI
Anglo Platinum Ltd	Mining	✓
Anglo Coal South Africa (Anglo American)	Mining	
AngloGold Ashanti Ltd.	Mining	
BHP Billiton Hillside Aluminum	Mining	
Gold Fields	Mining	
Impala Platinum Holdings Limited (Implats)	Mining	
Kumba Resources	Mining	
AECI	Chemicals	
SASOL	Chemicals	✓
Deloitte	Commercial services	
Barloworld Ltd.	Conglomerates	
Pretoria Portland Cement (Barloworld)	Construction materials	
Procter & Gamble SA Ltd.	Consumer durables	
Eskom	Energy utilities	
Absa	Financial services	
African Bank Investments Limited (ABIL)	Financial services	
Investec	Financial services	
Nedbank Group	Financial services	
Old Mutual South Africa	Financial services	
Standard Bank Group Ltd.	Financial services	
Mondi Paper Ltd.	Forest and Paper products	
Sappi	Forest and Paper products	
MTN Group	Telecommunications	
British American Tobacco South Africa	Tobacco	
Spier Holdings	Tourism/leisure	
Umgeni Water	Water utilities	

Certain technology changes that are being contemplated in the South African mining and resources sector are being driven by the underlying intent behind the GRI indicators. These technology changes will be discussed in more detail later.

4. SUSTAINABLE DEVELOPMENT INDICATORS IN THE SOUTH AFRICAN CONTEXT

Prior to South Africa's first democratic election in 1994 the legislative regime in force was repressive and favoured the white population in every respect and scant regard was given for the principles of sustainable development in any form legislation. However in 1993 a new Constitution of the Republic of South Africa was drafted taking cognizance of, amongst other things, global issues around human rights and social and environmental justice. These changes have given rise to certain legislative changes that are discussed below.

The Constitution of South Africa specifically includes an "environmental and sustainable development clause" in Section 24 of the Bill of Rights chapter, which embraces the principles of sustainable development and reads:

- " *everyone has the right to*
- *an environment that is not harmful to their health or well-being; and*
- *have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measure that*
- *Prevent pollution and ecological degradation*
- *Promote conservation; and*
- *Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.*"

The Constitution compels government to give effect to people's environmental rights and places government under a legal duty to act as a responsible custodian of the nation's environment.

Furthermore, it compels government to pass legislation and use other measures to secure sustainable development. To this end the South African government has undertaken a law reform programme to ensure that the principles of sustainable development become inculcated in all aspects of the country's legislation.

The most important new piece of legislation that has been drafted in terms of the law reform programme is the National Environmental Management Act (NEMA), Act No 107 of 1998. This Act provides an underlying framework and set of principles that all future legislation, and legislation promulgated after 1998, in South Africa must consider (Costus, T. 2005). Furthermore, NEMA provides a definition of sustainable development as:

"*the integration of social, economic and environmental factors into planning, implementation and decision-making so as to ensure that development serves present and future generations.*"

The NEMA principles require the consideration of all relevant factors by all organs of state when drafting legislation and evaluating development projects, including the following:

That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimized and remedied;

- ✓ That pollution and degradation of the environment are avoided, or, where they cannot be altogether avoided, are minimized and remedied;
- ✓ that the disturbance of landscapes and sites that constitute the nation's cultural heritage is avoided, or where it cannot be altogether avoided, is minimized and remedied;
- ✓ that waste is avoided, or where it cannot be altogether avoided, minimized and re-used or recycled where possible and otherwise disposed of in a responsible manner;
- ✓ that the use and exploitation of non-renewable natural resources is responsible and equitable, and takes into account the consequences of the depletion of the resource;

- ✓ that the development, use and exploitation of renewable resources and the ecosystems of which they are part do not exceed the level beyond which their integrity is jeopardized;
- ✓ that a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions; and
- ✓ that negative impacts on the environment and on people's environmental rights be anticipated and prevented, and where they cannot be altogether prevented, are minimized and remedied

The legislation that governs the mining industry has not escaped the law reform process. South Africa's Minerals Act of 1991 has been reviewed as part of the law reform process. The new legislation, known as the Minerals and Petroleum Resources Development Act 28 of 2002 (MPRDA), came into operation on 1 May 2004. Section 37 of the MPRDA embraces the guiding sustainable development principles, as set out in section 2 of NEMA, making them applicable to mining projects. The MPRDA has been controversial legislation in South African context in that it has eliminated the notion of private ownership of mineral rights and has given effect to the principle that the State is the custodian of the nation's mineral resources and that the State has the right to exercises sovereignty over all the mineral resources within the country (Costus, T. 2005).

One of the objectives of the new Act is to ensure that holders of mining rights contribute towards the socio-economic development of the areas in which they are operating. In order to achieve these objectives, section 23 of the MPRDA states that the Minister must grant a "mining right" if the granting of such right will, *inter alia*, further the objectives of the prescribed social and labour plan as required by Section 25 of the Act. The social and labour plan requirements are detailed in Chapter 2, Part II of the regulations promulgated in terms of the MPRDA and must include the following details :

- processes pertaining to management and down scaling and retrenchment, which must include the establishment of the future forum and mechanisms to save jobs and avoid job losses and a decline in employment;

- mechanisms to provide alternative solutions and procedures for creating job security when job losses cannot be avoided; and
- mechanisms to ameliorate the social and economic impact on individuals, regions and economies where retrenchment or closure of the mine is certain.

The South African Mining Charter was developed in consultation between the mining and minerals industry and Government, ratified in October 2002 and published in General Notice 1639/2004 in Government Gazette GG2661 of 13 August 2004 in terms of section 100(2) of the Mineral and Petroleum Resources Development Act, 2002, (MPRDA). The Broad-based Socio-economic Charter for the Mining Industry (the Mining Charter) is designed to bring into effect the aims of the MPRDA. The goal of the Charter is to 'create a mining industry that will proudly reflect the promise of a non-racial South Africa'. The Government produced an annexure to the Mining Charter with measures, or indicators, for assessing the progress of mining companies in respect of a number of key areas as they relate to socio-economic goals. This document is known as the 'Mining Scorecard'. There are nine elements of the Mining Scorecard. Each element and its sub-requirements are detailed in Appendix 1.

In addition to the MPRDA there are other Acts that govern the way environmental resources should be governed, all of which have been promulgated post 1994. These include the National Air Quality Act and the National Water Act.

The National Air Quality Act was approved and gazetted in February 2005. The overall objective of the Act is to reform the law regulating air quality in order to protect the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development while promoting justifiable economic and social development. The Act also provides for the introduction of national norms and standards relating to emission limits and levels and ambient air quality.

The National Water Act of 1998 eradicates the distinction between public and private water and does away with the concept of riparian rights, as was contained under previous legislation. The National Government is the "public trustee" of all of the nations water resources and therefore has the power to regulate the use, flow and control of all water in the country. A National Water Resources Strategy has been drafted as a requirement of the legislation and specifically requires, *inter alia*, maximization of water re-use, recycling, treatment and introduces a waste water discharge charge system for disposal of final effluent into natural water courses.

From this brief legislative overview it is evident that sustainable development principles have been adopted and embraced in the legislative reform process in South Africa. These legislative changes and the challenges posed by the global sustainable development agenda have lead to technology changes to improve mining companies performance and 5 such examples are discussed in detail.

5. SUSTAINABLE DEVELOPMENT INDICATORS AND TECHNOLOGICAL CHANGES IN THE SOUTH AFRICAN MINING AND RESOURCES SECTOR

The global sustainable development agenda and the South African legislative reform processes have resulted in mining and resources companies searching for new technologies to assist with improving their sustainable development performance. Five such examples are discussed in more detail.

5.1. Economic Capital –Fuel Cell Research and Beneficiation

The GRI Mining and Metals Sector Supplement Core Indicator contemplates "value add" under indicator MM2 "Value added disaggregated to country level". Furthermore, the South African Mining Charter poses the following questions:

- Has the mining company identified its current level of beneficiation?

- Has the mining company established its baseline level of beneficiation and indicated the extent that this will have to be grown in order to qualify for an offset?
- Current beneficiation position?

One of the objectives of the South African Department of Science and Technology, as set out in the National Research and Development Strategy, which was adopted in 2002, is to achieve mastery of technological change in South Africa's economy and society, mainly by means of innovation. Within this context, the Department is tasked with identifying and developing the lead sectors that will potentially expand the base for the creation of wealth, and position South Africa to compete successfully within the dynamic knowledge economy. To this end the Department of Science and Technology has identified the hydrogen economy and related fuel cell technologies as a "Frontier Science and Technology" area that could potentially change the innovation course of the country's natural resources, and yield multiple social and economic benefits. Hydrogen and fuel cells are believed to be the energy solutions for the 21st century, by enabling clean efficient production of power and heat from a range of primary energy sources. Fuel cells produce power-using hydrogen as a source of fuel and as such do not directly emit poisonous gases to the atmosphere, as the only by-products in the process are heat and water. As yet, this energy source is not entirely renewable and without secondary emissions because most liquid hydrogen fuel is produced using non-renewable energy. Nevertheless, emissions legislation in place in the USA will require an increasing number of zero emission vehicles to be sold.

If the transition to hydrogen is realized it is expected to greatly reduce dependency on oil and gas, and reduce carbon dioxide emissions, especially when used in efficient fuel cells. In the spectrum of technologies that interconnect to build up the hydrogen economy vision, platinum plays a crucial role as a catalyst that converts hydrogen to electricity. According to the International Platinum Association, no other material has been shown to be as effective as platinum in Proton Exchange Membrane fuel cells. The significance of this fact raises multiple issues for South Africa and its endowment with platinum resources.

The South African Government is supporting research, that is currently being undertaken at the University of the Western Cape's South African Institute for Advanced Materials Chemistry (SAIAMC), into fuel cell technology and has launched the South African Fuel Cell Initiative that brings together scientists who are currently conducting research in this field.

The SAIAMC explores the synthesis and characteristics of advanced materials, including nanomaterials, and designs and develops processes for their manufacture and application in energy generation and the hydrogen economy; cleaner processing and chemicals production; and environmental remediation. The SAIAMC has numerous facilities including, *inter alia*, 5 fuel cell and hydrogen testing stations 0.1W – 1 kW; 3 catalyst testing reactor units with online gas chromatographs; nano manufacturing facility with complete production cycle; fuel cells modeling workstation; AUTOCHEM 2910 catalyst tester and computer modeling facility with FEMLAB process development software.

The Institute is currently involved in research into direct methanol fuel cells; fuel cell components; fuel cell modeling; lithium battery development; hydrogen production, storage and separation; fuel cell catalysts; electrolysis catalysts and hydrocarbon conversion under mild conditions. A number of product prototypes have been developed by the Institute including a fuel cell battery charger; fuel cell back-up system; large lithium battery for automotive applications; hydrogen storage cylinders and a methane oxidation reactor.

In addition the Government and academic initiatives, Anglo Platinum's marketing agent, Johnson Matthey, established an auto catalyst manufacturing plant at Germiston near Johannesburg in 1992 on the strength of the South African Government's motor export incentive scheme. Other manufacturers followed suit and today South Africa produces more than 10% of the world's catalytic converters using South African labour, PGMs and stainless steel.

Anglo Platinum has had exploratory discussions with Johnson Matthey to determine what options exist for additional fabrication of platinum products in South Africa. From these discussions, and other initiatives, it is anticipated that further local beneficiation options may arise.

South Africa's World of Platinum recently launched a branded range of platinum jewellery called "Djadji" for sale in jewellery stores around the world. Anglo Platinum is giving guidance, advice and funding to the World of Platinum. Furthermore, Anglo Platinum has a number other initiatives in place to encourage local platinum jewellery manufacture including:

- A platinum loan scheme for South African jewellery manufactures;
- the annual Plat Africa jewellery design competition for local jewellery designers;
- the Platinum jewellery manufacture studio in Stellenbosch.

South African gold mining companies have similar initiatives underway through Project AuTEK and various jewellery design studios. Project AuTEK's is pursuing research into the development of new industrial uses for gold such as in catalysts in the chemical industry and nano-technology and is supported by Gold Fields, AngloGold-Ashanti and Mintek . This research could result in the development of new markets for gold.

