Earth Observation for Monitoring and Observing Environmental and Societal Impacts of Mineral Resources Exploration and Exploitation – The EU Project EO-MINERS

Dr. Horst Hejny
Mineral Industry Research Organisation – MIRO
Concorde House, Trinity Park
Solihull, Birmingham B37 7UQ
United Kingdom.

Email: horst.hejny@miro.co.uk
Phone: +49 2858 9188970

ABSTRACT

Given the current status of political discussion in Europe about raw materials problems, the sustainable development of the extractive industry and the reduction of its environmental footprint is among the key topics in this discussion. In this context, the European Commission approved the EO-MINERS project (Earth Observation for Monitoring and Observing Environmental and Societal Impacts of Mineral Resources Exploration and Exploitation).

One of the scientific and technical objectives of EO-MINERS is to assess policy requirements at macro (public) and micro (mining companies) levels and define environmental, socio-economic, societal and sustainable development criteria and indicators to be possibly dealt using earth observation (EO) technologies. Further to that, the project will use existing EO knowledge and carry out new developments on three demonstration sites (Sokolov lignite mining area, Czech Republic, Witbank coal field, South Africa, Kumtor gold mine, Kyrgyzstan) to further demonstrate the capabilities of integrated EO-based methods and tools in monitoring, managing and contributing reducing the environmental and societal footprints of the extractive industry during all phases of a mining project, from the exploration to the exploitation and closure stages. Finally, it will contribute providing reliable and objective information about affected ecosystems, populations and societies, to serve as a basis for a sound “trialogue” between industrialists, governmental organisations and stakeholders.

INTRODUCTION

Mining and extractive industry have played a significant role in the development of many countries all over the world. The industry has been, and continues to be an important contributor to both national and regional economies and is critical to national defence. Mining, and the industries it supports, is among the basin building blocks of a modern society. The world today is facing and increasing mineral resource demand. This has been illustrated by the European Commission Vice President Günter Verheugen, responsible for enterprise and industry policy, who said: "*European industries need predictability in the flow of raw materials and stable prices to remain competitive. We are committed to improve the conditions of access to raw materials, be it within Europe or by creating a level playing field in accessing such materials from abroad*".

In recent years, the EU's total material requirement has remained at a constantly high level – roughly 50 tonnes a year per head of the population since the middle of the 1980s. But in this time the weight of imports and their environmental impacts have considerably increased (EEA 2003). The bulk of this increase is attributable to ores, mineral fuels, metalware and products such as glass, ceramics and precious stones. These four categories account for most of the ecological impact of imports. More than half of these originate in the developing countries, while fewer resources are extracted in Europe itself. Numerous mines have closed in Europe during the last few decades, either because of natural exhaustion or because they were not profitable. With the closure of mines environmental pressure has been reduced in Europe but risen in other regions. The environmental footprint of EU material consumption has shifted from Europe to other regions.

At the same time, the ecological impacts of imports into the EU have increased. One tonne of imports leaves behind an average amount of 5 tonnes in mining waste, emissions and erosion in the exporting country (Schütz/Moll/Bringezu 2003). This ratio has more than doubled over the past twenty-five years, and in the case of ores has quadrupled from 1:4 to 1:16 tonnes. This suggests that the acquisition of raw materials is becoming more and more costly, that more energy has to be used, and that more waste is left behind by mining operations. The analysis of the ecological impacts of imports to the EU reveals that environmental burden are shifted with significant social and economic consequences in other parts of the world.

The global dimension of this problem is being increasingly recognized. Access to raw materials was on the agenda of the G8 Summit on 6-8 June 2007. On that occasion a Declaration on "Responsibility for raw materials: transparency and sustainable growth" was adopted, which addresses the key priorities for a sustainable and transparent approach to this

question. In addition, the Competitiveness Council meeting on 21 May 2007 has invited the Commission to develop a coherent political approach to the issues arising. As a result, the European Commission launched in autumn 2008 ”The Raw Materials Initiative – Meeting our Critical Needs for Growth and Jobs in Europe” (COM(2008)699).

The exploitation of natural resources in many developing countries has been considered as a vital part of economic growth, employment and infrastructure development, but it has come at a cost to the environment. Early mining operations have left a historical legacy of negative environmental impacts that affect our perception of mining. With the emergence of the concept of sustainable development, it is now recognised that environmental protection is as fundamental to a healthy economy and society as it is development. The challenge is to simultaneously promote both economic growth and environmental protection.

