SUSTAINABILITY IN MINING ENGINEERING:
SEEKING A MODEL FOR EDUCATION AND RESEARCH

Silvana Costa and Malcolm Scoble

Sustainability Working Group
Department of Mining Engineering
University of British Columbia,
6350 Stores Road, Vancouver, B.C., Canada. V6T 1Z4
Phone 604 822-1247
Fax 604 822-5599

ABSTRACT

This paper considers how the Mining Engineering Department at UBC is addressing the need to integrate sustainable development into education and research on behalf of industry and society. In particular, it considers the evolution of a new collaborative and multidisciplinary model for education and research, the Sustainability Working Group (SWG). This Group has brought together a diverse array of disciplines from academia, industry, government, NGO’s and mining communities. The operational mechanisms and structure of SWG have enabled momentum to be gained through several multidisciplinary educational and research networking initiatives.

A learning process has evolved within UBC’s Department of Mining Engineering over the last six years, a period when industry has faced much change. This process initially focused on understanding the nature and the relevance of sustainable development principles to mining and its communities (Veiga, Scoble, McAllister, 2001). It then addressed how sustainability should be integrated in a functional manner into our academic culture for educational and research development.

Central to this learning process were the following issues:

- How can the University respond to the increasing awareness of social as well as environmental responsibilities in designing, planning, developing, operating and closing mines?
- What should be our role in providing academic support to the mining industry and to communities of interest?
- What learning model could facilitate capacity for our mining faculty to legitimately lead sustainability teaching and research initiatives?
• What networking mechanism, interdisciplinary or multidisciplinary, could serve the need for educational and research development in the context of the UBC Campus, and other Universities and institutions?

This paper reviews the concept of sustainable development and its application to the mining process. It then describes the operational model adopted in the evolution of what has become the Sustainability Working Group (SWG) within our Department. It concludes with a summary of some current SWG educational and research initiatives.

The goal of the SWG is to develop educational and research initiatives aimed to enhance the integration of sustainability concepts within the mine life cycle. A related goal is to train a new kind of researcher and practitioner; one that is familiar with the scientific and engineering challenges but also able to contend with the complexities of ecological, economic and social realities.

**WHY SUSTAINABILITY?**

The World Commission on Environment and Development in their Brundtland Report defined sustainable development as meeting “the needs of the present without compromising the ability of future generations to meet their own needs.” (United Nations, 1987).

The Mining Association of Canada led an early initiative in 1992, promoting a national multi-stakeholder process entitled the Whitehorse Mining Initiative (WMI), (WMI Leadership Council, 1994). Eighteen months of discussion involving the mining industry, senior

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**Table 1. Guiding Principles for Sustainable Development (IIED, 2002)**

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

**Social Sphere**
- Ensure a fair distribution of the costs & benefits of development for all those alive today.
- Respect & reinforce the fundamental rights of human beings, including civil & political liberties, cultural autonomy, social & economic freedoms, & personal security.
- Seek 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 & the environment, including remediation of past damage.
- Minimize waste & environmental damage along the whole of the supply chain.
- Exercise prudence where impacts are unknown or uncertain.
- Operate within ecological limits & 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 to build trust, shared goals & values.
- Ensure that decisions are made at the appropriate level, adhering to the principle of subsidiarity where possible.
governments, labour unions, Aboriginal peoples, and the environmental community led to the adoption of the WMI Accord. This adopted a strategic vision for a healthy mining industry in the context of maintaining healthy and diverse ecosystems in Canada, and for sharing opportunities with Aboriginal peoples.

Natural Resources Canada (2001) has recognised sustainable development as “the integration of environmental, economic and social considerations — as the key to ensuring we maintain our quality of life and continue to create jobs, without compromising the integrity of the natural environment or the ability of future generations to meet their own needs.” It has also stated that “Natural resources epitomize the challenge of sustainable development. Few sectors have more direct impact on the natural environment, yet few are more important to the economic and social health of every region in Canada.”