These initiatives have had, and will continue to contribute to the GDP of South Africa and will have a positive impact on the Country's "economic capital".

5.2. Natural Capital – Air Quality Management

The GRI Core Indicator "EN 10 – NOx, SOx, and other significant air emission types" contemplates initiatives to use reduce emissions from mining and smelting processes.

Anglo Platinum's Waterval Smelter has implemented new technology to greatly reduce sulphur dioxide (SO_2) emissions, through its Anglo Platinum Converter Process (ACP). The ACP was designed to replace the Pierce-Smith Converter technology so that the Smelter could reduce its SO_2 emissions to less than 20 tons/day on average. Figure 3, depicts the PS converter in operation with associated SO_2 fugitive emissions.

Figure 3 - PS converter technology and associated fugitive emissions

Before the ACP process was chosen as the technological solution, a team of Anglo Platinum process engineers undertook an extensive technology review, which included visiting 13 smelters in more than 7 countries and consulting widely with technical experts. As part of this technology review it was recognized that a pyrometallurgical process, which would produce a continuous high strength SO_2 stream, would be the starting point from which an efficient environmentally controlled operation could be designed and implemented. Eight pyrometallurgical options of local and international design were investigated before Anglo Platinum selected the Sirosmelt process, which was developed by the Australian Research Organization, CSIRO, and is marketed by, amongst others, Ausmelt and has been adapted and developed to the requirements of nickel-copper matte smelting.

The ACP process has many advantages over other processes in that it has the capacity to handle varying moisture feeds, can operate in a continues or batch mode, captures 98% of all generated sulphur and is capable of precise metallurgical control, to name a few. Figure 4 is a schematic cross-section of the ACP vessel showing the lance feed points and gas off take points.

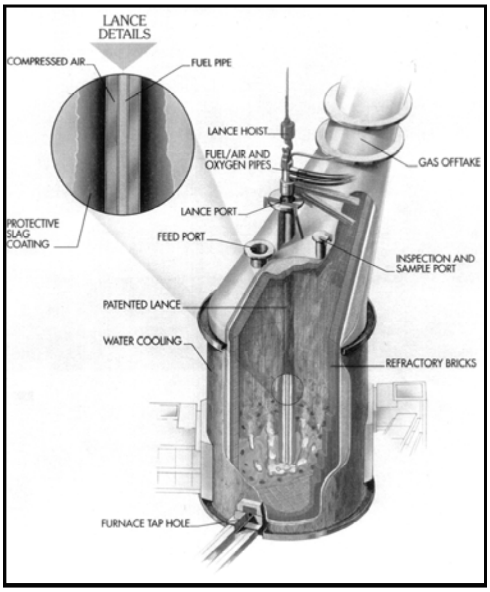

Figure 4 - Schematic of the ACP vessel

The fact that the new converter captures 98 % of all generated sulphur by design, as opposed to Pierce-Smith Converter capture of 55 %, meant that SO_2 emissions to the atmosphere are greatly reduced to less than 20 tones of SO_2 per day from past levels in the region of 180 tones per day.

As part of the ACP project and technology upgrade an entire new acid plant has been constructed to “fix” the converter off-gas. Process engineers evaluated numerous different acid plant technologies and configurations before the double adsorption contact acid plant was selected. The acid plant is able to accommodate interruptions in the ACP gas flows and associated significant variations in off-gas quantities and constituents. The acid plant allows for 98 % sulphur capture when running efficiently and has greatly reduce the occurrence of SO_2 emissions to the atmosphere during process upset conditions.

The ACP process and its associated infrastructure was a R 1,661 billion project and is able to produce 72 000 tons of converter matte per annum at full production. The ACP has greatly reduced sulphur dioxide emissions and Figure 5 shows how sulphur dioxide emissions have been reduced since the plant has been in full operation.

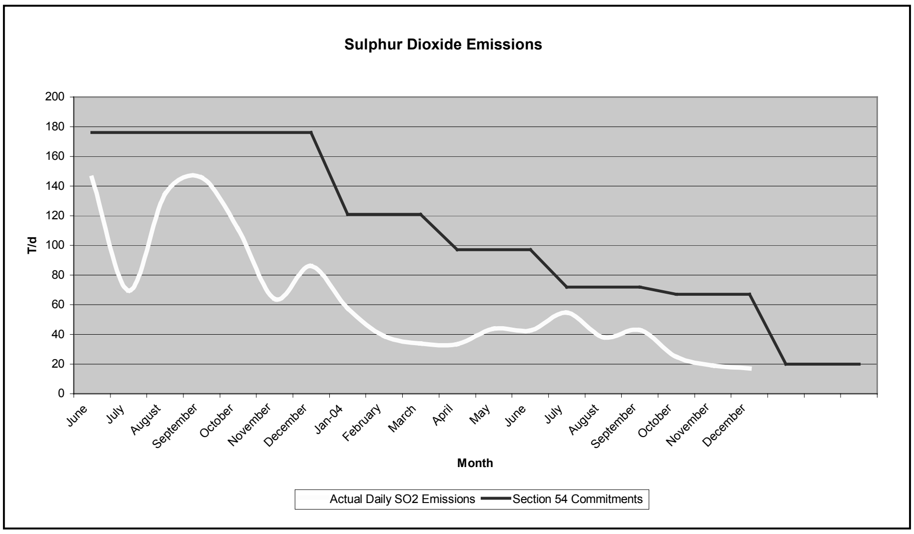

Figure 5 - Graph showing the reduction of sulphur dioxide emissions from Waterval Smelter as a result of the commissioning of the new technology

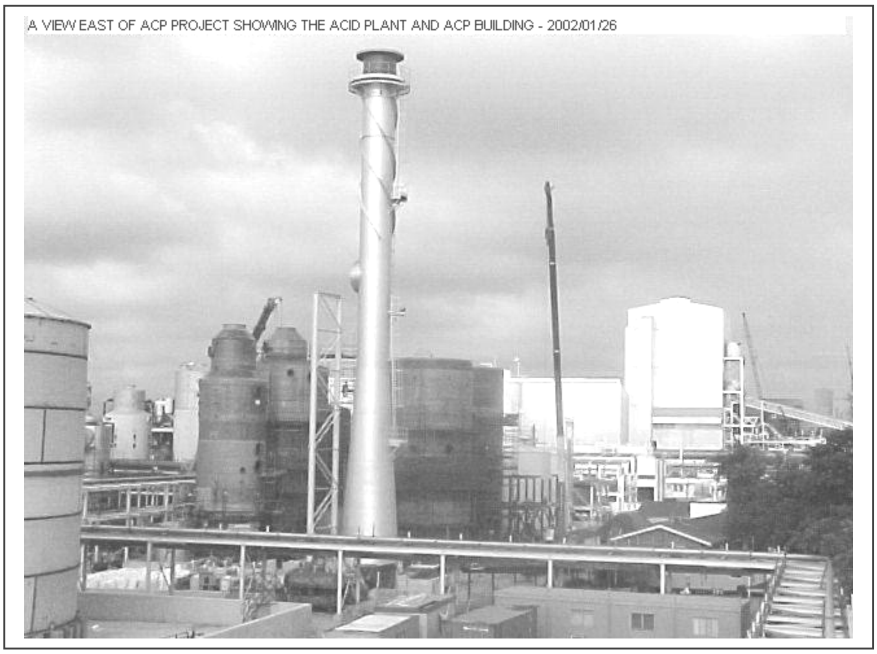

Figure 6 - Photograph of the new ACP Plant at Waterval Smelter

5.3. Natural Capital – Energy and Air Quality Management

The GRI Core Indicator "EN 3 – Direct Energy Use" contemplates initiatives to use renewable energy sources and to increase energy efficiency under Additional Indicator EN 17. The underlying intention of these indicators is to reduce greenhouse gas emissions and encourage improved usage efficiencies of non-renewable energy. Two projects are currently under way in the South African resources sector. One at Mondi Kraft's Pulp and Paper Mill in Richard's Bay and one at Amandelbult Mine.

- **Mondi Kraft Biomass Project**

Mondi Kraft intends to use biomass from local forests as a renewable energy in steam boilers, thereby doing away with the dependency on coal. Briefly, Mondi and other timber processors (chippers) in the Richard's Bay area are presently transporting and land filling their biomass waste at a local municipal landfill site. This biomass will be re-directed to the Mondi biomass boiler, which has an additional capacity for a further 170 tones per day. This will result in the reduction of CO_2 emissions from fossil fuels. In addition, methane emissions from land filling biomass waste will be avoided. The proposed project activities, after implementation, will result in a reduction of coal consumption due to increased utilization of biomass for on-site thermal energy production (Thorne, S. and Terblanche, C., 2004). The boundaries of the project are shown schematically in Figure 7.

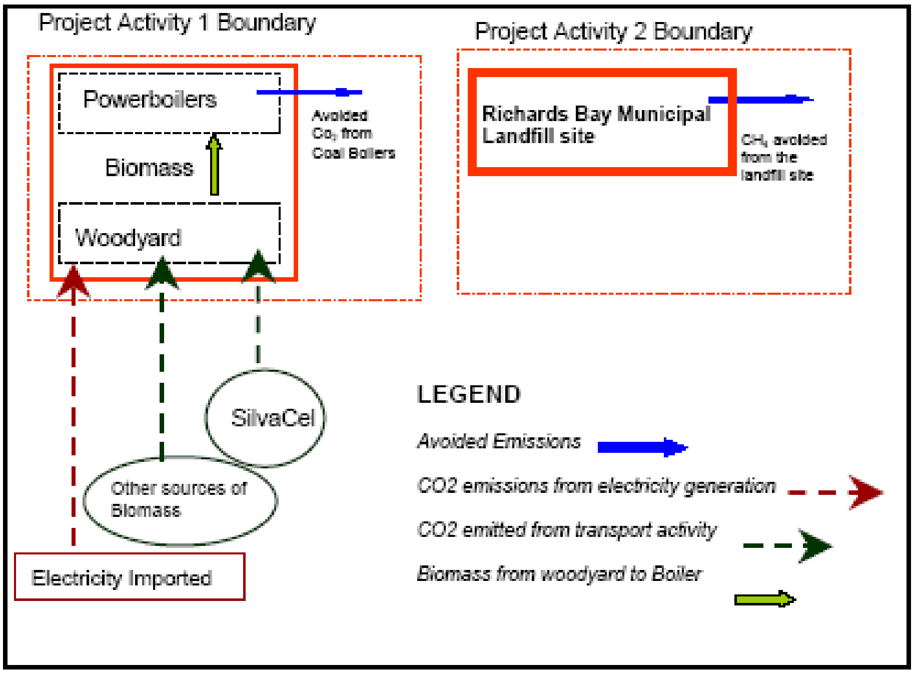

Figure 7 - Boundaries of the Mondi Biomass Project

The sustainability index matrix in Table 2, has been developed by Helio International and adapted by the SouthSouthNorth project to appraise projects against sustainable development indicators. The appraisal tool is used as South Africa has not yet established their Designated National Authority nor the institutional infrastructure to define whether projects contribute to Sustainable Development or not. The indicators are qualitatively rated -3 to 3 for least to most contribution to the indicator. As a threshold or ceiling indicators 2 and 3 must provide positive contributions to distinguish the project from business-as-usual in the South African context. For further explanation of the SD matrix tool visit www.southsouthnorth.org.

The project scores 10 out of a possible maximum of 24, which indicates that the project activity will have a positive impact towards sustainable development rather than a negative one. The self-imposed sustainable development eligibility threshold that includes positive scores for indicators 2 and 3 is met for this project (Thorne, S. and Terblanche, C., 2004).

It is anticipated that the Mondi Biomass Project will reduce greenhouse gas emissions by 684 kiloton's CO_2 equivalent over a 10-year period (Thorne, S. and Terblanche, C., 2004).