The responsible management of Earth’s environment is one of today’s most pressing concerns and a central motivation for the Group on Earth Observations (GEO). Sound environmental management of mining activities can avoid high remediation costs, which frequently might drain public funds. Surface and groundwater pollution, soil contamination, and terrain instability all cause damage that can affect urban and sub-urban areas. Understanding and monitoring pollution processes in mining areas is therefore of concern to a very wide user community, including central government bodies or agencies, local authorities, industry, environmental groups and individual citizens. Facing legal and social pressures, also the mining industry is interested to minimize the impacts on environment and society. Formerly due to often accumulating remediation costs, nowadays these activities play an important role at the stock market and an increasing environmental awareness is an essential aspect of modern mining management. But the technology platform to support such critical environmental monitoring is diverse, geographically inconsistent, site specific, lacks integration across technologies and is therefore far from complete. Understandably, it is currently a gap within GEO’s Global Earth Observing System of Systems, which concentrates on issues such as Disasters and Climate Change.

The non-energy extractive industry (NEEI) of the EU-25 generated a direct turnover of about €40 billion, and provided employment to about 250,000 people in 16,629 enterprises in 2004 (SEC(2007)771). Estimated indirect employment provided by NEEI industry is up to 4 times greater than the directly employed, and is clearly a significant contributor to the economy of the EU. The use of these primary raw materials in the products of other branches of EU industry means they have a central role in guaranteeing industrial and economic sustainability. Nevertheless current demand exceeds production, and so the EU is heavily

dependent on mineral and metal imports leading to an annual trade deficit of about €11 billion (SEC(2007)771). Metallic minerals accounted for 90% of this deficit (€10 billion), while there were also net trade deficits in construction minerals (€456 million) and industrial minerals (€798 million).

Several national and international initiatives, both from the private or the institutional sectors, have been developed to address the sustainable development of the extractive industry and the reduction of the environmental footprint.

One can cite:

- Both the EU's 2001 Sustainable Development Strategy (SDS) (renewed in 2006) and the 2005 Thematic Strategy for the Sustainable Use of Natural Resources aim at a decoupling of economic activity from environmental impacts by considering the entire life cycle of resource use. This means that environmental impacts are considered at each stage of the life-cycle of the product and the raw materials – during extraction, transport, processing/refining, the use phase of the products made from it, and when a product or raw material becomes waste at the end of its useful life – thus avoiding negative impacts being shifted to other environmental media, to other stages of the life-cycle, or to other countries.
- The ETP-SMR Strategic Research Agenda (SRA). The Implementation Plan (IP) focuses on ways and means to implement the most urgent activities outlined in the SRA. In particular the short Term Research Priority 8 mentions "Helping cities in mining regions secure their strategic land, water and biodiversity resources by the use of modelling and economic tools".
- ICMM (International Council on Mining and Metals) members have committed to the ICMM Sustainable Development Framework. The Sustainable Development Framework comprises three elements and a set of 10 Principles (including a set of supporting position statements), public reporting and independent assurance. The Framework has been developed systematically since the formation of ICMM in 2001, with its foundations in the Mining, Minerals, and Sustainable Development (MMSD) project.
- The SDIMI, an international forum for the Sustainable Development indicators in the Mineral Industry, which objective is to assist the mining and minerals industries in their global transition to sustainable development. SDIMI states that "*Meeting the development needs of the world's growing population without depriving future generations of the means to meet their own needs, better known as Sustainable*

Development is the key challenge facing the minerals and mining industry. At present, a special focus of public perception is placed on environmental and social consequences of mining. Growing environmental and social concerns, supply chain procurement standards as well as public pressure and regulatory measures will profoundly shape the global mining business in the near future. In order to cope with these challenges the mining and minerals companies are forced to integrate sustainable development as well as stakeholders' participation into their business strategies and policies. Up to now there are on-going discussions and projects on the development of sustainability indicators however these different efforts haven't resulted into a common agreement yet".