In the Department of Mining Engineering at UBC we believe that mining can be undertaken responsibly and that mining has a genuine role to play for society in constructively facing sustainability issues. We are dedicated to assisting the industry to develop technologies, practices and policy in its transition to alignment with the principles of sustainable development.

MINING AND SUSTAINABILITY

The motivation to address sustainability issues by the minerals industry was recently reflected in the formation of the Global Mining Initiative (GMI), developed by ten of the world’s largest mining companies under the auspices of the World Business Council for Sustainable Development. The GMI launched an independent research program, the Mining, Minerals and Sustainable Development (MMSD) project. The results were presented in Toronto at a conference in 2002 and summarized in a final MMSD report by the International Institute for Environment and Development (IIED, 2002). MMSD proposed a framework based on a set of guiding principles for each of the four dimensions of sustainable development, including the social, environmental, economic and governance spheres. Presented as aspirations for the mining industry, these principles are intended to recognize diversity, limitations in knowledge and capacity, as well as society’s need for minerals (Table 1). MMSD directed stakeholders’ concerns to nine key challenges facing the mining industry (Table 2). These represented the most pressing issues identified through the various consultative mechanisms used by MMSD.

British Columbia’s mining companies have played a prominent leadership role by integrating sustainability into their policy and practice. This follows on from genuine achievements in developing leading practice in environmental management and technology. Mine closure and reclamation in British Columbia has also been
seen to be associated with social impacts on affected mine communities, such as the Quintette, Bullmoose, Brenda and Island Copper Mines. The recent closure of the Sullivan Mine and the long term diversification of the town of Kimberly has proven to be a model of leading practice. Significant social impacts will be a challenge associated with the closure of the Highland Valley Copper Mine over the next decade. The Eskay Creek and Sechelt mines are prominent examples in British Columbia of successful collaboration with local First Nations communities. Vancouver-based companies are also developing leading sustainability practices associated with their offshore mining operations and associated community issues (e.g., Teck Cominco’s Red Dog and Antamina mining projects).

In more recent times, industry has recognised the growing business case for sustainable mining. For example, this was reflected in a keynote presentation in March 2003 at the PDAC Annual Conference in Toronto by Mr. Jim Carter, President of the Mining Association of Canada: “In the face of increased regulatory and public expectations, companies must earn what is called a “social license to operate.” Failing to do so will result in loss of stakeholder support, the disfavour of regulators and perhaps even lead to the demise of the business operation. These factors make a compelling business case for companies to operate responsibly when it comes to environment, economic and social matters.”

MINING ENGINEERING: EDUCATION AND RESEARCH

Mining engineering involves the design, planning and management of operations for the development, production and eventual reclamation of earth resources extraction projects. This requires a very diverse set of skills. The Mining Engineer has traditionally been viewed as the “Jack of all trades and master of none.” The UBC Mining engineer has always been highly regarded for the strengths in both mining and mineral processing. Our current view of mining engineering is that it integrates these traditional strengths with aspects of environmental and social sciences. The growing awareness of the needs to integrate environmental and social considerations has broadened this skills base even further. One question relates to the relative weighting given to courses and training in these four areas. An earth resources extraction company employs a range of specialist professionals to take responsibility for the many dimensions of its operations but it is still the mining engineer that is expected to be the broad generalist that can integrate the diversity and have a minimal competency in all of the principal areas. This has been the clear view expressed by our Department’s Industry Advisory Committee.

The Bachelor of Applied Science degree in Mining Engineering at UBC is accredited by the Canadian Engineering Accreditation Board and as such can be used towards satisfying the admittance criteria for membership in one of Canada’s Provincial Engineering Associations. The UBC mining engineering
Table 2. Nine Key Challenges Facing the Mining Sector (IIED, 2002)

Viability of the Minerals Industry.
The minerals industry cannot contribute to sustainable development if companies cannot survive & succeed. This requires a safe, healthy, educated, & committed work force; access to capital; a social license to operate; the ability to attract & maintain good managerial talent; & the opportunity for a return on investment.