Table 2 - Sustainability matrix used by Mondi for the Biomass Proiect

Sustainability Indicators	Score	Comments
Indicator 1 - Contribution to the mitigation of Global Climate Change	+3	Against a baseline the estimated reduction of emissions are approximately 684 kilotonnes $CO_{2\ equivalent}$
Indicator 2 - Contribution to local environmental sustainability	3	The improvement in local air quality by reducing SO_2 and NOx emissions from coal as the consumption of coal is reduced by replacement by biomass. In the Richards Bay area the reduction in methane emissions from landfill as the amount of biomass landfilled will be reduced.
Indicator 3 - Contribution to net employment generation	1	The increased employment involved in construction and commissioning the systems. Small-medium to medium sized Enterprises (SMME) – creation of job opportunities in additional transport needs
Indicator 4 - Contribution to the sustainability of the balance of payments	-1	Some of the technologies linked to the separating and handling of biomass waste may have to be imported. Contribution to the lower import of coal. Contribution to the lower amount of biomass waste to landfill.
Indicator 5 - Contribution to macroeconomic sustainability	0	Neutral. There will be no impact on national imports or exports. Minor impact expected on regional import of coal to the KZN area as the amount of coal reduction compared to the total amount of coal transported by rail from other regions is small.
Indicator 6 - Cost Effectiveness	2	The project is only cost-effective if the carbon financing is included. In such a case the internal rate of return makes the project cost effective for the project participant to finance.
Indicator 7 - Contribution to technological self-reliance	0	Technological self-reliance stays similar to the baseline case. Some additional electricity has to be imported from the national grid but is offset by the reduced amount of coal that has to be imported from other regions by rail. Biomass is accessible locally.
Indicator 8 - Contribution to the sustainable use of natural resources	2	Energy efficiency improvement and the use of renewable energy reduce the use of natural resources.

❑ Amandelbult Mine Low Energy Lighting Project

Numerous mines in South Africa are evaluating the viability of replacing their lighting systems with low energy lighting, thereby saving on electricity costs and reducing secondary greenhouse gas emissions. One such mine is Anglo Platinum's Amandelbult mine.

A survey at the mine revealed the residences, hostel areas, shaft surface areas, training center, hospital, main stores, security, services, central workshop and concentrator plant's total annual energy consumption amounted to 8 384 281 kWh, at the cost of R 1,463,856 (includes kVA charges). A similar survey of the underground areas revealed that there are 32 673 light fittings, 1713 fluorescent and 30 690 incandescent lights, all operating 24 hours per day, 365 days per year. The annual energy consumption of the 30 690 incandescent lights was calculated at 18 819 108 kWh or 67 749 GJ.

An investment of R4 million has enable the mine to start replacing all existing lights underground and on the surface with Voltex low energy light bulbs. This project will save the mine an estimated 68,196 GJ of electric energy annually, which would reduce the mine's annual electricity bill by R2,6 million. This reduction represents a 2.41% saving of the mine's 2004 energy usage base of 2,833,572 GJ.

Using the South African conversion factors provide by Eskom, this energy saving translates into a reduction of greenhouse gas emissions by 16 800 tons per annum, CO_2 equivalent.

In addition R1 million will be saved annually due to reduction of costs for maintenance, reduced consumption of replacement lamps, less damages and theft and reduced amount of lamps held in the inventory. Therefore, the total annual saving will be in the order of R 3 million.

5.4.Natural Capital – Water Treatment and Re-use

The GRI Core Indicator " EN 5 – Total water use" contemplates total water recycling and reuse under additional indicator EN 22. This indicator is intended to encourage the re-use and recycling of water.

At a mining operation in the North West Province of South Africa, water quality monitoring indicated that elevated nitrate concentrations in mine water prevent the re-use of this water in the mining process. The Council for Scientific and Industrial Research (CSIR) was consulted to look at various treatment technologies that could effectively reduce the nitrate levels to enable the water to be re-used in the mining process.

Two treatment options were evaluated for the mine water and these were, the Biological De-nitrification and Electrostatic De-ionisation.

- **Biological De-nitrification**

Biological de-nitrification is a process in which the oxidized nitrogen substances, i.e. nitrates and nitrites are reduced to nitrogen gas, such as N_2O and N_2, using organic carbon as electron donor. It was discovered that waste cellulose solids, such as sawdust and leaf compost can provided the carbon source for heterotrophic denitrification (Shelp, G. 2005).

The CSIR conducted laboratory studies to investigate whether the nitrate rich waste stream from the mine could be biologically denitrified to such a quality that the treated water could be re-used in the concentrator plant by using the fermentation products of the mine wood waste as the carbon and energy source for the de-nitrifying bacteria. Various different reactors were constructed to de-nitrify the water.

Figure 8 - Photo showing pack bed reactor at the CSIR

The tests conducted indicate that the NO_3 removal is dependent on the Chemical Oxygen Demand (COD) production from the wood waste fermentation process. The COD concentration produced from 500g wood waste was < 100 mg/ℓ after 18 days of hydrolysis/fermentation. If taking into account that in order to obtain good nitrate removal, the COD/NO_3-N ratio should be 2.5. Thus to remove 600 mg/ℓ nitrate, 1500 mg/ℓ COD is needed. So for 1500 mg/ℓ COD, 7500 gram wood waste would be needed to treat 1 liter of waste water (Shelp, G. 2005).

The results of the test work showed that to treat 3 Mℓ/d would require 22 500 tones of wood per day. This fact, together with the fact that a biological reactor can only remove the nitrates, made this treatment process an un-attractive option for the mine.

- **Electrostatic De-ionization**

The DesEl process operates on the principles of capacitive deionisation to remove ionic compounds referred to as total dissolved solids (TDS). The main component of the DesEl System is a novel, electrostatic charging system that behaves as a capacitor and is comprised of inexpensive carbon electrodes. The capacitor is energized using direct current, creating positive and negatively charged surfaces. Ionic compounds such as iron, chloride, arsenic and nitrate are attracted to and electrostatically adsorbed onto the surface of the electrodes (Figure 9).

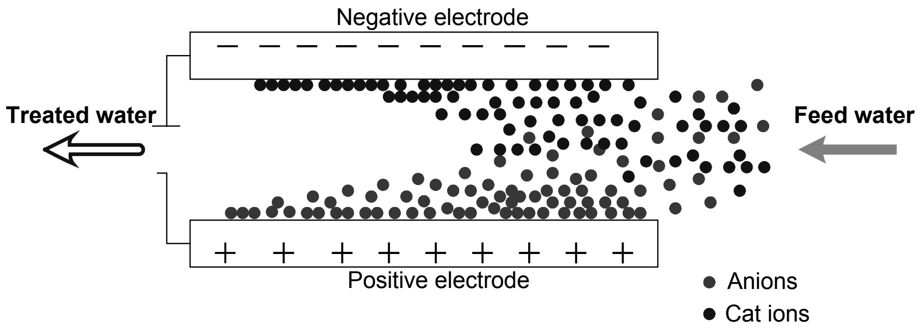

Figure 9 - Simple Flow through Capacitor during purification cycle

To regenerate the system, the polarity of the cell is reversed causing the capacitor to release the contaminants into the cell channels. The contaminants are removed from the cell by flushing with a small quantity of liquid forming a concentrated solution. The operating potential is relatively low (approximately 1.3V) such that no electrolysis reactions occur precluding breakdown of the capacitor material and the formation of secondary solid phases. The DesEl system automatically cycles through a purification, regeneration and purge cycle. The process uses a Programmable Logic Controller (PLC) to control all cycle times, and using a conductivity set point to initiate the opening and closing of solenoid valves.

During the purification cycle, the conductivity controller monitors the conductivity of the solution at the outlet of the capacitive cell and controls the position of a solenoid valve. If the conductivity of the treated solution is less than the desired set point, treated water will be discharge as the purified stream. If the conductivity rises above the set point, the water will be circulated through the cell till the discharge set point is reached. The removal of ions from the aqueous solution is thus monitored via conductivity measurements.

Various different scenarios were tested by altering the conductivity set point, regeneration and purification cycle times. The initial criteria were to optimize Nitrate removal as well as optimize water recovery. Table 3 gives the two scenarios where this was achieved. Note the reduction in all other Ions as well. Figure 10 shows graphically that the DesEl process can reduce the nitrate concentration to below the mine's permit requirement in a three-stage process (Shelp, G. 2005).

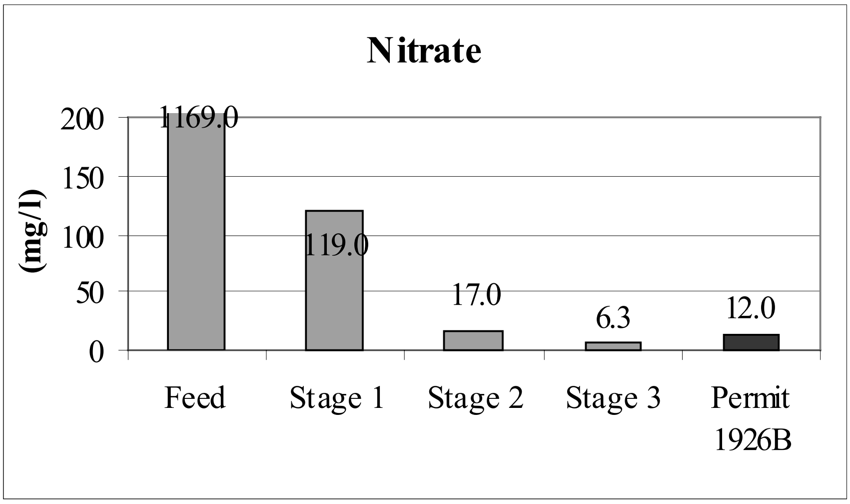

Figure 10 - Bar chart depicting the results of the removal of nitrate from mine water

These positive results encouraged the mine to go ahead and install the World's first Pilot DesEl unit. It was delivered and installed at the mine early in 2005 from where various treatment scenarios are being conducted on a continuous cycle. The unit will treat 10 000 liters of mine water per day. Results obtained from this study will enable the CSIR and the mine to design a cost effective and sustainable water treatment system that could be the answer for elevated nitrate concentrations in the mining industry. Figure 11 –12 depict photographs of the pilot plant.

Table 3 - Water quality results at the stages of the DeSel process

Parameter		Optimum nitrate rejection Exp 2.4			Optimum water recovery Exp 3.5		
		Feed	Treated	Waste	Feed	Treated	Waste
	Unit		Stage 1	Stage 1		Stage 1	Stage 1
Volume	mL	2430	1900	530	2540	2180	360
EC (mS/cm)	mS/cm	8.13	1.4	40.6	8.13	1.4	40.6
TDS	mg/l	5770	872	18997	5763	992	28779
Salt Load	%	100	11.81	88.19	100	14.78	85.22
Sulphate	mg/l	520	79	1713	520	90	2596
Magnesium	mg/l	135	20	443	135	23	672
Calcium	mg/l	651	98	2143	650	112	3246
Manganese	mg/l	0.26	0.01	0.92	0.26	0.02	1.41
Sodium	mg/l	329	50	1083	329	57	1641
Nitrate	mg/l N	853	129	2810	852	147	4257
Ammonia	mg/l N	293	44	964	292	50	1460
Cations (+)	meq/l	78.86	11.91	259.62	78.76	13.56	393.31
Anions (-)	meq/l	71.80	10.85	236.39	71.71	12.35	358.11
Ave (Cat, An)		75.33	11.38	248.01	75.23	12.96	375.71
Water recovery	%		78.19			85.83	
Salt removal	%		84.89			82.78	
Nitrate rejection	%		86.5%			85.2%	
TDS removed	mg/l		4898			4771	
Hydraulic Flux rate	ml/min/m2		76			76	
Electricity cost	c/kWh		18.0			18.0	
Treatment cost (Feed)	R/m3		1.19			1.19	

Figures 11 and 12 - Photographs of the DeSel pilot plant at the mine

6. CONCLUSION

The global sustainable development agenda has resulted in the South African mining and minerals sector adopting a number of sustainability indicators against which it measures and reports its performance against.

Furthermore, the South African Government has fully embraced the principles of sustainable development in its law reform processes and has incorporated the principle in, *inter alia*, the Constitution, National Environmental Management Act and Minerals and Petroleum Resources Development Act.

In order to improve on their sustainable development performance and meet international and South African requirements, a number of South African institutions and companies have implemented and are conducting research into new technologies. Five such examples were discussed in detail to demonstrate how they are maximizing and protecting economic and natural capital.

