

# ADDRESSING ACID DRAINAGE IN THE AUSTRALIAN MINERALS INDUSTRY<sup>1</sup>

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**Abstract.** The national survey of the extent of acid drainage (AD) conducted in 1997 confirmed that AD was a significant environmental issue for the Australian minerals industry. The recommendations arising out of that survey served as a basis for actions by government, industry, industry-support organisations such as the Australian Centre for Minerals Extension and Research (ACMER) and other research organisations to enable more effective prevention and management of AD.

This paper documents the extent of AD in the industry, the government regulations and guidelines for AD management, industry initiatives, the role of ACMER and other organisations in assisting industry through research and technology transfer, and the efforts being made to deal with AD at abandoned mines.

Management of AD in the industry is being assisted by the linkage of Australia (through ACMER) into the International Network for Acid Prevention (INAP) Global Alliance which is facilitating the interchange of knowledge on AD as well as coordinating global research on the topic.

**Additional Key Words:** regulation, research, technology transfer, abandoned mines.

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## **Introduction**

Australia is mineral-rich with a great diversity of mineral deposits and is among the world's top six producers of black coal, bauxite, copper, diamonds, gold, iron ore, lead, nickel zinc, mineral sands and uranium. Thus it is not surprising that mining and mineral processing make a major contribution to the Australian economy, with exports valued at A\$67,400 million in 2004/2005 representing 42% of the country's merchandise exports.

Although the total area of the Australian landscape disturbed by mining is relatively small (<0.05%) compared to that devoted to cropping and grazing ( $\approx 60\%$ ), the potential for local severe environmental impacts on land resources can be high, particularly with the increasing trend to larger mines. Impacts from acid drainage (AD) (also referred to as acid mine drainage or acid rock drainage) have been, and continue to be, a significant issue for the minerals industry in Australia.

Collective government and industry recognition of the importance of AD as an environmental issue for the industry came in 1992 with the first national workshop on the topic. Subsequently, a systematic survey of the extent of AD in the Australian minerals industry was initiated by the Commonwealth Department of the Environment, Sport and Territories and the Australian Centre for Minesite Rehabilitation Research (now the Australian Centre for Minerals Extension and Research (ACMER)) in 1996. This study was undertaken by the Australian Nuclear Science and Technology Organisation (ANSTO) with the support of the minerals industry through the Minerals Council of Australia (MCA) (Harries, 1997). At the 6<sup>th</sup> International Conference on Acid Rock Drainage (ICARD), Bell (2003) reviewed the actions undertaken by government, industry and industry-support organisations to address the AD issue following the national survey in 1996.

This paper briefly documents national progress since 2003 on government regulations and guidelines for AD management, industry initiatives, research and technology transfer to assist the industry to address AD, and the initiatives being undertaken to deal with AD at abandoned mines.

## **Government Regulations and Guidelines for Prevention and Management of Acid Drainage**

The status of legislation covering the prevention and management of AD in Australian States, discussed by Bell (2003), has changed little in 3 years, with most States not having specific legislation to deal with AD, which is covered within various Mining, Environmental Protection and Contaminated Site Acts. Some States have technical guidelines on environmental management in mining, within which are specific sections on prediction, management and treatment of AD.

At the Fifth Australian Acid Mine Drainage Workshop, organised by ACMER in 2005, regulators pointed to the lack of standard protocols across States for evaluating the risk of AD in proposed mines.

## **Industry Response to the Challenge of Managing Sulfidic Wastes**

In 2004, the Minerals Council of Australia (MCA), launched “Enduring Value” the Australian Minerals Industry Framework for Sustainable Development, which builds upon the Australian Minerals Industry Code for Environmental Management first introduced in 1998. Put simply, Enduring Value signifies the commitment of the member companies of MCA, which produce in excess of 85% of Australia’s mineral production, to contributing to the sustained growth and prosperity of current and future generations through the integration of economic progress, responsible social development and effective environmental management (see <http://www.minerals.org.au/enduringvalue>).