The Control, Use, & Management of Land.
Mineral development is one of a number of often competing land uses. There is frequently a lack of planning or other frameworks to balance & manage possible uses. As a result, there are often problems & disagreement around issues such as compensation, resettlement, land claims of indigenous peoples, & protected areas.

Minerals & Economic Development.
Minerals have the potential to contribute to poverty alleviation & broader economic development at the national level. Countries have realized this with mixed success. For this to be achieved, appropriate frameworks for the creation & management of mineral wealth must be in place. Additional challenges include corruption & determining the balance between local & national benefits.

Local Communities & Mines.
Minerals development can also bring benefits at the local level. Recent trends towards, for example, smaller work forces & outsourcing affect communities adversely, however. The social upheaval & inequitable distribution of benefits & costs within communities can also create social tension. Ensuring that improved health & education or economic activity will endure after mines close requires a level of planning that has often not been achieved.

Mining, Minerals, & the Environment.
Minerals activities have a significant environmental impact. Managing these impacts more effectively requires dealing with unresolved issues of handling immense quantities of waste, developing ways of internalizing the costs of acid drainage, improving both impact assessment & environmental management systems, & doing effective planning for mine closure.

An Integrated Approach to Using Minerals.
The use of minerals is essential for modern living. Yet current patterns of use face a growing number of challenges, ranging from concerns about efficiency & waste minimization to the risks associated with the use of certain minerals. Companies at different stages in the minerals chain can benefit from exploring further recycling, re-use, & re-manufacture of products & developing integrated programmes of product stewardship & supply chain assurance.

Access to Information.
Access to information is key to building greater trust & cooperation. The quality of information & its use, production, flow, accessibility, & credibility affect the interaction of all actors in the sector. Effective public participation in decision-making requires information to be publicly available in an accessible form.

Artisanal & Small-Scale Mining.
Many millions of people make their living through artisanal & small-scale mining (ASM). It often provides an important, & sometimes the only, source of income. This part of the sector is characterized by low incomes, unsafe working conditions, serious environmental impacts, exposure to hazardous materials such as mercury vapors, & conflict with larger companies & governments.

Sector Governance: Roles, Responsibilities, & Instruments for Change.
Sustainable development requires new integrated systems of governance. Most countries still lack the framework for turning minerals investment into sustainable development: this need to be developed. Voluntary codes & guidelines, stakeholder processes, & other systems for promoting better practice in areas where government is unable to exercise an effective role as regulators are gaining favor as an expedient to address these problems. Lenders & other financial institutions can play a pivotal role in driving better practice.

postgraduate research degrees are a Masters in Applied Science and a PhD in Applied Science. These are not qualifying professional degrees in engineering. Their emphasis is on research through a thesis project with associated course work. This course work tends to be primarily related to facilitating the capability to perform the research. This effectively provides the powerful capability to admit postgraduate students in mining engineering to the Department with prior degrees from diverse disciplines. This is with the proviso that their academic background and possible work experience demonstrate a genuine relevance to the research and a high level of achievement. All postgraduate students, however, are expected to take an adequate coursework program to ensure a sound basic knowledge of mining engineering regardless of their prior degrees. These circumstances have fostered a SWG postgraduate student community that is
multidisciplinary in terms of background, professional experience, gender and nationality. This contributes significantly to a healthy and rewarding working and social environment within the Department. The research thesis committees are also multidisciplinary, which fosters a good level of interaction with other Departments.

THE UNIVERSITY ROLE

UBC has historically aimed to assume the role of innovator in addressing the changing needs of society and reinforcing its values:

"Universities help shape our civil society by emphasizing the importance of democratic rights and freedoms, and by educating global citizens who are politically, culturally, and socially aware. Universities also provide solutions through research, discovering knowledge and creating new technologies that can bring hope to millions who may be suffering from poverty, malnutrition, or disease. A third contribution by universities is the development of economic opportunities through innovation: a culture of innovation is the backbone of a strong and healthy economy that can withstand even the most catastrophic events." (University of British Columbia President Martha Piper, 2003)

It is the role of the university to facilitate the dialogue between academics, students and practitioners, in order to promote the generation of innovative solutions for problems facing our society.