There is no doubt that technology will play an important part in helping government, industry and society deal with the challenges posed by sustainable development.

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Appendix 1 - Mining Charter Requirements and Associated GRI Indicators

Applicable SD Capital	Description	Applicable GRI Reference Heading
Human Capital	Human Resources Development	Labour /Management Relations LA 3, 4 and LA 13 Training and Education Diversity and Opportunity LA 10 and LA 11 Non-discrimination HR 4
	Has the company offered every employee the opportunity of being functionally literate and numerate by the year 2005 and are employees being trained?	
	Has the company implemented career paths for HDSA employees, including skills development plans?	
	Has the company developed systems through which empowerment groups can be mentored?	
	Employment Equity	Employment LA 1, LA 2 and LA 12 Diversity and Opportunity LA 10 and LA 11 Non-discrimination HR 4
	Has the company published its employment equity plan and reported on its annual progress in meeting that plan?	
	Has the company established a plan to achieve a target for HDSA participation in management of 40% within five years and is it implementing the plan?	
	Has the company identified a talent pool and is it fast-tracking it?	
	Has the company established a plan to achieve the target for women participation in mining of 10% within the five years and is it implementing it? 3	
	Migrant Labour	
	Has the company subscribed to Government and industry agreements to ensure non-discrimination against foreign migrant labour?	
Social	Mine Community and Rural development	

Applicable SD Capital	Description	Applicable GRI Reference Heading
Capital	Has the company cooperated in the formulation of integrated development plans and is the company cooperating with Government in the implementation of these plans for communities where mining takes place and for major labour-sending areas? Has there been effort on the side of the company to engage the local mine community and major labour-sending area communities? (Companies will be required to cite a pattern of consultation, indicate money expenditures and show a plan.)	Community SO-1 and SO-4 MM 7 and MM 10 Public Sector EC 12
	Housing and Living Conditions	Strategy and management – HR 2
	For company-provided housing, has the mine, in consultation with stakeholders, established measures for improving the standard of housing, including the upgrading of hostels, conversion of hostels to family units, and promoted home ownership options for mine employees? Companies will be required to indicate what they have done to improve housing, show a plan to progress the issue over time and demonstrate that they are implementing the plan.	
Human Capital	For company-provided nutrition, has the mine established measures for improving the nutrition of mine employees? Companies will be required to indicate what they have done to improve nutrition, show a plan to progress the issue over time and demonstrate that they are implementing the plan.	Health and safety L A 15 and Strategy and Management HR 1
	Procurement	
Human and Social Capital	Has the mining company given HDSAs preferred-supplier status?	Suppliers EC 3 – EC 4 and Ec 11
	Has the mining company identified current levels of procurement from HDSA companies in terms of capital goods, consumables and services?	

Applicable SD Capital	Description	Applicable GRI Reference Heading
	Has the mining company indicated a commitment to a progression of procurement from HDSA companies over a three-to-five-year timeframe in terms of capital goods, consumables and services and to what extent has the commitment been implemented?	
	Ownership and Joint Ventures	
	Will the mining company achieve HDSA participation, in terms of ownership of equity or attributable units of production, of 15% in HDSA hands within five years and 26% within ten years? 5	Providers of Capital EC 6 Non-discrimination HR 4
	Beneficiation	
	Has the mining company identified its current level of beneficiation?	Customers EC 1 Non-discrimination HR 4
	Has the mining company established its base line level of beneficiation and indicated the extent that this will have to be grown in order to qualify for an offset? 6	
	Reporting	
	Has the company reported on an annual basis its progress towards achieving its commitments in its annual report?	

3

Some Important Aspects Related to Sustainability of Gold and Unit-Operations

PERSPECTIVE ON INDICATORS OF SUSTAINABILITY FOR THE GOLD AND SILVER EXTRACTION INDUSTRY

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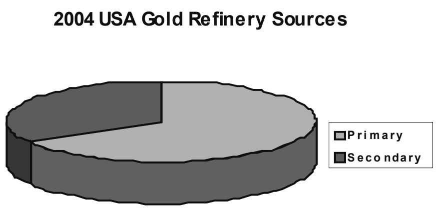
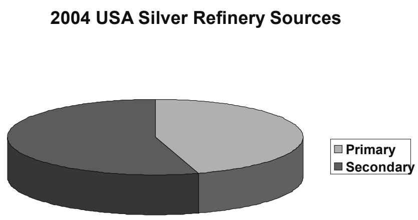
Gold and silver extraction offers some nearly unique aspects when viewed in terms of mining sustainability. The mining and extraction of gold and silver also have many of the same characteristics in terms of sustainability as the mining and extraction of other minerals and metals. Examples of some of the concerns regarding the mining sustainability of gold are found in the recent San Francisco Chronicle article of October 6, 2005, entitled "Firm's Quest for Gold Touches off Land Mine Chilean Activists Struggle to Halt Plan to Excavate Glaciers"[1]. The first point made for the forbidding of the mining of the gold is that the mine would be run using foreign capital as indicated by protesters shouting slogans such as "We are not a North American colony". Lack of concern for the local population is another concern demonstrated by critics pointing out that the handling of the glaciers located at the proposed mine site could irrevocably harm the livelihood of thousands of peasant farmers and Daquita Indian tribes living downslope.

The unique concern for gold mining sustainable mining is also reported in the same article as some environmentalists are even more concerned about Barrick's planned use of sodium cyanide to extract gold from the ore. The concerns for the environment are significant when cyanide is used in the process but one of the unique features using cyanide in gold mining is the consequences of spills and leaks. Rainforest[2] reports 22 major cyanide spills and leaks during the period of 2000 until February 2005. Of these spills seven were in Ghana, three in the United States, and two in China. Probably the one with the most news coverage was the accident in Baia Mare in Romania. Some critics have tried to tie cyanide spills with globalization.

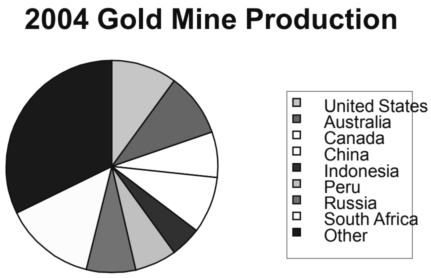
Another unique aspect of sustainable gold mining is the "green" gold movement. The major tenet of this movement is that there should not be any gold mining. Those who promote the argument base their position on their view that there is a lack of any worthwhile use of gold and that the world's wants for gold can be easily satisfied by previously mined gold. It is indeed difficult to initiate sustainability indicators if all the "green" gold philosophy is adopted. Some proponents of "green" gold who do not advocate the total banning of gold production advocate strong environmental constraints, socially responsible programs for the indigenous populations and the purchase of gold from non-corrupt entities. The development of indicators may weigh the merits of such goals.

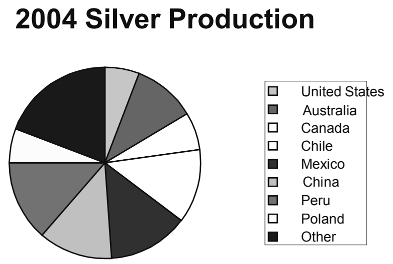
The argument for no production of gold is based on the end use of it. GFMS.Ltd. has reported for the World Gold Council[3] that approximately 2,600 tons of gold was used jewelry consumption, 400 tons for industrial and dental purposes and another 475 tons was used for investment and monetary uses in 2004. While in the United States the United States Geological Survey[4] (USGS) estimated the uses in 2004 were 92% jewelry and arts, 4% electrical and electronics, and another 3% for dental. The USGS has reported that "Of the estimated 150,000 tons of all gold ever mined, about 15% is thought to have been lost, used in dissipative industrial uses, or otherwise was unrecoverable or unaccounted for. Of the remaining 128,000 tons, central banks hold an estimated 32,000 tons as official stocks, and about 96,000 tons is privately held as bullion, coin, and jewelry." A significant amount of the gold refinery resources in the USA is from secondary sources, but even a greater proportion of the silver refinery sources come from secondary sources.





The views of the sustainability of gold and silver mining are divergent because of the locations of the major gold and silver producing mines. It can be seen from the major national producers that the mines are distributed in most of the continents and in developed and developing nations.





The goals and, therefore, the indicators for sustainable mining are certainly complex when regional goals and requirements are taken into account. Added to the complexity are the stakeholders with interests in sustainable development and mining. Included are governmental agencies, capitalists, non-governmental organizations, indigenous populations, employers, workers, etc. With so many interests, why examine indicators based on a commodity. Nearly all mineral commodities are produced, sold and utilized globally. The investment capital for mining projects is global with the private or public investors having opportunities worldwide. Production practices in any one area have impacts nearly everywhere. Many of the operating companies have mining interests that are located in more than one region. And certainly the buying practices of the industrialized nations impact nearly all.

The corporate leaders of the minerals industry have responded to the call for sustainable development. The best source of their response is found in the report of the Mining, Minerals and Sustainable Development Project[5]. In the report they state, "One of the greatest challenges facing the world today is integrating economic activity with environmental integrity, social concerns, and effective governance systems. The goal of that integration can be seen as 'sustainable development'. In the context of the minerals sector, the goal should be to maximize the contribution to the well-being of the current generation in a way that ensures an equitable distribution of its costs and benefits, without reducing the potential for future generations to meet their own needs."

Sustainable development and mining sustainability are supported by four 'pillars'; economic sphere, social sphere, environmental sphere, and governance sphere. Each sphere has a set of guiding principles as indicated in Table 1.

Table 1 - Sustainable Development Principles.

Economic Sphere

- Maximize human well-being
- Ensure efficient use of all resources, natural and otherwise, by maximizing rents
- Seek to identify and internalize environmental and social costs
- Maintain and enhance the conditions for viable enterprise

Social Sphere

- Ensure a fair distribution of the costs and benefits of development for all those alive today
- Respect and reinforce the fundamental rights of human beings, including civil and political liberties, cultural autonomy, social and economic freedoms, and personal security
- See to sustain improvements over time; ensure that depletion of natural resources will not deprive future generations through replacement with other forms of capital

Environmental Sphere

- Promote responsible stewardship of natural resources and the environment, including remediation of past damage
- Minimize waste and environmental damage along the whole of the supply chain
- Exercise prudence where impacts are unknown or uncertain

- Operate within ecological limits and protect critical natural capital

Governance Sphere

- Support representative democracy, including participatory decision-making
- Encourage free enterprise within a system of clear and fair rules and incentives
- Avoid excessive concentration of power through appropriate checks and balances
- Ensure transparency through providing all stakeholders with access to relevant and accurate information
- Ensure Accountability for decisions and actions, which are based on comprehensive and reliable analysis
- Encourage cooperation in order to build trust and shared goals and values
- Ensure that decisions are made at the appropriate level, adhering to the principle of subsidiarity where possible.

The minerals industry stakeholders and leaders have described nine key challenges facing the minerals industry in the quest for mining sustainability. These challenges are:

- Visibility of the minerals industry,
- The control, use and management of land,
- Minerals and economic development,
- Local communities and mines,
- Mining, minerals, and the environment,
- An integrated approach to using minerals,
- Access to information,
- Artisanal and small-scale mining,
- Sector governance: roles, responsibilities, and instruments for change.

Indeed, the mining industry is making more than a good gesture effort in embracing the sustainability initiatives. The leaders of the mining industry believe they will benefit by at least one or more of the following:

- Enhancing public reputation;
- Establishing a business leadership position;
- Building competitive advantage;
- Securing public 'licence to operate';
- Attracting and retaining quality employees;
- Attracting investment capital;
- Driving internal behavior change;
- Initiating efficiency improvement;
- Attracting better quality business partners;
- Maintaining strong shareholder support;
- Minimizing business risk;
- Avoiding, or at least delaying, onerous statutory regulation;
- Increasing capacity for innovation;
- Maintaining access to land;
- Believing it is simply the right thing to do.

Last year I had the opportunity to discuss the trends and opportunities in sustainable mining for the phosphate mining industry. The United Nations, through the United Nations Environment Programme's product, *Environmental Aspects of Phosphate and Potash Mining*[6], has sponsored an excellent review of a significant part of mining sustainability, that of environmental consequences. Although specific indicators have not been elucidated for the phosphate industry, progress has been made towards making goals that can be utilized in many regions in the world.

