

enviromine2009

Proceedings of the

**First International Seminar
on Environmental Issues in
the Mining Industry**

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FOREWORD

The period immediately following the MMSD process, which was completed in 2002, required global mining companies and industry associations to frame a response to the resultant ten principles of sustainable development. This has meant that the face of mining has changed forever, with a strong consideration of so-called triple bottom line issues, ie, environment, social and economic (or planet, people and profit). The first Enviromine conference, as the name suggests, will focus on the first of these factors.

Mining companies are not considered by society as acceptable unless they can demonstrate commitment to more than the economic outputs from mining. Indeed, the concept of weak sustainability, ie, conversion of mineral resources in the ground into societal wealth, is now generally known and reasonably well understood when just a few years ago few people inside or outside the mining industry would have heard of it. Mining and minerals extraction is a fundamental societal process of weak sustainability. The first Enviromine conference is an opportunity for industry, consultants and academics to participate in an ongoing dialogue about the environmental aspects of mining and minerals extraction. It is highly appropriate that the conference be held in Chile as this country has been such an important part of the change to global mining practices.

A large number of both simple and sophisticated indicators of sustainability have been proposed and many mining companies have published their performance using their preferred indicators over a period of years. At Enviromine, conference participants will hear about the latest developments in indicators appropriate for Chilean and international conditions. Of critical importance is that the indicators are supported with scientific rigor and engineering excellence to ensure that they can be interpreted with confidence. Enviromine will be a venue where papers will be presented that demonstrate this necessary rigor and excellence across the full spectrum of environmental issues facing the mining industry.

Of course, environmental management is not just about industry reporting performance. It is also about understanding and developing effective regulatory governance for mining. An effective regulatory regime coupled with high quality scientific development and engineering implementation, positions industry in such a way as to grow community confidence that this new era of mining is here to stay. This is critical to the protection, maintenance and indeed growth of the social license to operate that the industry will need increasingly in the future.

Why will the need become greater? The first reason is that many countries with mineral wealth are also developing their

economies. As wealth grows so does the pressure from society to find the necessary minerals through importation rather than mining. Second, as time progresses ore quality is decreasing and so more resources, e.g., land, water and energy are required to extract the same quantity of metal. Unfortunately, at the same time, the availability of these resources is decreasing. There is more competition for water in more locations. There is a strong probability that energy supply will be constrained by carbon emissions to the atmosphere and CO₂ uptake by oceans. Therefore, for mining to maintain access to the resources necessary, environmental performance will have to become even better than today. This seems to be a very difficult requirement. A second era of minerals industry sustainability commitment will be needed for this. It must be supported by a new outlook on integration of environment into the overall mine plan. Environment as a factor added to the end of the mine planning process will not be enough. The next challenge for scientists and engineers is to define this integration and to develop practical tools for industry that can be applied effectively. The challenge for industry is to avoid complacency as a result of the tremendous progress since 2002 and ensure progress is not halted by lack of resourcing for innovation for the next phase of changes.

It is our belief that Enviromine is an important part of this ongoing journey. We believe that the papers and speakers at Enviromine will rise to this challenge and demonstrate global leadership of the mining industry in facing these very serious challenges. We hope you enjoy the conference and even more, find long term value in the papers that have been published in this volume.

Chris Moran and Jacques Wiertz

Editors

ENVIROMINE 2009

PREFACE

The growing expectations of the community for environmental protection, more demanding environmental regulations and competing land use represent important challenges for the viability of mining activities. In response to these concerns, mining industry has introduced management policies and practices and adopted technologies to reduce and minimise environmental impacts of mining operations.

The correct prediction, prevention and control of environmental impacts of mining operations require the design and development of new methodologies and innovative technologies. Even though significant effort has already been undertaken by most operators, there is a need for constant improvement of environmental management throughout the mine life cycle, from the design stage to closure.

Sustainability and environmental design of mining projects, risk assessment, impact assessment and forecasting, best environmental practices, sustainable water management and effluent treatment, remediation and rehabilitation of minesites and social issues are the main topics discussed in the papers found in these proceedings.

Thanks to the contributions of authors from fifteen countries, forty six peer-reviewed technical papers and six keynote addresses are included in this publication. Enviromine 2009 Seminar reflects the efforts undertaken by the mining industry to strive for more sustainable mining and metallurgical processes. It should be of interest to all the professionals involved in the design and operation of mining projects and, in particular, to those committed to adopting better environmental practices.