The Department of Mining Engineering at UBC recognised the transition to the challenging economic and socio-political environment in which the mining industry operates today. It made a commitment to take a leadership role, fostering responsible mining practices and enabling technologies. These aim to facilitate innovative mining and mineral processing methods to address the technical challenges and important social and environmental issues faced by the mining sector. What has grown from this is a deliberate holistic strategy for the integration of social-political and economic issues. This evolution is ongoing and set in a continuous improvement mode.

SWG: AN EDUCATION AND RESEARCH MODEL

Two models appeared to be options as vehicles for this evolution: a dependent and an independent model. In a dependent model we would rely on other UBC Faculties and Departments to assist us directly in providing the education and research for the mining industry by contributing their supervision, capacity and postgraduate students. Strong but dispersed outliers of sustainability expertise existed on the UBC campus for collaboration. Concerns, however, centered around the coordination, strength and longevity of such
dependencies. The graduates from such a model would be less likely to carry forward a strong mining knowledge and commitment to the industry. Also, it would be more difficult in this model to grow long term capacity within the Mining Engineering Department to benefit both education and research.

The second model of independent evolution was chosen, whereby we set out to grow and retain the capacity within the Department, whilst still working closely with colleagues in other UBC disciplines and associated organizations and industry. In parallel to our past response to the perceived need to integrate environmental science into our education and research, we decided to grow our own capacity, introducing sustainability issues to the traditional mining sub disciplines to reflect our vision for the Next Generation Mining Engineer.

Our independent model evolved over the course of five years as a core group of professors and postgraduate students interacted to coalesce into what came to be called the Sustainability Working Group (SWG). This is a group of researchers and practitioners dedicated to informal collaboration in a flexible learning mode. Members needed to be from diverse backgrounds to provide credibility and the required range in capacity. Success with the independent model should result in a legacy of capacity, growing the future ability to relate all aspects of mining engineering to sustainability. Our Departmental aim through SWG is to develop the capacity to integrate sustainability principles into all aspects of our teaching, in parallel with a world class program of research. The model required that we integrate postgraduate students from other necessary disciplines to add the diversity to fuel the growth of the initiative. We still needed to develop the commitment of academics from other disciplines at UBC and other Universities to join the graduate student supervisory teams and to fill critical gaps. The last link was to bridge to industrial, governmental and NGO partners in what proved to be a collaborative, interactive learning mechanism. Figure 1 attempts to show graphically the principles of this evolving model.

SWG is a unique combination of members: students, academics, industry professionals, government and NGO members. These are characterized by a common motivation: responsible mining. They fulfill the critical need for diverse specialties in skills and experience that include: mining, mineral processing, geology, environmental science, commerce, geography, landscape architecture, law, and anthropology. This multidisciplinary group provides a broad knowledge base, a fertile atmosphere for creativity and innovation, and the credibility of a neutral academy. The common goal is a more responsive and responsible mining sector, one that advances issues of sustainability throughout the sector – in the boardroom, the core shack, the mine and beyond.
SWG currently comprises half a dozen associated professors from UBC, University of Alberta (Canadian Circumpolar Institute), and the University of Waterloo (Department of Environmental and Resource Studies), with 13 PhD and Master’s graduate students in the Mining Engineering Department (Table 3), 6 postgraduate students from other Departments and Universities, and over a dozen members from industry, government, NGO’s etc. The intention is to respond to current challenges, such as community participation in mining, development, capacity building, environmental impacts, Aboriginal issues, land access, conflict and poverty alleviation, among others. Amongst the participants, there is expertise in several languages and life and work experience in a number of mining regions and countries, such as Brazil, Colombia, China, Ghana and Peru.