- African Mining Vision 2050 is Task Force developed under the auspices of the the United Nations Economic Commission for Africa (ECA). The taskforce, jointly established by the African Union (AU) and ECA, also includes representatives from the African Mining Partnership (the intergovernmental forum of African ministers responsible for mining), the African Development Bank (AfDB), UNCTAD, and UNIDO. Among short term (less than 5 years) objectives are : a) Improve public participation (Consultation and information sharing/ participatory decision making/ dispute resolution mechanism) in the mining sector and b) capacity building
- Sixteen African ministers responsible for mining in their respective countries have launched the African Mining Partnership (AMP), with the aim of championing and coordinating mining and mineral-related initiatives under the auspices of NEPAD - the New Partnership for Africa's Development. The ministers have identified mining programmes and projects in six key areas: Artisanal or small-scale mining; harmonisation of mining policies; environment and sustainable development; beneficiation; human resource development; and promoting foreign investment and indigenous participation in mining ventures.

OBJECTIVES

General objectives

The aim of EO-MINERS is to bring into play EO-based methods and tools to facilitate and improve interaction between the mineral extractive industry and the society in view of its sustainable development while improving its societal acceptability.

Strategic objectives

Mining companies, regulatory bodies and stakeholders need various EO-based tools and methods adequately juxtaposed regarding the local contexts and applications (in compliance with GEO and GMES objectives and tasks).

Forecasting impacts, footprints, and relevant remediation measures require developing prospective tools. GIS using EO data will enable to visualise prospective evolution over time (flow modelling), playing on one or several GIS-layer parameter. For instance, population migration flow is often taken into account during the pre-feasibility phase, but not properly monitored further.

Cumulative impacts must be adequately addressed at regional scale (valley, district...), including induced impacts (population migration, livestock impact …) with respect to the concept of heavily exploited area.

As the EU is strongly interested in the establishment of measures for raw material flow analysis, especially for imported mineral resources, this project will contribute to the development of measures that can be used to analyse the mining operations taking the individual potential ecological and social footprint into account. Thus, the project directly supports the monitoring of three major EU policies:

- The Sustainable Development Strategy
- The Raw Materials Initiative
- The Thematic Strategy for the Sustainable Use of Natural Resources.

Eventually these developed methods and products should be integrated into Environmental Management systems (ISO 14000) and such integration must be properly addressed.

Scientific and technical objectives

The scientific and technical objectives of EO-MINERS are three fold:

- Assess policy requirements at macro (public) and micro (mining companies) levels and define criteria and indicators to be possibly dealt using EO:
  - Environmental criteria and indicators
  - Socio-economic criteria and indicators
  - Societal criteria and indicators
  - Sustainable development criteria and indicators
- Use existing EO knowledge and carry out new developments on demonstration sites to
  - further demonstrate the capabilities of integrated EO-based methods and tools in monitoring, managing and contributing reducing the environmental and

societal footprints of the extractive industry during all phases of a mining project, from the exploration to the exploitation and closure stages.

  - contribute making available reliable and objective information about affected ecosystems, populations and societies, to serve as a basis for a sound "trialogue" between industrialists, governmental organisations and stakeholders.
  - summarize and to document the developed models and algorithm, as well as the results of the "trialogue" to establish a baseline for a compendium of best practise approaches that will assist the on-going and necessary dialogue between society and mining industry.

- Capacity building, communication and dissemination among:
  - ETP-SMR
  - International and national organisations (EU, AU, UNEP, UNECA, etc)
  - Extractive industry associations and individual companies
  - Governmental representations
  - NGO's

METHODOLOGY

The work plan (see Figure 1) starts with the identification of the needs from industry, regulatory bodies and stakeholders (society, NGOs) to evaluate the indicators and parameters to be taken into account in the assessment of the environmental, socio-economic and societal footprints of the extractive industry at each stage of a project, from exploration to exploitation and closure. Corporate level (extractive industry and relevant associations) as well as public level (regional, national to international) will be considered.

This stage will serve as the basis for:

- Identifying parameters and indicators that can be addressed by Earth Observation methods, and to be used during the EO tools and methods development phase over demonstration sites
- Identifying stakeholders to be addressed during the dissemination phase at the end of the project

A strong RTD component will consist in developing EO-based tools and methodologies to observe and monitor the environmental and societal footprint of extractive industry activities over three demonstration sites located in heavily exploited areas:

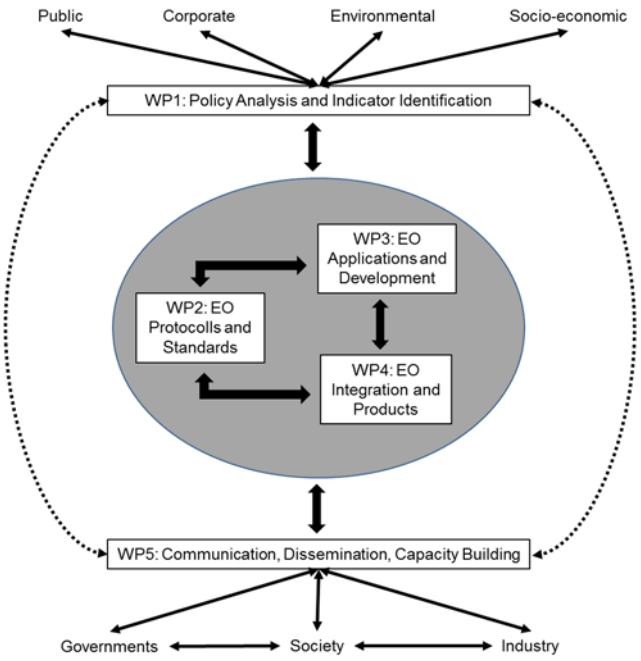

Figure 1: EO-MINERS workplan

- In Europe: Sokolov lignite open cast mine in Czech Republic
- In Southern Africa: Witbank Coalfields, Mpumalanga Province, South Africa
- In Central Asia: Makmal gold mine in Kyrgyzstan

Innovation will consist in the juxtaposition and/or fusion of various EO data through models or data integration schemes which fit at best with i) site specific requirements, and ii) the parameters and indicators to be addressed as defined during the previous stage.

In the perspective of the societal acceptability of extractive industry, one of the major aim of the project being to define tools "opposable" during discussions between the parties involved in a mining project life, a particular attention is paid to the definition and application of protocols and standards to EO data and added value products that guarantee the "quality and objectivity" of data and products.

Dissemination activities are addressed through:

- Communication, dissemination and capacity building: The target audience will include, but not be limited to, the European Technology Platform on Sustainable Mineral Resources (ETP SMR), national and international organisations (e.g. EU, UNEP, UNECA, etc), the extractive industry and their trade associations, and NGOs.;
- Initiating and developing a sound "trialogue" (definition: "An interchange and discussion of ideas among three groups having different origins, philosophies, principles, etc.") between the three main groups involved, the industry, governmental

organisations and other stakeholders (e.g. NGOs) based on reliable and objective information about ecosystems, populations and societies affected by mining activities.

EXPECTED RESULTS

The work of EO-MINERS is structured in 5 technical work packages (see Figure 1). WP1, entitled "Policy Analysis and Indicator Identification", addresses the need to assess policy requirements and define criteria and indicators to be possibly dealt using EO methods and tools. It aims to identify the information requirements from policy for the selection of appropriate Earth Observation techniques and the formulation of protocols and standards in subsequent work packages. WP1 will produce an analysis of policies related to the environmental and social footprint of mineral industries. Policies from three stakeholder categories will be under study: companies, public authorities and civil society. WP1 identifies policies that address the environmental and social footprint of mineral industries of corporations, public authorities and civil society. Based on the policy analysis, WP1 derives specific information demands on the three levels for the development of footprinting indicators for the European Technology Platform on Sustainable Mineral Resources (ETP-SMR).

The core of the project aims at developing EO-based tools for helping monitoring and observing the impact on the environment and on the society of the exploration and exploitation of mineral resources.

To this end, project RTD will primarily focus on the improvement of EO targeted applications and developments over selected demonstration sites over the world. Innovative approaches will be carried out in processing together various EO data sets through different combination of them. Data fusion algorithms and specific processing algorithms will be tested and/or developed at this stage, taking into account site conditions and various thematic requirements defined by the mining companies and geological surveys. GIS thematic map layers issued from these developments will then be used for footprint assessment and risk analysis

WP3 (EO application and developments over demonstration sites) hence will contribute to develop high level EO-based data products applicable to the different stages of mining activities within the life cycle of mining operations. Those products will allow to observe, to monitor and to quantify social and environmental impacts caused by mining activities over the selected demonstration sites and aiming to understand their "footprint". As satellite based remote sensing focuses more on a regional – and sometimes up to a national – scale, airborne remote sensing maintains the opportunity to record mineral extraction sites with high

resolution (geometrically and thematically). Based on detailed reference data, quantitative measurements are made possible. This allows the detection of surface covering materials, their spatial pattern and thus the delineation of "hot spots". The definition and the establishment of procedures that allow the repeated generation of reliable and plausible data sets are prerequisites for GIS-based analyses.