When studying a mineral commodity relative to mining sustainability precious metals, especially gold, offer some unique facets. When evaluating indicators for mining sustainability of precious metals mining projects these unique facets must be weighed into the determination of the goals and indicators. Gold mining has developed much controversy. It can be easily seen that attempts to discuss sustainable gold mining that the controversies associated with gold mining and extraction must be addressed in the development of the goals and indicators. The first controversial point is the chemistry used to liberate gold: cyanide. Indicators based on facts and science, not hysteria, must be developed to truly measure the success of the hydrometallurgy in terms of environment, health and safety.

Artisanal mining certainly is not unique to gold mining, but a significant portion of the wealth generated from artisanal mining is derived from gold mining. As we know, the importance and the attitudes of artisanal mining vary strongly by region. Yet, if we view precious metals as a commodity and wish to examine indicators for the sustainable mining of gold and silver the question of artisanal mining must be addressed and suitable indicators must be developed.

Silver mining has some aspects that are different for gold mining and indicators for sustainable mining of silver need to reflect these differences. Although cyanide is used in both gold mining and silver mining the efficiencies in silver mining are significantly less than gold mining. Also, significant silver is produced as a by-product. The uses of silver are broader than jewelry manufacture and a significant portion of silver is recycled. All these factors lead to the conclusion the indicators for silver mining sustainability will be significantly different than those used for gold mining.

Nearly all the principles stated by MMSD and nearly all the indicators presented by other authors and workshop attendees are applicable to the gold and silver mining and extraction industries. I offer some refinements to the indicators that have been recommended. Gold and silver mining and extraction can only be considered as a sustainable activity if the processes are conducted in manner that minimizes the potential for environmental, health and safety catastrophes. Nearly any reagent, especially cyanide, which can extract gold from its ore, is very reactive. Therefore, environmental release indicators must take into account the quantity of the release and the rate of release. Precious metals extraction sustainability is very dependent on being accident-free.

Because of the use of cyanide and the chemistry of mercury and arsenic that may be present in gold and silver ores additional indicators should include health records of employees and the citizens within range of the outfalls of precious metals mines and mills. Much notoriety is given to NGO claims of death and illness derived from being in the proximity of a gold mine and mill. Certainly sustainable mining development can not be claimed if the employees and citizens surrounding the facility are suffering death and illness from the activities.

The socio-economic benefits indicators should be carefully reviewed and constructed when studying the sustainability of gold and silver mining. Indicators that can track a value-added impact should be considered. I believe this is especially true regarding artisanal mining efforts.

Therefore, in conclusion, I offer the following suggestions for key sustainability indicators for the gold and silver mining and extraction industries:

- ✓ health and safety records of employees
- ✓ health records of surrounding citizens
- ✓ toxic spill records with special attention to intensity of spills, and
- ✓ value added both locally and nationally.

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4. http://minerals.er.usgs.gov/minerals/pubs/commodity/gold/index.html#myb

5. http://www.iied.org/mmsd/finalreport/ - International Institute for Environment and Development, Mining, Minerals and Sustainable Development Project, 2002.

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OVACIK GOLD MINE

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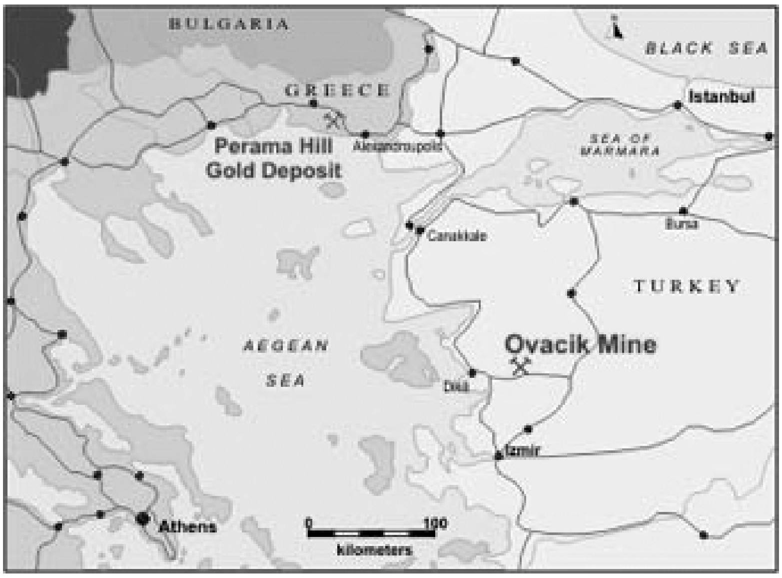
Note from the editors

The Ovacik Mine is located 106 kilometres north of the city of Izmir in western Turkey. Ore is mined from both open pit and underground operations at a rate of approximately 1,500 tonnes per day. Between the mine start-up date of May 2001 and November 2005, the Ovacik Mine produced 569.757 ounces gold and 550.003 ounces silver. Detailed past production figures might be obtained from "google", as well as some aerial photos. The IMPC group participating at the IMPC Antalya´s Workshop on Indicators of Sustainability for the Minerals Extraction Industries has had the opportunity of visiting the operation and discuss several of its aspects with Koza´s staff members.



Ovacik Gold Mine is an operation of Koza Gold Company which is a subsidiary of Koza Group, Turkey. OGM demand leadership in safety, stewardship of the environment and social responsibility. Mine is located about 12 km west of Bergama and 100 km north of Izmir, Turkey.

The mine processes annual 450.000 tons of ore excavated from the open pit and the underground operations. The ore is crushed and ground and then fed into leach tanks and followed by the carbon adsorption and desorption circuits for gold recovery. The elute is cycled through the electro winning cells. The gold and silver sludge is removed from the cathodes and smelted. Dore bullion is shipped and refined in Istanbul Gold Refinery and sold in Istanbul Gold Stock Market.

The waste is treated utilizing a two stage incoSO_2/Air prior to discharge in to the Tailings Dam. The first stage uses SO_2 and air to oxidize free and weak acid dissociable cyanide. Copper sulphate is added to catalyze the reaction and to precipitate residual iron cyanide as an insoluble salt. At the second stage ferric sulfate is used to precipitate arsenic and antimony.

Tailings pond embankments are built as a rock-fill dam structures and constructed to withstand earthquake of 0.6 g, the bottom of the tailings pond is covered with 50 cm of clay, a 1,5 mm HDPE geomembrane, 20 cm of clay and a filter bed. The decant water is pumped back to the process for reuse.

OGM is one of the few mines in the world to have both destruction unit and tailings pond and thus there is "zero discharge" to the environment. Tailings effluent, decant water and tailings pond water are monitored on daily basis.

At closure, the tailings pond will be rehabilited and revegetated.

From the beginning of production OGM's environmental measurements are closely controlled by an Inspection and Monitoring Committee formed by Izmir Governor Office each month. Operation continued without any environmental non-compliance issues. Our environmental performance is beyond our commitments.

Ovacik Gold Mine as being the first gold mine of Turkey had been faced with considerable opposition from a range of organizations and people. The Turkish media, under pressure from some local politicians and environmentalists with support of foreign lobby groups, pushed some local villagers to participate in demonstrations. To resolve this public controversy and to allay the concerns of the villagers, our company designed an efficient communication and public participation program. We worked hard to restore the confidence of the community. We communicated to the public our wishes to operate a safe and commercially viable mining operation for the benefit of both the company and the local community. The negative activities have been significantly reduced in the last years by a new stakeholder management plan, local employment policy and good community relations.

Ovacik Gold Mine creates value for the company, for the stakeholders, for our employees and for the communities in which it works. Our mission is to improve social and economic development of the region and adopt transparent policy giving to live in peaceful coexistence.

Our commitment to safety, environment and social responsibilities allow our stakeholders to benefit from the application of training and technology and provide sustainable development opportunities for them.

In establishing peaceful coexistence, public consultation was one of the most effective tools. Through the implementation of the public consultation we have informed our stakeholders periodically. Cooperative participation with civil society was the most effective means of identifying potential social and environmental issues and identifies feasible solutions in a communicative and transparent manner.

We have developed and implemented a process to identify and document all stakeholders who may be impacted by the operation or those who have an impact on the operation. A stakeholder database have been maintained and continually updated. We have provided a level of engagement and communication with external stakeholders. Any potential impact on site, new project developments, community investments, local employment and business support, environmental issues are communicated with stakeholders.

OGM is the most significant employer in the area. A local recruitment policy and training program were implemented and currently 82 % of the workforce is from the local area. OGM preference for the supply of goods and services is to its closest neighbors followed by the Bergama-Dikili region. Company requires to supply good and services in the same quality, at competitive prices, within agreed delivery times and in compliance with the company's safety and environmental commitments.

OGM supports local development not only through the generation of wealth in the area, but also through project and programs aimed at promoting development and improving the quality of life in the local area.

The company drilled water bores and constructed water supply systems to Ovacik and Camkoy villages. The energy bills are paid by the company and maintenance of the systems are provided.

A training program for young villagers has been programmed. It is a four year program and each year a group of villagers will be trained in different fields. This year program covers the training of 9 young girls from neighboring villages in computer skills and admin works.

Wedding houses have been built for Ovacik and Narlica villages. A new road shortcutting the connection of Narlica village to the main road has been constructed. Bridges are built. A water bore of Saganci village has been drilled. Roads and sport fields of villages have been repaired. A medical office for Ovacik villages, a new sewerage system for Camkoy and a religious temple for Narlica have been projected. Vineyard and pinenut trees projects for Camkoy have been prepared.

OGM supports sporting clubs in Bergama and neighboring villages. Many schools are supported. Scholarships and summer trainings to university students are supplied.

THE LOS ROJAS PROJECT – CONFLICT RESOLUTION BETWEEN A LARGE SCALE MINING COMPANY AND SMALL SCALE MINERS

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1. INTRODUCTION AND HISTORY

The Las Cristinas deposit in Venezuela, is situated in a tropical rainforest environment, in the centre of the Kilometre 88 mining district. It was worked intensively during the early 80´s by as many as 10.000 small scale miners, using gravel pumps, monitors (high pressure water jets) and sluice-boxes with mercury in open circuit. By 1984, unregulated mining activities had become so problematic in the southeastern part of the country that a special federal commission was convened to consider ways of bringing the situation under control. Based on its recommendations, the government vested responsibility for exploration, development and exploitation of the precious mineral resources of the area in the state development corporation, Corporacion Venezolana de Guayana and a plan for the regularization of mineral activity in the region was drafted. Under the plan, the Las Cristinas tracts were reclaimed by the state and then consolidated with a view towards developing the property on a large scale. In 1990, the deposit was put out for international tender. The area was cleared of all mining activity and settlement. Approximately 4000 people were displaced, of which 2800 ended up being resettled to two sites outside of the concession.3

1 Worked as consultant to the Los Rojas Project (1997-2000).
2 Formerly Sustainable Development Coordinator of Minera Las Cristinas and Placer Dome Latin America, and Manager of the Los Rojas Project.
3For more of the historical detail of the Project, the reader is referred to Jeffrey Davidson, " Building Partnerships with Artisanal Miners on Las Cristinas," which appeared in the March 1998 issue of Mining Environmental Management.

At the end of 1992, the state development corporation formally turned over the property to Minera Las Cristinas, the joint venture operating company made up of Placer Dome Venezuela and the Corporacion Venezolana de Guayana. At that moment, the property was free and clear of all buildings and mining operations. While many miners had left the area, those that remained, around 1000, were mainly those without the means to leave. They continued to try to work in the area, but now as ¨illegal¨ miners, on any property to which they could gain access. Some also began to find their way back to Las Cristinas. Because of the new land and resource ownership situation, the miners were forced to adjust the way they mined. Monitor operations had also been made illegal, nor did many have the means to mount such operations. Small-scale mining in the area became largely artisanal in nature. On Las Cristinas, miners were limited to washing of sands and old monitor tailings in the field or bagging, transporting and milling the material off property. In fact, several simple processing plants were built in the villages, using hammer-mills and mercury in open circuit. They were fed with material ¨illegally¨ removed from the surrounding concessions, including Las Cristinas.