Research funding to date has been gained from various sources, primarily government, international organizations, and private companies. Sources include: the World Bank Group, Extractive Industries Review, National Sciences and Engineering Research Council (NSERC), the Canadian Institute of Health Research, Natural Resources Canada, MMSD Global and North America, and Canadian exploration and mining companies. Individual students have also obtained academic funding from various public and private organizations such as the UBC Bridge Program, NSERC, the World Bank, International Development Research Council, Teck Cominco Ltd., IMA Exploration, among others. Graduate students have also received scholarships from NSERC, the Cy and Emerald Keys Foundation and the Killam and Trudeau Scholarship programs.

The SWG primary partners and sponsors are communities affected by mining, aboriginal groups, mining companies, financial institutions and international organizations, NGO’s/civil society, engineering services/consulting companies, government, equipment suppliers and educational institutions.

SWG offers the potential to influence and contribute to educational program development as well as research. It also takes responsibility for leading lifelong learning in support of Sustainable Mining.

EDUCATIONAL INNOVATION

In undergraduate education, SWG members are involved in two undergraduate courses in the UBC Applied Science Faculty, taught to the broad population of engineering undergraduates: APSC262 Sustainability and APSC450 Professional Engineering Practice. This year it plans to launch a new course for engineering undergraduates on Aboriginal Peoples and Engineering. It seems remarkable nowadays that the education of UBC engineers, particularly mining engineers, involves no compulsory courses relating to Aboriginal
Peoples. A new postgraduate course in mining was launched by SWG two years ago, *Mining and Society*, that is proving to be a popular foundation course that undergraduates may also take as an elective.

Figure 1. Sustainability Working Group concept within the UBC Mining Engineering Department.

Mature students with no prerequisite educational qualifications are able to economically and conveniently complete internet-based courses during the year from remote locations such as a mine site. They then have a further option to attend short courses at Summer and Winter Institutes on the UBC Campus. Completing an internet-based foundation course in a topic and its associated campus short course enables anyone to
accumulate points towards a UBC Certificate in Mining Studies. Completion of four pairs of internet and campus-based course combinations then qualify the learner for the UBC Certificate (www.cstudies.uc.ca/appsci/mining). Courses aim to link mining, mineral processing, environmental and social issues, providing students with the opportunity to update their mining expertise, including their understanding of sustainability.

![Diagram showing multidisciplinary aspects of sustainability]

**Figure 2. Sustainability Working Group: Scope of Educational and Research Activities.**

SWG is collaborating by developing internet-and campus-based courses in sustainability for the Certificate program. The prospects for the further evolution of this Lifelong Learning model are exciting, particularly when the growing issues relating to globalization, skills and training, and struggling mining schools are considered (Scoble, 2003).

**MULTIDISCIPLINARY RESEARCH**

Collaboration and partnership between disciplines is critical. Satisfying this demand at the practical level can be challenging, often for pragmatic reasons such as: conceptual and methodological differences between disciplines, prejudices, and the fact that different disciplines often compete for the same research funds. In mining practice it is not uncommon to observe the traditional "silo" effect of inadequate integration between sub disciplinary groups at minesite, for example: geology, surveying, mining, processing, and maintenance.
Responsible mining implies due regard for economic, environmental and community wellbeing. We feel that this conforms to the spirit of “Sustainable Mining”.

SWG research aims to contribute to technology development, new practices, policy and regulation in support of Sustainable Mining. Core competencies are considered to be in mining engineering, but strongly supported by economics, law, anthropology and communications. The Group provides complementary synergies, and often critical support, to the traditional mining, mineral processing and environmental expertise existing in the Mining Engineering Department. The rationale is non-intrusive, bringing the social sciences to complement existing technical expertise. Thus due consideration can be given to community and policy issues in developing and implementing the next generation of sustainable mining systems. In a recent initiative, SWG is developing research synergies with a newly-formed multidisciplinary research network, Network North, based in the University of Alberta and focusing on the social issues confronting Canada’s northern communities.