Based on the site specific developments carried out in WP3, RTD in WP4 (EO integration and products) is intended to contribute to the development of generic EO data integration schemes, EO products and EO-driven environmental modelling scenarios adapted to various situations, whose reliability and objectivity cannot be disputed by all parties involved in any stage of a mining project. Such products aim to characterise affected ecosystems, populations and societies and become an indisputable basis for a sound "trialogue" between industrialists, governmental organisations and stakeholders. WP4 also addresses GEO and GEOSS process and tasks, by using these outputs to define core elements of an environmental observing system and examining how this system fits in GEO and contributes to building GEOSS. Today, there are no GEO observing systems dedicated to this function. EO-MINERS is designed to fill that gap by identifying existing GEO observing systems that are suited to the task, modifying them as required and adding new ones where necessary. To this end, a major GEO Minerals Workshop is a mid-term milestone. A key outcome will be contributions to existing, as well as suggestions for new, GEO Work Plan Tasks and SubTasks.

Developments carried out in WP3 and WP4 rely on data that fully comply with protocols and standards, e.g., data calibration, data validation and data quality assurance, from upstream (data acquisition phase) to downstream (the added-value EO-based product delivery phase) as well as through the processing chain (algorithms). WP2 (Protocols and standards for EO products) will take care of robust and reliable standards and protocols that guarantee the repeatability of the methods deployed.

Eventually WP5 focuses on dissemination, promotion and capacity building actions in order to provide bodies involved and interested in impact assessment of mining activities as well as all other interested parties with the results of the project work. Further, WP5 will also concentrate on developing means for a sound "trialogue" (definition: "An interchange and discussion of ideas among three groups having different origins, philosophies, principles, etc.") between the three main groups involved, the industry, governmental organisations and other stakeholders (e.g. NGOs). This "trialogue" will assist towards the reconciliation of interests in order to reach common agreement upon actions to deal with environmental and social impacts of mining activities. One individual task will be dedicated to IPR and

exploitation. Main emphasis will be put on developing and maintaining an exploitation plan identifying all project results and especially those with commercial potential.

WORK DONE SO FAR

The EO-MINERS project is scheduled to run until January 2013. Therefore, the project didn't produce too many results yet.

The work concentrated basically on the following topic:

- Policy assessment
- Development of indicators
- On-site and airborne data collection and assessment
- Dissemination activities

For the selection of applicable Earth Observation techniques, the project has identified and analysed policies related to the footprint of mining industries, at corporate, authority and civil society level. Information requirements have been derived and appropriate indicators assessed and selected for all three levels, covering both social and environmental indicators of corporate sustainability reporting and macro-economic indicators for governmental policy-making. The results of the analyses will define the demand for the development and application of Earth Observation services by the ETP-SMR and thus frame subsequent work. In a final iteration loop, the response to the tested Earth Observation services will be analysed.

Concerning sustainable mineral resource use, a variety of stakeholders at different governance levels (from local to global level) could be identified. Their policies (or strategies and agendas) have different objectives that potentially can be supported by EO services. Hence, in a first step such policies and strategies related to mining activities at three different levels will be reviewed in order to identify core concerns.

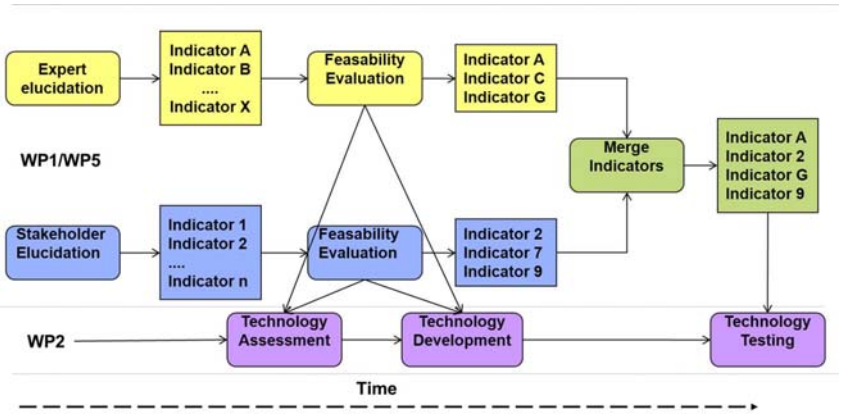

Figure 2: Indicator identification process

The project will develop material that eventually will be used in deriving and defining indicators for various issues that EO-MINERS will be addressing. In this way not only the various technical communities within EO-MINERS will contribute to a valid and useful set of indicators, but also a wide variety of stakeholders outside the project team.