During the period following the resettlement, tensions were high between all of the ¨foreign¨ companies who held properties in the area and the local small miners´ communities. A point was reached where tensions turned confrontational, as the miners marched onto properties en masse, attacked company assets, and even detained and intimidated employees. In the case of Minera Las Cristinas (MINCA), the company was sufficiently concerned to comission an assessment of the social and political risks to mine development potentially posed by the presence of the small miners and their unresolved grievances. This study helped to clarify local realities, relationships, and problems, and served to sensitize company management to local perceptions and concerns. Management quickly understood that a more stable, constructive

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This article was published –in a prolonged version- in: Risk Communication between Mineral Property Owners and Local Communities, Mining Journal Books, London 2003 relationship with the local communities was necessary, and that it would have to be proactively created. Management went a step further, internally acknowledging the legitimacy of the displaced communities' livelihood concerns. What had been seen as a potential stumbling block to further investment then became an opportunity to make the investment work not only for the company, but also for the communities. This allowed the company to experiment with a very different kind of approach to conflict resolution and to relationship building with artisanal miners.

In August 1994, the company started afresh, implementing an initial policy of passive accommodation with the small miners. The miners were allowed to work on the property with hand equipment (bateas, shovels, etc.) as long as they did not intrude on or interfere with active company exploration sites. The company also designated a part of the concession, which was selected by the miners, but appeared not to be amenable to large scale exploitation, as a small scale mining area from which the miners were able to back and transport material off property. After an initial trial period of one year, during which time additional community work and field studies were undertaken, the company and the miners decided to move beyond passive accommodation to constructive engagement and a formal cooperation project with the small miners was approved . In January 1996, the „Los Rojas Small Mining Project" (LRP) was officially started. A working group was formed, consisting of MINCA staff and representatives of the small scale miners to plan and carry out the cooperation project.

2. AIMS OF THE LOS ROJAS PROJECT

- Reduce developmental risks for the main property
- Reduce tension and stabilize the relationship between local mining communities and the company
- Setting up a legal, organized working area for the small scale miners
- Co-operation with the remaining small miners in the area, in the following fields:
    - Technical (geology, mining, mineral processing)

  - Financial (start-up mining costs, credits for equipment)
  - Environmental (environmental control, clean mining and processing techniques, planning and implementation of environmental measures)
- Training centre for the large mining project (mining, processing, industrial safety)
- Several key-points of the project are described below.

3. ACTIONS TAKEN IN THE LOS ROJAS PROJECT

3.1. Organization and administration

It was clear from the beginning, that dealing with a large number of individual miners was not possible and that the small miners had to be organized in some form. Under the Venezuelan mining law, modified by a succeeding series of decrees, independent mining by individuals had been prohibited artisanal mining was limited to an organized group activity. Consequently, to be legal, the miners had to be organized. First one, then later several mining associations were formed. . To learn from other experiences, a group of small miners and company support staff visited Bolivia, to see how artisanal mining was organized and how the mining and processing were carried out elsewhere.. MINCA provided technical support to the associations for all necessary legal and administrative paper-work. Additionally, training courses in administration and accounting as well in mining laws and regulations were organized for the benefit of the miners.

3.2. Mining

First one, then later several mining operations were established and run with guidance and assistance from MINCA personnel, all within the Las Cristinas concession. Since the use of monitors was prohibited at that time, and underground mining was considered to be too dangerous, it was decided, to use dry open pit mining with backhoes and dump trucks on a trial basis. The overlying weathered host rock was extracted with backhoes and transported by trucks to a previously disturbed drainage area where it was used to rehabilitate the site.. In this way, the quartz veins were exposed and then manually mined. The vein material was then processed. In that phase, MINCA covered the costs of overburden and host rock removal. The high. This particular approach to mechanized mining idled a large number of association members, since the number of miners needed for vein material recovery and for work in the mill was relatively small. This method proved unsatisfactory due to its high costs and to the fact, that a considerable amount of gold carried in the host rock was not recovered. Furthermore, it created a culture of idleness, turning many members into watchers of the machines working in their stead, as opposed to providing productive work for themselves. It was soon obvious, that this was not the appropriate way and never would have the chance to become economically sustainable. As it happened, a recent mining regulation allowing for the use of monitors in already disturbed areas. The regulation provided an opportunity to evaluate the use of hydraulic monitors in a controlled mining environment with an approved environmental management plan. Settling ponds were constructed, a water quality monitoring system set-up, and wherever the water system was closed, recharged only by rainfall. The old practices of using mercury at the mining front and in the discharge to the sluice box. were abandoned, and sluice-box design optimized based on the characteristics of the material.. Going „back" to the use of monitors, gravel pumps and (improved) sluice-boxes had several advantages: recovery of the gold present in the weathered host rock paid for the mining costs; use of a traditionally known and simple, low-investment technology accepted and self-managed by the miners, no or less dependence on heavy equipment; improved overall gold recovery and production due to the use of improved (mercury-free) sluice-boxes. The total amount of feed to the mill could be raised substantially, due to more complete recovery of gold bearing vein material and the recovery of small high grade veinlet material from within the host rock which was then processed together with the coarse quartz veins in the mill.

3.3. Processing

By the beginning of the Los Rojas Project, the miners had discovered the presence of near surface, relatively accessible veinlets and veins in less disturbed and higher ground within the project area. The miners abandoned the bagging of old tailings for the mining of primary material. Old tailings would only be mined again when the vein material ran short. Until their own mill was built, the Los Rojas miners continued to ship material to the independent mills in the villages. These mills were simple, comprised of hammer mills, amalgamation plates and later the amalgamation plates were replaced by home-made centrifugal concentrators into which the mercury was poured. Mercury losses to the tailings were high, and recoveries although they improved with the use of the centrifugal concentrators did not exceed 50%. Low recoveries benefited the plant owners, who not only took a percentage of the recovered gold (25% or more for gold from low grade tailings and 10'20% for gold from vein material), but also retained the rich tailings which they sold to leaching plants. Amalgam was usually burned in the open air at the mill and at the gold buyers, who were located in both commercial and residential areas of the villages.

The miners´ dream was to break their dependency on the mill owners. They very much waned to have a processing plant of their own, and made this a central point of the Los Rojas Project. Agreement. To learn more about milling techniques, the Bolivia study tour also included visits to MEDMIN project sites, where cleaner processing methods had successfully been implemented. The issue of a processing plant for Los Rojas was tackled on a step by step basis, starting with a pilot plant, then a provisional mill using local technology, and finally an improved ¨intermediate¨ technology processing plant. The plant was designed and set up initially as a dedicated mill for the use of the Los Rojas Artisanal Miners Association, but later on in 1999, when additional associations were organized and began working within the concession, the plant was converted into a toll mill, in which materials from different mining associations could be milled on a batch basis.. It was the aim from the beginning, that the small miners would one day be able to self-manage and operate the processing plant. Therefore, the technology had to be simple, easy to maintain and repair, easy to operate and control. The company paid for all processing equipment, but the future hope was that the miners would eventually be able to purchase the plant from the proceeds of their improved production and recovery. From the start, the small miners were included in the design and construction of the plant, which created a sense of co-ownership and responsibility. In their wishes to proceed technologically, the miners over-estimated their capabilities of handling complex processing equipment. So the first lay-out was relatively complicated, and influenced by the flow-sheets the miners had seen in Bolivia (where small miners are generally well trained ex-miners from the closed-down state owned tin mines). The new plant reflected these ambitions. The company was willing to underwrite investment in a more complicated flow-sheet, as the plant was to be set up to test different equipment and processing ideas and was understood to be an integral part of the learning and capacity building process for the miners. Finally, step by step, the miners decided to simplify the flow-sheet and to take out the ball-mill (which is not suitable for batch processes) and the Knelson-Concentrator, which required too much attention to maintenance of its operating parameters for the modest amount of additional recovery it yielded.. In the end the flow sheet was simplified and the final plant configuration consisted of a crushing step (jaw crusher), two steps of grinding with hammer-mills each followed by gravity concentration with spirals, finally a strake (carpet-only sluice-box) as scavenger. The three pre-concentrates (spiral I, spiral II, strake) were then upgraded on a Wilfley shaking table to produce a high grade first concentrate, which was then amalgamated in closed circuit, and a second low-grade concentrate (gold bearing iron-oxides) to be sold to leaching plants. Overall recovery into the first concentrate was around 70%, including the second concentrate it reached over 90%. The amalgam produced from the first concentrate was then burned in a retort, the mercury was recovered; amalgamation tailings were re-cleaned on the shaking table. Mercury losses into the amalgamation tailings were minimal. The plant has a tailings pond, which also provided for the complete re-circulation of process water. The operation costs were paid by the miners on a cost per ton basis. The plant technology proved to be very successful. It was copied within Venezuela and got many visitors from different areas, even from Columbian small miners. Even after the withdrawal of Placer Dome from Minera Las Cristinas in May 2001 to the present time, the plant has continued to operate with minimal or no technical assistance from the new operators of the Las Cristinas property.

In the later phase of the project, when mining switched over to the use of hydraulic methods, the traditional sluice-boxes were successfully modified in order to improve free gold recovery and enable a most complete recovery of gold bearing quartz pieces and pebbles, which were used as additional feed for the processing plant. The improved sluice box design was soon adopted by other miners operating outside the concession and project area.

3.4. Environment

The Los Rojas Project was the first area in Venezuela, where small miners worked in compliance with the environmental laws and norms. First, all necessary planning was done by MINCA with the miners, including the procedures to get the environmental permits, which were granted.. A number of environmental measures have been implemented, such as tailings dams (individual and common), re-forestation of mined-out areas, collecting of scrap and garbage, regularly ,measurements of water quality, etc., accompanied by appropriate training courses for the small miners.

3.5. Training

A major emphasis was laid on training and education of the small miners. Either training courses were held and-or training occurred on the job in various fields (industrial and mining safety, equipment operation and maintenance, clean mining and processing technologies, environmental control, first aid, administration, etc.). During the last phases of the formal project, the company worked with a national non-government organization, Tierra Viva, to work with all of the miners´ associations to improve their capacity to plan projects, to resolve internal and external conflicts, to identify and prioritize needs and to communicate concerns more effectively.

3.6. Technical and Financial support

Technical and financial support were provided in a variety of ways. A project team made up of company employees was organized to implement and oversee the project and provide technical assistance to the Associations. Other company technical specialists provided additional support on an as needed basis, for example the environmental specialists in the drafting of the permit applications and the environmental management plans, maintenance and mill specialists in the construction, operation and maintenance of the plant, civil and earth works specialist in the design of dams and dykes, procurement specialists for the purchase of project equipment.. The company also procured the services of external specialists, such as an accountant to set up the Association ledgers and to teach them how to maintain them, a mineral processing engineer to design the plant and oversee the monitoring of plant performance and improvements, the NGO, Tierra Viva, to provide organizational and planning training for the Associations. The development costs of the mine and the investment costs of the mill were borne by the company along with the cost of the project team and the costs of procuring special services and external support. A revolving loan fund was set up to help the Associations to buy or upgrade machinery (especially in the processing plant, but also for mining equipment). The Associations invested themselves, providing sweat equity and volunteer labour for many of the mine development and maintenance tasks.

4. BENEFITS OF THE LOS ROJAS PROJECT FOR THE SMALL MINERS, FOR THE COMPANY, FOR THE AREA

The benefits to the community based small scale miners included among other things: legalized operations, better production, more income, better and safer working conditions, acquisition of new knowledge and training, experience in working together as a group, education and first experience in an „ordered" form of working. The safety and legal security of the project afforded new work opportunities for women and led quickly to the elimination of child labour in the concession. The miners were able to realize almost the total value of their labours by eliminating the middle players (the independent mill owners, the equipment financers, and the illegal gold buyers)..

With the very first steps, the company saw a dramatic reduction in the tension between itself and the local mining communities. The small scale miners over time were transformed from adversaries to allies. The company was able to proceed with the development of the property in relative peace and harmony with the support of the communities. The education and development of the local workforce via the mine and mill had already provided the company with a source of valued employees. The local goodwill capital built up through the Los Rojas Project and other community works served the company well when Las Cristinas development delays and construction suspensions tested the patience of all stakeholders. With the project recognized as an industry best practice by the World Bank and later by Conservation International, it boosted Placer Dome's international reputation as a corporate leader in social responsibility.