Enduring Value provides an operational framework for the 10 sustainable development principles adopted by the International Council on Mining and Metals (ICMM) in 2003. Principle 6, which states “Seek continual improvement of our environmental performance” have five elements, several of which have particular relevance to the management of sulfidic wastes.

To meet legislative requirements and the commitments of Enduring Value, the larger companies are conducting in-house research and sponsoring research organisations to develop better methods of (1) characterisation of the potential of mine wastes to produce AD, (2) cover design for long-term containment of sulfidic materials, and (3) cost-effective treatment of existing AD.

### **Research**

A description of all relevant research is not possible in an overview paper such as this, but brief mention will be made of some of the more substantial research, which has been conducted since that discussed at the 6<sup>th</sup> ICARD (Bell, 2003). Much of this research was reported on at the Fifth Australian Acid Drainage Workshop held in Fremantle, Western Australia, from 29 August to 2 September 2005 and for which Proceedings are in preparation.

**Prediction of AD Potential.** A 6-year industry- and government-sponsored Australian Minerals Industry Research Association (AMIRA) project conducted by the University of South Australia, Adelaide, and Environmental Geochemistry International (EGI), Sydney, has evaluated (1) the accelerated (peroxide) oxidation net acid generation (NAG) test reactions and the surface and bulk oxidation mechanisms in different geochemical waste types, (2) the kinetic NAG test for predicting the kinetics of sulfide oxidation and acid generation, (3) potential kinetic control factors, and (4) extending the short-term AD assessment tests to longer-term estimates of acid production and neutralisation potential. This research, which has been led by Prof R. Smart and Dr R. Schumann at the University of South Australia in association with Dr S. Miller at EGI, has resulted in a set of experimental methods for classifying the geochemical reaction characteristics of different waste rock samples and their acid forming (or non-acid forming) behaviour (ARD Test Handbook, <http://www.amira.com.au/>).

Other research, related to prediction, includes that involving Dr J. Bennett and colleagues at ANSTO Minerals on (1) the development of a meter to rapidly measure the intrinsic oxidation rate of sulfidic materials in the laboratory, (2) the prediction of the physical and geochemical behaviour of waste rock dumps using the SULFIDOX model, and (3) the International Network for Acid Prevention (INAP) Scale-up Project at Diavik, Canada, which aims to gain a better understanding of the relationships between current techniques at various scales used to predict poor quality drainage from waste rock. In this project, ANSTO is working with the University of

Alberta, the University of British Columbia, and the University of Waterloo (see <http://www.anstominerals.com/>).

Assistance for mining companies in characterisation of the AD-generating potential of wastes is also being provided by the recent development of the RISATECH™ portable sulfide-sulfur analyser (<http://www.risatech.com/>) by Mr P. Scott and Mr D. McConchie.

In consultation with industry, ACMER has developed a project entitled “Standard Protocols for the Long-Term Prediction and Monitoring of Mine Lake Water Quality” which particularly addresses sites with potential AD and which will involve ANSTO, CSIRO and University of Western Australia staff.

Prediction of sulfide oxidation at circum-neutral pH in arid environments, where wetting of wastes is episodic, is being investigated by Dr C. Hinz and students at the University of Western Australia.

Management. As reported at the 6<sup>th</sup> ICARD (Bell, 2003), in much of mainland Australia, conventional oxygen barrier covers for sulfidic waste are generally not as effective as those in humid climates, because evaporation greatly exceeds rainfall leading to drying of compacted layers. A number of companies are conducting on-site research to determine the most effective cover systems for their operations with the aid of research organisations and consultants. Programs for coal (Garvie et al., 2003), iron ore (O’Kane and Waters, 2003), and metalliferous operations (Williams et al., 2003), reported upon at the 6<sup>th</sup> ICARD, are being continued to enable longer-term data on cover performance to be obtained. A feature of some of this research is the collaborative involvement of Canadian scientists, Mr M. O’Kane and Prof W. Wilson, who have considerable experience in cover design in North America.

Issues and research related to the design of store-release covers for mines in the semi-arid and arid regions of Australia, particularly Western Australia, have been reviewed recently by Campbell (2004).