Thus a multi-pronged approach to developing indicators was proposed (see Figure 2), consisting of a heuristic development by expert elucidation, site-specific conceptual models for the three study sites and a deliberative approach elucidating out-side stakeholder input. The three processes, the expert driven ones and the deliberative one will run in parallel. Once the three sets of indicators have been derived they were analysed for their respective coverage. For instance, conceptual site models were analysed for any processes or features that have not been covered by the set of ‚expert-derived' indicators and the latter were updated accordingly. This process went through several loops of iterations. In other words, it was undertaken to consolidate the various sets of indicators into one set. This consolidated set of indicators (see Figure 3), together with results from EO services based on them will be subject to final stakeholder evaluation towards the end of the project.

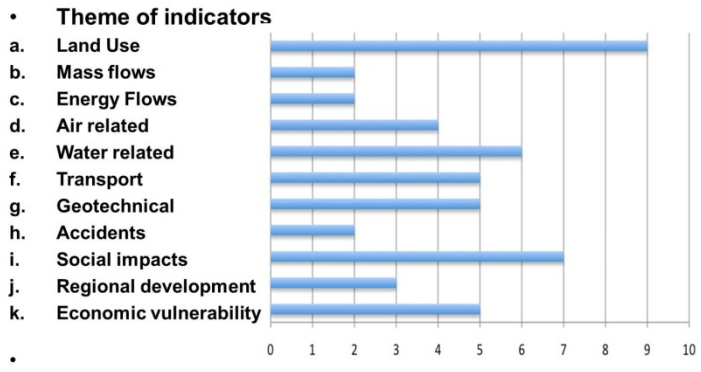

Figure 3: Groups of indicators

The project is currently in the process of linking the derived indicators with EO techniques.

CONCLUSIONS

Mining and the extractive industry will continue to play a significant role in the development of many countries all over the world and especially in the context of mineral raw materials supply. The social acceptability of a mining project, from exploration to closure, is among the major key issues to be dealt with. EO-MINERS scientific and technical objectives are to: i) assess policy requirements at macro (public) and micro (mining companies) levels and define environmental, socio-economic, societal and sustainable development criteria and indicators to be possibly dealt using Earth Observation; ii) use existing EO knowledge and carry out

new developments on demonstration sites to demonstrate the capabilities of integrated EO-based methods and tools in monitoring, managing and contributing reducing the environmental and societal footprints of the extractive industry during all phases of a mining project and iii) contribute making available reliable and objective information about affected ecosystems, populations and societies, to serve as a basis for a sound "trialogue" between industrialists, governmental organisations and stakeholders.

EO-MINERS already completed the first steps of policy assessments and indicator development. We are now working on linking the indicator to EO techniques in order to provide the most suitable EO methods and tools for the envisaged tasks.

The first steps of EO-MINERS were quite successful so that we are confident to reach our objectives.

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REFERENCES

African Union (2009), African Mining Vision 2050

European Commission, COM (2005)670, Thematic Strategy on the sustainable use of natural resources

European Commission, COM (2005)658 final, On the review of the Sustainable Development Strategy - A platform for action

European Commission, COM (2008)699, The Raw Materials Initiative – Meeting our Critical Needs for Growth and Jobs in Europe

European Commission Staff Working Paper, SEC (2007)771, Analysis of the competitiveness of the non-energy extractive industry in the EU

European Environment Agency (2003), Europe's environment, the third assessment

European Technology Platform on Sustainable Mineral Resources (2009), Strategic Research Agenda, Rev 3

International Council on Mining and Metals (ICMM) (2003), Sustainable Development Framework – 10 principles

Schütz, Moll, Bringezu (2003). „Globalisierung und die Verlagerung von Umweltbelastungen.“ Wuppertal Papers, Wuppertal Institut für Klima, Umwelt, Energie GmbH

EO-MINERS partners (2011), Non-public reports about project results