The local area and communities as a whole benefited from an improved environmental situation, especially regarding mercury contamination, and modest but significant improvements in the overall social and economic situation of the area, especially given the lack of alternate employment, education and training opportunities.

RUSSIAN PERSPECTIVE ON INDICATOR OF SUSTAINABILITY FOR FLOTATION PROCESSING OF MINERALS

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ABSTRACT

Flotation in Russia has good perspective for further sustain development. Its technological and ecological problems can be solved by the use of physico - chemical models of flotation derived on the base of theoretical prerequisites of the new offered hypothesis in automation systems.

1. INTRODUCTION

Russia is reach in mineral resources and flotation is widely used in mineral processing of many kinds of raw materials and especially in processing of ores of non-ferrous metals [1, 2]. For the last 6 years the production of metals has been increased, approximately: copper – by 50%; nickel – by 40%; zinc – by 20%; lead – by 290%.

Flotation processes are used widely also in non-traditional branches of industry for solution of non-traditional problems, for example in: metallurgy (for separation of fainshtein, separating of criolite, etc.); chemical industry (for separation of NH_4Cl and $NaHCO_3$, etc.); biology (for separation of bacteria, etc.); agriculture (for separation of seeds, etc.); food industry (for purifying of wines, etc.); medical industry (for separation of medicinal preparations, etc.); urban economy (for treatment of waste materials, etc.); ecology (for separating of polluting admixtures, etc.) [1]. In hydrometallurgy and in solution of ecological problems flotation processes are developed and used especially intensively [3].

Good perspectives of further sustain development of flotation are based on the possibility for transition of qualitative ideas to quantitative regularities using conception of the new offered hypothesis of flotation.

By this conception efficient flotation of minerals can be realized only if there fulfilled two obligatory conditions: the hydrophobic or hydrophobised by chemosorbed collector surface ensuring the potential possibility of flotation, and presence on the surface of physically adsorbed collector carrying out kinetic functions in attachment and flotation of a particle on a bubble. Non-fulfillment of one of the named conditions results in depression of minerals flotation [4-6]. The conception is the theoretical premise necessary for creation of more efficient reagents and substantiation of optimal conditions for technological processes of flotation [1, 7, 8].

2. WAYS FOR FURTHER DEVELOPMENT AND INTENSIFICATION OF FLOTATION TECHNOLOGICAL PROCESSES

Forms of reagents sorption are determined by the character and state of the mineral surface and reagents in solution. They can be defined as the result of thermodynamic analysis and chemical computations [7, 9-11].

Reliable determination of the mineral surface and reagent state allows carrying out chemical and thermodynamic computations, analysis of their possible interaction from positions of molecular orbits, chemically active groups, theory of soft and rigid acids, alongside with the account of electro-physical properties of minerals and power heterogeneity of their surface [1].

Possibility of such computation and the presence of the criterion for flotation and depression of minerals allow not only explaining existing methods for intensification of recovered minerals flotation but permits also to substantiate optimal conditions for their realization, as their essence is optimization of the collector adsorption layer composition.

Optimization of the ratio of chemically fixed and physically adsorbed collector species in the adsorption layer on the mineral surface in these conditions can be achieved [9, 10] by:

- additions of apolar or non-ionogenic heteropolar compounds in flotation with sulphydrilic, oxyhydrilic and cationic collectors in the case of slowed down and insufficient physical sorption of ions or molecules of collector on the mineral surface. Optimal conditions of their use are determined by pH value of zero charge of the surface and can be determined theoretically for every concrete case;
- use of mixtures of collectors possessing different ability to oxidation (as sulphydrilic collectors) or to dissociation and hydrolysis (as oxyhydrilic and cationic collectors). The quota of easier oxidizing xanthate with a longer hydrocarbon chain and stronger hydrolizing oxyhydrilic and cationic collectors in a mixture grows with increase in the ratio of electrons and holes on the surface of minerals, and on the contrary. The positive effect is obtain in Russia with the use of multicomponent collectors (reagents SJG, SGM, Beraflot-3026, LIFAM etc.) including in their composition both ionogenic and non-ionogenic components [12].
- application of electrochemical treatment of collectors solutions and pulps with the purpose for change in pH and Eh – potential values and the state of solid and liquid phases of pulp up to the optimal ones ensuring, according to the diagram Eh-pH, the necessary composition of the collector sorption layer on the surface of mineral to be floated or depressed. Regulation of the pulp Eh-potential value can be carried out also by charging of reagents - oxidizers or reagents - reducers, purge of gases (air, nitrogen etc.) or the heat treatment of the pulp [1];
- use of X-ray and radioactive radiation treatment with the purpose of change in minerals electro physical properties (Fermi's level and the ratio of electrons and holes concentrations [13] determining the composition of the adsorption layer) on the base of data of their preliminary determination (by results of measurements, for example, of Hall's effect and so on);

- choice of frothers (secondary adsorption) for circuits of bulk and selective flotation. Optimal conditions for their use are determined by the pH of zero charge calculated for the mineral to be floated.

Securing of the necessary composition of the adsorbed collector layer formation on the mineral surface is also the essence of activation of minerals flotation. Its necessity is caused by crystal-chemical or electro-physical peculiarities of minerals.

Activation of mineral flotation is reached by:

- moving away of secondary formations by their dissolution and naking of the mineral surface (for example, of beryl, diamond, pyrite) ensuring not only sharp increase in the hydrophobicity degree of the surface but also creation of optimal conditions for formation on it of the collector sorption layer necessary for flotation of mineral. Optimal conditions for dissolution of hydrophilic coatings on minerals can be determined by chemical computations on the basis of properties of compounds to be dissolved [1, 7];
- chemisorption of cations (for example, on the surface of quartz) ensuring the possibility of subsequent chemisorption and physical sorption of collector, or formation of a new phase (for example, of sulphide film on the surface of oxide lead and copper minerals) ensuring hydrophobisation of the surface at the expense of xanthate chemisorption and physical sorption of dixanthogen molecules – owing to partial oxidation of xanthate on the sulphidized surface. Theoretical substantiation of optimal conditions for activation in these cases can be obtained by results of computation of bordering condition for interaction of activating ions with the surface [7, 14].

For example, the minimum - necessary for activation of pyrite the concentration of copper ions derived theoretically [7, 15] coincides practically with the experimentally determined one (Figure 1).

Similarly, the derived concentration of sulphide ions necessary for formation of the sulphide film on oxide, for example, lead minerals answers the optimal ones (Figure 2) obtained by experimentally in sulphidation and flotation of these minerals in laboratory and industrial conditions at Zyrianovskaya plant [16].

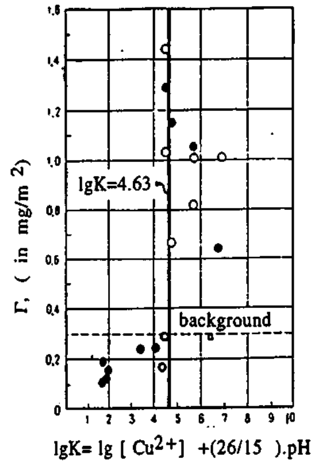

Figure 1 - Influence of the lg K value on the sorption density of copper on the pyrite surface

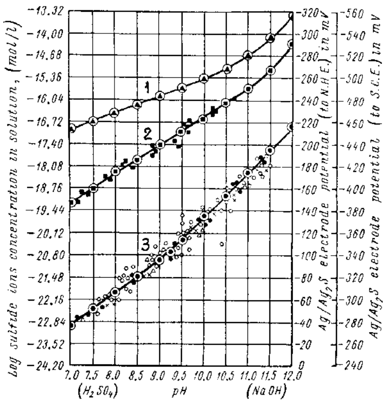

Figure 2 - Influence of pH on the [S^{2-}] value ensuring the maximal rate of flotation of crocoite (1), pyromorphite (2), primary oxide lead minerals (cerussite, anglesite, wulfenite) and galena from oxide and sulphide-oxide ores (3) of the fifths deposits of the former USSR: φ - the potential value of the sulphide-silver electrode

The essence of depressing action of reagents as compared with activation, on the contrary, is connected with hydrophilisation of the surface (at the expense of chemisorbed collector compounds destruction and fastening of hydrophilic complexes) or prevention of physically adsorbed collector species formation in the adsorbed layer (at the expense of change in the potential value of the surface).

Optimal conditions for depression of minerals can be theoretically substantiated as a result of thermodynamic analysis of the system [7, 17].

3. WAYS FOR OPTIMIZATION OF CONDITIONS OF FLOTATION TECHNOLOGICAL PROCESSES

Optimal conditions for flotation of minerals are observed at the certain potential value of their surface ensuring formation of the necessary sorption layer of collector.

For sulphide minerals it is checked up by the product value $[MeOH^{+}]$ $[Kx^{-}]$ = K in the near-electrode layer which is provided with the certain ratio of reagents concentrations in pulp [7, 17].

For non-sulphide minerals – it is checked up by the zero charge potential value received as the result of complete chemical computation of the "closed" system [18].

The derived physico-chemical models do not depend [19-21] on a deposit of ores and its genesis (Figure 3) and can be used in automation systems as the criterion [2, 18].

Optimal conditions for selective flotation of minerals answer to the maximal difference in collector concentrations necessary for their flotation. The difference in values of the necessary concentration of collector for flotation of minerals is obtained as the result of physico-chemical modeling of optimal conditions for their flotation [20, 22].

For example, in separation of zinc and iron sulphides in the calcareous medium [19] the maximum selectivity is observed at the ratio of reagents concentration equal to -14.85 (Figure 4).

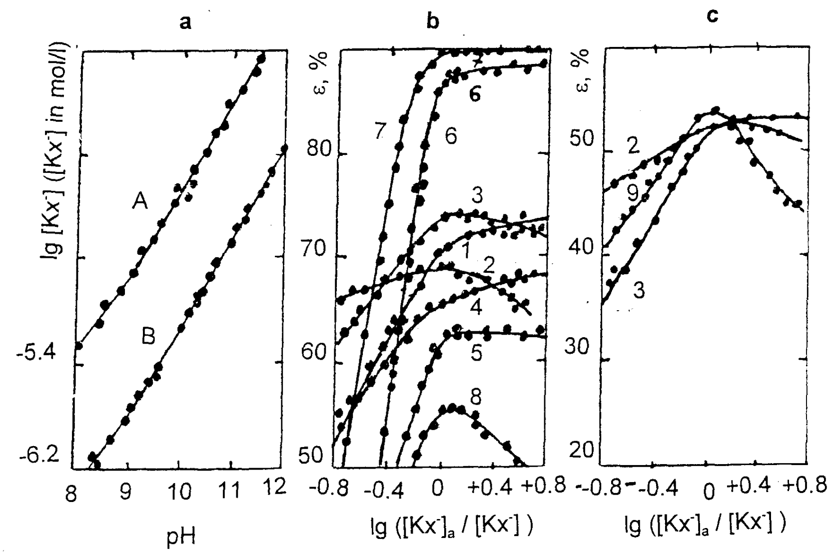

Figure 3 - Effect of pH value on the required ethyl (A) and butyl (B) xanthate concentration ($[Kx^-]$) during flotation of galena from different deposits (a); effect of excess and deficiency of xanthate in slurry on recovery *(ε)* of lead (b) and zinc (c) at Belousovskaya (1 - 4), Zyryanovskaya (5,6), Sullivan (7), Almalykskaya (8,9) plants

In separation of carbonate and phosphate minerals in the presence of phosphoric acid [22, 23] the maximum difference in values of the necessary concentration of collector for flotation of minerals to be divided and floatability of minerals is observed at the certain pH value (Figure 5).