The SWG research projects have tended to focus to date more on the participatory processes in mine planning, community development and community relations in the mine life cycle and the facilitation of dialogue within the industry and amongst the industry and other stakeholders. Table 3 shows the current SWG Masters and PhD students, their prior degrees and current projects. Summaries of three characteristic projects are now presented. Further details of the full SWG research program are accessible on the UBC Mining website (www.mining.ubc.ca). The Department of Mining Engineering currently has 54 Master’s and PhD Students evenly distributed in four research groups: mining, mineral processing, environment and sustainability (SWG).

Project Abstract I: Building Effective Indicators of Sustainable Mine Reclamation: A Case Study of Mine Reclamation in British Columbia

Collaboration: Highland Valley Copper Ltd.

In order to explore for new mineral deposits on public lands, companies must develop site appropriate strategies for assuaging public concern that mining causes long-term social and environmental harm. Key to this strategy is the need to prove that mine closure and reclamation programs can be consistent with the idea that mining is a temporary use of the land. To provide this proof a process must be found that simply and effectively communicates to the local community how the mine is to make the transition from operational mine to final closure and beyond. An effective vehicle for communicating this is through the use of community-based indicators of sustainable mine reclamation. The concept of Visible Stewardship, the unequivocal physical expression of care and commitment to sustainable development principles, and the management tools that will facilitate the objective measurement, evaluation and reporting of a company’s reclamation program, may be the key for building trust in the ability of the industry to reclaim former mine sites for the benefit of future generations.
Project Abstract II: Public Policies for Mine Waste Management Technologies
Collaboration: Bridge (CIHR/MSFHR Strategic Training Program)

The primary objective of this research is to help develop and structure potential policy frameworks to guide the implementation of mine waste management technologies to meet liability and sustainability issues. This project aims to investigate alternatives to situations where there may be little incentive to mitigate or eradicate the effects of mine waste, appropriate expertise is not employed, and the risks to mining companies and the public are high. This study will develop economic and technical models (including environmental models) to simulate the effects of proposed policies and the decision-making process used to implement a particular technology. The potential interactions between stakeholders, the mine and waste treatment technology will be considered.

Project Abstract III: A Protocol to Assess Mercury Pollution and Remedial Measures in Artisanal Gold Mining Communities
Collaboration: NSERC; Brazilian Centre for Mineral Technology Research (CETEM)

A laboratory methodology using the earthworm Eisenia fetida was developed to assess mercury bioavailability in mine tailings and aqueous solutions. The method was also used to evaluate the efficacy of remedial alternatives, such as caps. The quick, inexpensive and simple earthworm protocol was specifically developed to prioritize contaminated sites based on the potential for mercury incorporation into biota with specific consideration of the technical and financial limitations inherent in artisanal mining communities. The protocol was field-tested in an artisanal gold mining community in Brazil and transferred to mercury pollution researchers at a major Brazilian research centre (CETEM).

CONCLUSION

The dominant challenges currently faced by the mining industry are increasingly related to sustainability issues: ecological as well as socio-economic matters in mining operations and neighbouring communities. However, there are no standards or models to be followed in integrating sustainability principles into mining education and research. The other engineering disciplines and Canada’s Professional Engineering Associations are also facing similar challenges. The socio-political environment and the obvious struggle for a social license to operate have created close to insurmountable barriers to mine development in many parts of the world. Nonetheless, the industry and educational institutions have been slow in reacting and adapting to recent trends. The academic arena must take leadership in creating the sort of professionals, services and research that will help the industry adapt. It is paramount, nonetheless, that the industry supports the academic initiatives from the very outset. Professors, researchers and students need the assistance from mining practitioners and communities in identifying research priorities, specific challenges and avenues for exchange and continuous learning.
Sustainability is a complex concept and we remain in a learning phase, wrestling with its integration. The multidisciplinary nature of SWG and its vitality has provided the flexibility to understand sustainability in its many forms. The SWG students have successfully created educational, professional and information exchange networks with other departments at UBC, other universities, mining and consulting companies as well as NGOs, government institutions and international organizations. Interestingly, such networking has functioned in two ways. SWG students have developed research and learned from other groups, but they have also introduced to other departments and institutions, often for the first time, the knowledge that is accumulating in the Mining Department and in the mining industry. When SWG students participate in seminars or projects within other departments and institutions, they not only learn from other perspectives, but also present to them the challenges and the new paradigm faced by mining professionals. It has proved to be an effective means to disseminate information and knowledge, to promote the industry and its recent accomplishments, and to give mining a fresh, modern and progressive face.