ACKNOWLEDGEMENTS

We are excited to initiate this year the series of Enviromine seminars and especially proud to host the first one in Chile. Producing such a complex event has been a rather challenging task which has required a lot of disciplined effort from many people. This Seminar would not have been possible without all those people who have put in long hours of hard work, dedication, energy and talent. We thank them most sincerely for their contributions of time and expertise to this project. Our heartfelt appreciation goes to:

- Mr. Igor Gonzales, Seminar Chairman, for his great enthusiasm and continuous support, despite his very busy agenda.
- The authors for their invaluable contributions, monumental efforts of meeting deadlines, and willingness to travel across the world in order to share their knowledge and experience. With your exceptional articles we were able to bring the latest environmental developments in mining to Chile. All papers in these proceedings were peer-reviewed, and we thank the authors for the willingness to invest their personal time and correct the articles, providing insightful comments thus ensuring the quality of this publication.
- The following sponsors for their generous support:
PREMIUM SPONSOR: *Barrick*; GOLD SPONSOR: *Golder Associates*;
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INSTITUTIONAL SPONSORS: *Consejo Minero, Fundación Chile, PDAC, SONAMI and Women in Mining*.
- The following media partners for their assistance in promoting the Seminar and bringing the updated information to you in a timely manner: *Area Minera, Business News Americas, Commodity, Ecoamérica, Gestión Minera, IMPC, MEI, Minergía, Nueva Minería and Panorama Minero*.
- The Gecamin team for their meticulous planning, hard work, professionalism and continuous commitment to making this Seminar a success.
- The staff of the Sustainable Minerals Institute, and especially Chris Moran, for sharing technical expertise and providing thoughtful insights on various organisational issues.
- Technical and Advisory Committees for their helpful advice and assistance in promoting the Seminar.
- And to you, readers and participants, whose interest and enthusiasm made this event possible and the whole experience extremely rewarding and enriching.

We truly hope that with your support the Enviromine seminar series will become a wonderful long-lasting tradition.

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ENVIROMINE 2009 Seminar is organised by Gecamin and the Sustainable Minerals Institute of the University of Queensland, Australia

Gecamin

Gecamin is a private company founded in 1998 in Santiago, Chile, with the purpose of designing, planning and producing technical events focused on technology innovations and process management in the mining and metallurgical industry. Gecamin strives to produce high quality events that position Chile as a centre of excellence for meetings on mining related topics.

Gecamin is committed to efficiently serving the mining professionals by constantly monitoring the industry trends, detecting and satisfying the clients' needs of technical knowledge exchange, through organising events that meet their highest expectations. This commitment is sustained through a quality management system based on the international ISO 9001:2000 standard.

Gecamin's events are primarily focused on technological innovations in the following areas:

- Environmental and social impacts of mining activities
- Mine closure
- Water in mining
- Automation and control
- Mineral processing
- Hydrometallurgy
- Geology and geostatistics
- Mine and plant maintenance
- Paste and thickened tailings
- Solvent extraction
- Pyrometallurgy.

Gecamin annually organises various international technical conferences, courses and seminars with attendance averaging 300 delegates each. The events calendar can be found at www.gecamin.cl

Sustainable Minerals Institute

The Sustainable Minerals Institute (SMI) has over 40 years experience in minerals research, education, consulting and commercialisation. SMI's disciplinary roots lie in production, environment, people and we have the range required for serious sustainability research. The Institute consists of approximately 250 staff across six inter-related research centres dedicated to integrating research in mining engineering, geology, water, health

and safety risks, mined land rehabilitation and environment, social responsibility and community relations. The SMI is an initiative of industry, the University of Queensland and the Queensland State Government to boost capacity in research and education in sustainable development in the minerals sector. The SMI has grown strongly since its creation by generating new ideas, engaging industry in resourcing research and delivering relevant outcomes.

The vision at SMI is to be the research and delivery institution that companies, governments and research providers acknowledge as the first port of call in minerals sustainable development issues. SMI strives to be an innovative, respected and valued collaborator, as a provider of sound advice from strong disciplinary bases and grounded in site knowledge. SMI has an outstanding portfolio of research and an enviable education capability in sustainable development issues for the minerals industry.

The SMI has activities across a breadth of issues relevant to the Australian and international minerals industry. SMI engages with the industry and government at different levels, including the operating level of industry for research which is directly relevant to operational efficiency and process improvement; and senior executives in industry and government on the major challenges looming for the industry. The SMI has been consistently strong in research delivery in an industry environment. SMI also conducts postgraduate research at Masters and Doctorate level, Certificate, Diploma and Masters qualifications by course work, short course and workshop programmes and contributions to undergraduate education.

Through their training and outreach arms (*ACMER and JKTech*), SMI is renowned for world-class, globally delivered professional industry training. This is yet another form of ongoing engagement and consultation directly with industry participants that maintains SMI's research at the cutting-edge and increasingly relevant to the minerals industry.