A key input to cover models is the water use by vegetation, and currently there is a dearth of relevant data on the water use and extraction patterns by Australian native plants. In 2004, with funding from individual mining companies and INAP, ACMER commissioned researchers at the University of Queensland to review current knowledge on water use by native plants as a precursor to the commencement, in 2005, of a 3-year industry-sponsored project entitled “Designing Effective Store-Release Covers for the Long-Term Containment of Mine Waste – The Role of Vegetation (Stage 2)” which involves researchers from the University of Technology Sydney, the University of Queensland and the University of Western Australia.

Treatment. A range of active and passive treatment technologies are being tested and routinely used in treating acid and metal-containing drainage at mine sites in Australia. Dr J. Taylor, Earth Systems Pty Ltd, reviewed these at the Fifth Australian Acid Drainage Workshop (2005) and will be reporting on some of the current research by his organisation at the 7<sup>th</sup> ICARD.

#### Technology Transfer

An important consideration in ensuring mining companies are using leading practice in the prevention and management of AD is the dissemination, to all sections of that industry, of existing best practice technologies and the results of recent research.

ACMER. ACMER has an active technology transfer program covering the full spectrum of environmental and social issues affecting the minerals industry from exploration to operation and closure. In 2004, the Centre signed a contract with MCA to expand its technology transfer program to embrace the practical application of the Australian Minerals Industry Sustainable Development Framework through both accredited and non-accredited courses with flexible delivery.

ACMER short courses and workshops, which are conducted at a wide range of locations around the country, attract a mix of industry, government, academic, consulting and community personnel; a number of these courses/workshops are solely or partially devoted to AD issues.

Since organising the 6<sup>th</sup> ICARD in association with the Australasian Institute of Mining and Metallurgy (AusIMM), ACMER has organised 12 short courses (SC) or workshops (W) solely or partially devoted to AD at various locations around the country. In 2005, these included –

- Practical Monitoring for Improved Environmental Management (SC);
- Challenges to Establishment of Sustainable Ecosystems on Mined Lands across Diverse Biogeographic Zones (W);
- Sustainable Mine Closure – Fact, Fiction or Financial Liability? (W);
- Fifth Australian Workshop on Acid Drainage (W); and
- Environmental Management for the Minerals and Quarrying Industries (SC).

The Fifth Australian Acid Drainage Workshop, which was sponsored by INAP, had 31 presentations on topics covering prediction, management and treatment of AD. The scene for the workshop was set by Mr P. Dowd, Vice-President Australasian Operations and Managing Director of Newmont Australia Limited, who spoke on “The Business Case for Prevention of Acid Drainage”, which clearly showed, through case studies, how substantial liabilities for treatment of AD can be avoided when companies focus on prevention of AD through best practice mine planning.

The workshop provided the opportunity for two initiatives, viz. (1) assessment of the national progress in the characterisation and management of acid sulfate soils (ASS) and the relevance to AD characterisation and management in the minerals industry, and (2) involvement of workshop attendees (105) in a closure-plan “hypothetical” for a site having major AD issues and for which considerable data was available.

Invited papers from representatives of governments in Queensland (Mr C. Ahern) and Western Australia (Mr S. Appleyard and Mr R. Kay) documented how the issue of ASS, in coastal zones of Australia affected by agricultural and urban development, is being addressed (National Working Party on Acid Sulfate Soils 2000; and <http://www.deh.gov.au/coasts/cass/index.html>). A major outcome of the activities of a National Committee on Acid Sulfate Soils (NatCASS) has been the development, in 2004, of national guidelines (Australian Standard AS 4873) for laboratory methods for characterisation of ASS. Additionally, an Acid Sulfate Soil Technical Manual, providing soil management guidelines, has also been produced.

At the workshop, Dr S. Dobos, Consultant, assessed the common links between acid mine drainage issues and those encountered with acid sulfate soils, and pointed to the need for national

guidelines for characterisation and management of acid mine drainage to be developed with the involvement of regulators, industry personnel, researchers and consultants.