Table 3. Current SWG postgraduate students, research thesis topics and discipline of origin.

<table>
<thead>
<tr>
<th>Student</th>
<th>Degree</th>
<th>Project title (previous degrees)</th>
</tr>
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<tbody>
<tr>
<td>Jennifer Hinton</td>
<td>PhD</td>
<td>Clean Technologies, Risk Mitigation and Communication: Framework for Transformation in the Artisanal Gold Mining Sector (Geological Engineering; Mining Engineering)</td>
</tr>
<tr>
<td>Silvana Costa</td>
<td>PhD</td>
<td>Planning for Sustainability in Mining Communities (Environmental Design &amp; Planning; Architecture &amp; Urban Design)</td>
</tr>
<tr>
<td>Simon Handelsman</td>
<td>PhD</td>
<td>Human Rights Issues: Risks and Costs to Mining Operations (Mining Engineering)</td>
</tr>
<tr>
<td>Michael McPhie</td>
<td>PhD</td>
<td>Scenario Simulation and the Evolution of Sustainable Mining (Biology; Physical Geography; Environment &amp; Management)</td>
</tr>
<tr>
<td>Emanuel Aubynn</td>
<td>PhD</td>
<td>Sustainable Mining and Communities in Ghana (Computer Science; Economics; Human Geography)</td>
</tr>
<tr>
<td>Ginger Gibson</td>
<td>PhD</td>
<td>World Bank Group Financing of the Extractive Industries (Anthropology; Anthropology)</td>
</tr>
<tr>
<td>Stephen Roberts</td>
<td>PhD</td>
<td>Building Effective Indicators of Sustainable Mine Reclamation: a Case Study of Mine Reclamation in British Columbia (Political Science; Landscape Architecture)</td>
</tr>
<tr>
<td>Carol Odell</td>
<td>MASc</td>
<td>Evaluation of the Environmental Committee Model (Geological Science)</td>
</tr>
<tr>
<td>Carolina Silva</td>
<td>MASc</td>
<td>Public Policies for Mine Waste Management Technologies (Law; Commerce)</td>
</tr>
<tr>
<td>Sonia Aredeis</td>
<td>MASc</td>
<td>Local Solutions to Water and Effluent Treatment (Chemical Engineering)</td>
</tr>
<tr>
<td>Andrew Thrift</td>
<td>MASc</td>
<td>Integrating Stakeholders Perspectives into Waste Management (Mining &amp; Mineral Process Engineering)</td>
</tr>
<tr>
<td>Claudia Sandoval</td>
<td>MASc</td>
<td>Sustainable Dredging on the Lower Caroni River, Venezuela (Chemical Engineering)</td>
</tr>
<tr>
<td>AJ Gunson</td>
<td>MASc</td>
<td>Artisanal Mining in China (International Relations; Mining &amp; Mineral Process Engineering)</td>
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</table>
SWG aspires to serve as a broker, mediator and researcher, with the ability to tackle problems not readily dealt with by mining companies and their stakeholders. With more than 12 prominent mining companies guiding the Mining Department's Industry Advisory Committee, SWG is currently building a learning and research environment to generate highly qualified people, new technologies and innovative mining practices. This multidisciplinary approach provides both a broad knowledge base and a fertile atmosphere for interaction, creativity and innovation in education and research. The creation of SWG is difficult to imagine in any organization other than a university.

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REFERENCES