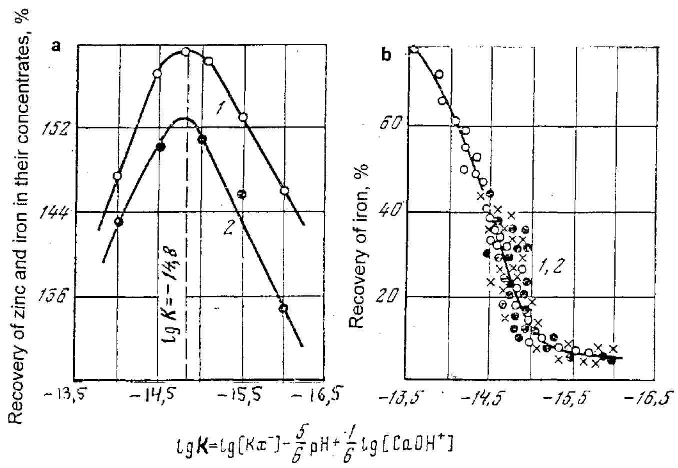

Figure 4 - Influence of lgK value on the total recovery of zinc and iron in their concentrates (a) and recovery of iron into the concentrate (b) in operations of the rougher zinc flotation at Belousovskaya (1) and Zyryanovskaya (2) plants

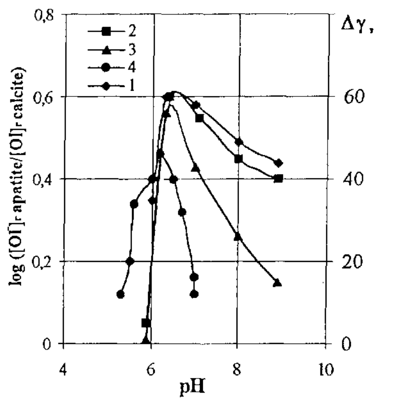

Figure 5 - Influence of pH: on the ratio of oleate concentrations necessary in the same conditions for flotation of fluor-apatite (1), carbonate-apatite (2), hydroxil-apatite (3) as regards to the necessary concentration for flotation of calcite and on the difference (Δγ) in recoveries of calcite and fluor-apatite (4).

Physico-chemical models of optimal conditions for technological processes derived are theoretically reasonable, confirmed at mineral processing plants. They can be used for creation of reliable automation systems at plants [1, 7]. Creation of analytical complexes for measuring of reagents concentrations in pulp is the condition of their wide use at plants.

Use of such systems will allow solving technological and ecological problems radically at the expense of increase in selectivity of processes, complexity of minerals usage, realization of complete water recycling at the enterprise.

4. WAYS FOR SOLUTION OF ECOLOGICAL PROBLEMS OF FLOTATION

There are two main reasons for the harmful effect of recycling waters on flotation of ores:

- the inconstancy of ionic, molecular and colloidal composition of recycling waters leading to the sharp violation of optimal physico-chemical conditions for reagents sorption and mineral flotation, destabilization of the flotation process and decrease in technological indices
- the change of physico-chemical properties of minerals as a result of their surface interaction with soluble components of recycling waters resulting in uncontrolled activation of minerals to be depressed, depression of minerals to be recovered, formation on their surface hydrophobic slimes or hydrophilic compounds depressing floated minerals

These reasons can be overcome by the use of special reagents in conditioning of recycle waters and flotation pulps according to the created determined physico-chemical models of optimal ion composition of the liquid phase of pulp used as the criterion for the functional control unit in automation systems. Typical cases are considered below.

4.1. Prevention of harmful action of ions reducing the concentration of collector in pulp

Linkage of collector as precipitates of difficult-to dissolved salts $MeAn_2$ is the main reason for harmful influence of recycle waters on flotation of non-sulphide ores and oxide ores of non-ferrous metals at plants [1, 23-26].

Essence of recycle waters conditioning in this case is cutting down of the calcium and other alkali-earth ions concentration in them up to values less then necessary for formation of fatty acid salts precipitates at the minimum – necessary for mineral flotation collector concentration value in the pulp. For these purposes, for example, three-sodium-phosphate, sodium carbonate or water glass can be used. The necessary concentration of such reagent ($[R^{2-}]$) can be computed on the base of the chemical equilibrium: $MeAn_2 \Leftrightarrow MeR$.

Then taking into account that $[Me^{2+}][An^-]^2 = K_1$ and $[Me^{2+}][R^{2-}] = K_2$ the necessary concentration of reagent will be described by the equation (1):

$$[R^-] \geq (K_2 / K_1)[An^-]^2 \qquad (1)$$

where: K_1 and K_2 are solubility products of fatty acid salt and inorganic salt, $[An^-]$ – the necessary concentration of collector for flotation of a mineral.

The system of principle for automatic control and regulations of the conditioning circuit is shown in Figure 6, a.

The use of such system for preliminary conditioning of recycle waters will allow to carry out complete water recycling at plants without reduction in indices of mineral processing, will reduce the consumption of reagents and exclude practically the pollution of earth waters and water pools of regions.

4.2. Prevention of harmful action of ions depressing floated minerals

For example, in the use of recycle waters at "Tirniauzskaya" plant (Russia) flotation of chalcopyrite and other sulphides get worse as their surface is passivating with the mixture of cuprous oxide Cu_20, ferric hydroxide (γFeOOH type) and silicate [24].

Activation of sulphides flotation is possible if to prevent formation or destruct passivating coatings on the mineral surface. It can be achieved, for example, through the use of sodium sulphide, sodium cyanide or reagents-stimulators of anodic corrosion (such as alkaline metal chlorides).

The industrial application of technology elaborated at "Tirniauzskaya" plant (with sodium sulphide) confirmed their efficiency in flotation of copper and copper-molybdenum ores.

The floatability of nickel – containing pyrrhotite and pentlandite in processing of copper – nickel ores is rather sharply worsened under the action of calcium and magnesium salts escaped from rocks and accumulated into recycle water [2].

Results of investigations at "Noril'skaya" plant (Russia) show that in such cases the maximum total recovery of copper and nickel to the bulk copper – nickel concentrate is reached if regulation of the bulk flotation circuit (Figure 6, b) is curried out in correspondence with the physico-chemical model for pentlandite flotation [2, 25].

4.3. Prevention of harmful action of ions activating flotation of depressed minerals

For neutralization of activating action of salts of alkaline-earth metals, for example, on gangue silicate minerals in flotation with oxyhydrilic collectors sodium carbonate, phosphate compound or soluble glass are used.

Prevention of flotation of one of major silicate minerals - quartz will be provided in conditions described by equation (2):

$$\lg[CaOH^+] = 5.56 - pH \qquad (2)$$

If for precipitation of calcium salts, for example, sodium carbonate C_0^c or sodium phosphate C_0^p are used the concentration of calcium-bearing ions is determined by conditions of their equilibrium with the calcium carbonate or calcium phosphate precipitate. The equations C_0^c = f(pH) or C_0^p = f(pH) derived can be used in automation systems for regulation of the consumption of a reagent used for precipitation of calcium salts in recycle waters or in flotation pulp.

Copper ions are undesirable in lead flotation of lead-zinc or polymetallic ores as they activate sphalerite [2, 19]. For their tying cyanides or sodium sulphide in small quantities are applied.

Prevention of zinc sulphides activation by copper ions in charging of sodium sulphide is based on formation of difficult - to dissolve copper sulphide CuS. The ratio between concentrations of copper $[Cu^{2+}]$ and sulphide $[S^{2-}]$ ions is supervised by the expression for the equilibrium constant of the reaction (3):

$$CuS \Leftrightarrow Cu^{2+} + S^{2-},\ \lg[S^{2-}] = \lg K - \lg[Cu^{2+}] \quad (3)$$

Activation of sphalerite will not be observed if $[Cu^{2+}]$ in pulp is less than the necessary one described by the equation (4):

$$\lg[Cu^{2+}] \leq +0.70 - 2pH \quad (4)$$

Substituting the expression for $[Cu^{2+}]$ from the equation (4) into (3) the equation of the minimum - necessary $[S^{2-}]$ preventing activation of zinc sulphides by Cu^{2+} ions can be received:

$$\lg[S^{2-}] \geq \lg K - 0.70 + 2pH \quad (5)$$

The reliability of the given equation has been confirmed and used in industrial conditions at "Zyryanovskaya" plant (Kazakhstan) in processing of polymetallic ores [19].

The derived equation (5) for concentration of S^{2-} ions preventing sphalerite activation by Cu^{2+} ions can be used as the criterion for the system of automatic control of the sodium sulphide consumption in the appropriate circuits of selective flotation not only polymetallic, but also, for example, copper-zinc ores.

4.4. Stabilization and optimization of the flotation process in recycling waters using

Stabilization of minerals flotation in the presence of recycling waters can be realized if the control systems based on the use of determined physico-chemical models of flotation processes are used.

Results of industrial testing at several plants have shown that the relationship $[X^-] = f(pH)$ for galena (Figure 1, a) [2, 7] should be adopted for lead-copper, lead-zinc, lead-zinc-pyrite or lead-copper-zinc-pyrite bulk flotation, the relation $[X^-] = f(pH)$ for pyrite [2, 7] during zinc-pyrite bulk flotation, the relation $[X^-] = f(pH)$ for pentlandite [2, 7] - in receiving of bulk copper-nickel concentrate, the relation $[X^-] = f(pH)$ for pyrrhotite [2, 7] - in receiving of the bulk nickel-copper-pyrrhotite concentrate.

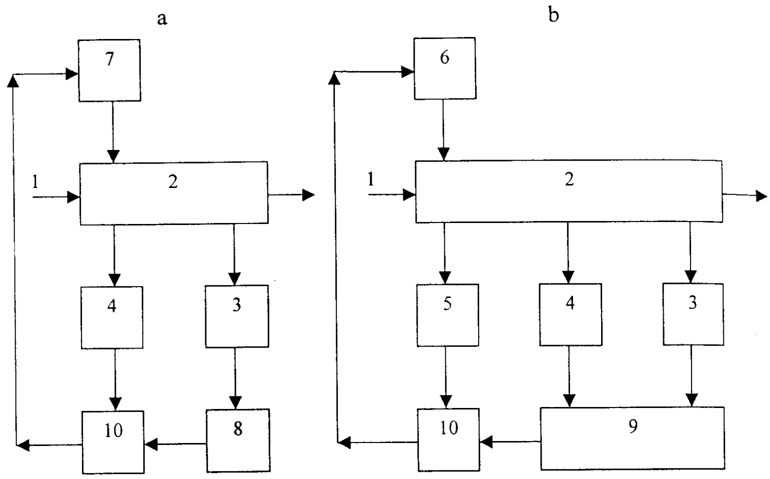

Figure 6 - Possible schemes of principle for systems of automatic control and regulation of processes of bulk flotation in the absence of lime (a) and flotation in the presence of calcium salts or sodium sulphide in the pulp (b): 1 - pulp, 2 - flotation, 3 - transducer of the pH value, 4 - transducer of the X^- ions concentration, 5 - transducer of the calcium or sulphide ions concentration, 6 - batchmeter of lime or sodium sulphide, 7 - batchmeter of xanthate, 8 - functional module generating the relationship $[X^-] = f(pH)$, 9 - functional module generating the value of the necessary calcium or sulphide ions concentration, 10 - regulator

The maximal recovery of metals is attained when the available xanthate concentration $[X^-]_a$ values are equaled to the calculated $[X^-]$ values independently of the mineral composition and genesis of ores to be treated, as well as commercial process peculiarities and recycling waters quality at individual concentrators (Figure 1, b, c).

The possible scheme of principle for systems of automatic control and regulation of bulk flotation processes is shown in Figure 6, a. The results of commercial operation of such system at "Zyryanovskaya" concentrator ensured a more than double reduction in xanthate consumption without any deterioration of ore beneficiation results [2, 19].

The use of automatic control systems based on the use of created physico-chemical models of the optimal ion composition of the liquid phase in conditioning of recycle waters and flotation pulps will permit to ensure sharp reduction in the reagents consumption and improvement in technological and technical – economic indices of mineral processing.

5. CONCLUSIONS

Good perspectives for further sustain development of flotation technology are based on the possibility for transition of qualitative ideas to quantitative regularities using conception of the new offered hypothesis of flotation. It permits to derive determined physico-chemical models for optimal conditions of technological processes of flotation with the use of recycling waters. Models can be used both for perfection of technological processes and elaboration of reliable automation systems to obtain maximum - possible technological and technical-economic indices of mineral processing plants performance.

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