ACMER proposes to facilitate the development of national guidelines with the involvement of groups such as NatCASS. Such a development in Australia would complement the proposed development of a global Guide for the Prediction, Prevention and Mitigation of Neutral and Acid Drainage from Sulfidic Wastes by INAP.

Australian Government. The Australian Government Department of the Environment and Heritage (DEH), together with the Australian minerals industry, produced 24 booklets on Best Practice Environmental Management in Mining over the period 1995 to 2003 (<http://www.deh.gov.au/settlements/industry/minerals/booklets/index.html>). One of these booklets is Managing Sulphidic Mine Wastes and Acid Drainage (1997). The booklets, including the latter, are to be progressively revised, and a Steering Committee consisting of representatives of the Ministerial Council on Mineral and Petroleum Resources (MCMPR), MCA, ACMER and NGOs has been established to oversee the new program (Leading Practice Sustainable Development Program) which will embrace social as well as environmental issues.

During 2003-2004, the Australian Government funded an Innovation Access Program grant to the Northern Territory Minerals Council for a collaborative project with the Northern Territory Government, Mines and Petroleum Management Division, to identify the best technologies for environmental management of mines in a monsoonal environment (Northern Territory Minerals Council (Inc.) and the Mines and Petroleum Management Division of the Northern Territory Government 2004). An outcome of the project was the development of a toolkit addressing many aspects of AD prediction, management and treatment (<http://www.ntminerals.org.au/> or <http://www.acmer.com.au/publications/other.html>).

AMIRA. As mentioned above, the results of research on AD prediction from industry-sponsored research on methods for classifying the geochemical reaction characteristics of waste rock samples and their acid forming potential is listed as the ARD Test Handbook on <http://www.amira.com.au/>.

### **Management of Acid Drainage on Abandoned Mines**

An abandoned site is an area of past mining activity where closure is incomplete and for which the title holder still exists; the term orphaned site is used for an abandoned mine for which a responsible party no longer exists (Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia, 2000). For simplicity, the term abandoned mine will be used here to cover both categories.

Because of the long history of mining in Australia (over 150 years), there are numerous abandoned sites, many of which generate AD. Bell (2003) documented government action to deal with four of the major AD-generating abandoned mines in Australia. State Government attempts to deal with these abandoned mines, particularly those producing AD, are being assisted by involvement of major consulting firms and by research on abandoned sites being conducted by some universities (e.g. by Assoc Prof B. Lottermoser at James Cook University).

In 2003, at the suggestion of MCA, ACMER organised a national workshop on the Management and Remediation of Abandoned Mines (Bell, 2004) which summarised the status of State Government initiatives to address the problems of abandoned mines. An outcome of this

workshop has been the establishment, in 2005, of an Abandoned Mines Working Group by the MCMPR; this group, which has representatives of State Government Departments from major mining States, the Australian Government Department of Industry, Tourism and Resources, and ACMER, will address issues which are impediments to abandoned mine rehabilitation.

In 2005, the MCA also developed a policy on abandoned mines, and this has the potential to facilitate industry-government collaboration in addressing this issue.

### **INAP Global Alliance**

ACMER, along with the Mine Environment Neutral Drainage (MEND) program in Canada, the Acid Drainage Technology Initiative (ADTI) in the USA, and the Partnership for Acidic Drainage Remediation in Europe (PADRE), is a member of the Global Alliance of INAP. The network facilitates linking of regional activities, coordination of technology transfer, and identification of research needs associated with acid drainage issues. Management of AD in the Australian minerals industry has been assisted through the sponsorship by INAP of AD workshops and AD-related research. Involvement of ACMER in the INAP initiative to produce a global AD guide will also assist in a move to gain acceptance for national guidelines on characterisation of potentially AD-producing wastes in Australia.

### **Conclusions**

AD continues to be a significant issue for many sectors of the Australian minerals industry, and for government bodies with the responsibility for regulation of the industry and for the rehabilitation of abandoned mines. Industry-sponsored research, and technology transfer activities by government and organisations such as ACMER, are assisting the industry not only to prevent AD in new mines through better planning and application of new technologies but also to remediate existing AD.

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