

## Acid Rock Drainage Challenges and a Path Forward

Terrence CHATWIN<sup>1</sup>, Dean WILLIAMS<sup>2</sup>, Mike CREEK<sup>3</sup>

<sup>1</sup>INAP, 2105 Oneida Street, Salt Lake City, UT 84109, USA, [tchatwin@inap.com.au](mailto:tchatwin@inap.com.au)

<sup>2</sup>Kinross Gold, 5370 Kietzke Lane, Suite 102, Reno, NV 89511, USA, [dean.williams@kinross.com](mailto:dean.williams@kinross.com)

<sup>3</sup>Newmont Mining, 1393 Royal Crest, Elko, NV 89801, USA, [mike.creek@newmont.com](mailto:mike.creek@newmont.com)

**Abstract** Acid Rock Drainage (ARD) is one of the most serious and long-lasting environmental problems of the mining industry. To address these problems, INAP, a network of international mining companies, has prepared the GARD Guide, a best practices guide for the prevention of ARD. This guide is found on the internet at [www.GARDGuide.com](http://www.GARDGuide.com), and is free for use by all mining stakeholders. INAP's approach to meeting this challenge is through teaming with partners across the globe and adapting the GARD Guide to meet the specific needs of all stakeholders. Finally, INAP plans to publish case studies of current mining practice that demonstrate ARD prevention.

**Keywords** ARD, GARD Guide, best practices, internet based, ARD prevention, case studies

### Introduction

Acid rock drainage (ARD) is one of the most serious and potentially enduring environmental problems of the mining industry. While most mines do not have an ARD problem, the few that do represent a significant liability for their owners as indicated in many of their financial disclosures. Unchecked, ARD can result in such extensive water quality impacts that it could well be this industry's most harmful legacy. Effectively preventing acid drainage is a formidable challenge for which applying best management practices early in the mining process has demonstrated success.

While not every old mining site has ARD, the Global legacy mining sites where ARD is an issue have created a difficult public image problem for the mining industry. To overcome this image the mining industry needs to differentiate between the mining companies of the present with those of the past. We need to continue to enhance and standardize our methods to characterize mining wastes and strengthen our models and tools to predict the potential generation of ARD. With this information, we can assure that appropriate mitigation measures are applied to potential acid

generating (PAG) wastes. With relevant monitoring we can continue to measure and improve our methods to prevent ARD.

In 2009, INAP published a best practices guide (INAP 2009) designed to prevent ARD. This guide is located on the internet at [www.gardguide.com](http://www.gardguide.com); it includes a discussion of the chemistry and physics of ARD formation and current characterization, prediction, prevention, mitigation, treatment and monitoring methods to help in the prevention of ARD. It is available for use by all.

We need to demonstrate that not only do we have the methods and resources to mine in a manner that mine wastes do not generate ARD, but that we are committed to achieving this goal. INAP believes that the mining industry has the best practices as set forth in the GARD Guide to demonstrate ARD prevention. Consequently, we need to develop a large compendium of case histories to justify this claim. This compendium of case studies will be one of INAP's upcoming projects. Each of these acts INAP performs is based on joint commitment of its members to the sustainable development of the mining industry. We believe that mining not only creates resources for the

world economy and value for the companies and its stakeholders, but it can create value for all if it is done in a sustainable manner.

### What is INAP?

The International Network for Acid Prevention (INAP) is an industry-led network created to help meet this challenge. INAP fills the need for an international body to mobilize information, experience and resources to prevent and address ARD. The network was created in 1998 to coordinate and facilitate global research on the management of mine wastes and the prevention of acid drainage. Since then, INAP has become a proactive, global leader in this field.

Two primary approaches that INAP uses to meet this objective are

1. planning and implementing cost-effective collaborative research to develop solutions for ARD issues and
2. information and knowledge transfer to all mining industry stakeholders across the globe.

INAP has been very effective in directing and funding applied research relating to ARD prevention. While INAP funding support is limited, we do have tools that make INAP research support extremely effective. The collaborative nature of INAP ARD research is key, based on the review and vetting of INAP research projects by multiple mining companies, whose experience, understanding and research needs are very broad. In this network, each research project has a project champion, typically from the INAP Operating Committee, who is responsible to assure that project stays on schedule and meets project objectives. In addition, we have many potential demonstration sites whose characteristics can fit research project needs. Because of the INAP network knowledge and understanding, our seed funding can be very effective in generating collaborative funding. Other funding agencies know that INAP's strong technical presence, our commitment of company champions and our

review and vetting of project plans, design and progress enhances the potential for program success. INAP member companies and partners are pleased with the successes of our research program.

### Global Alliance

To expand local engagement in the diverse mining regions across the globe INAP has supported the formation of the Global Alliance (GA). This is a network of regional organizations whose expressed purpose is to mitigate and prevent ARD. Currently, the GA is composed of eight regional groups located in:

- Australia – SMIKT, Sustainable Mining Institute – Knowledge Transfer
- Canada – MEND, Mine Environment Neutral Drainage
- China – CNAMD, Chinese Network for Acid and Metalliferous Drainage
- Europe – PADRE, Partnership for Acid Drainage Remediation in Europe
- Indonesia – INAD, Indonesian Network for Acid Drainage
- South Africa – WRC, Water Research Commission
- South America – SANAP, South American Network for Acid Prevention
- United States – ADTI, Acid Drainage Technology Initiative

Other regions and countries have expressed interest in participating in the GA.

### ICARD

Since its founding, INAP has acted as the virtual home of the International Conference for Acid Rock Drainage (ICARD). The most recent ICARD was held in Ottawa, Canada and was extremely successful with over 500 people in attendance for the courses, presentations and tours. In addition, INAP held a Path Forward Symposium to share innovative technical developments and concepts that related to the mitigation of ARD and its effects. Over 90 ARD practitioners participated in the symposium.

Seventeen innovative technologies and ideas were presented in a plenary session. Four focused discussion groups on (Biogeochemistry, Waste cover design, Innovative treatment technologies and Stakeholder engagement) and two additional plenary sessions were held to vet and expand the ideas presented. Results were forwarded to INAP for its consideration. A summary of the Path Forward was distributed to all attendees.

### **GARD Guide**

In 2009, INAP commissioned and published a best practice guide (INAP 2009) aimed at the identification and avoidance of potential ARD as well as addressing its management and treatment, which is found on the internet at [www.gardguide.com](http://www.gardguide.com) and is available free to all mining industry stakeholders. Since the publication of the GARD Guide, the eleven chapters of the GARD Guide have received over 700,000 total hits, for which a very focused and technical document; it has exceeded INAP's expectations. More details on the GARD Guide are found in a paper published in *Mine Water and the Environment* (Verburg *et al.* 2009). When INAP published the GARD Guide our purpose was to engage as many mining industry stakeholders as partners in its application and promotion. We were extremely pleased when the Global Alliance members volunteered to organize and teach short courses on the GARD Guide. Since that time, we have had numerous short courses and presentation on the GARD Guide in the USA, Australia, Canada, Brazil, Chile, Germany, Sweden, Indonesia, China, South Africa and Turkey, with most of the organization and instruction being performed by GA members.

Global Alliance members have also been instrumental in the translations of sections of the GARD Guide into relevant languages of their regions. The GARD Guide executive summary was translated into Spanish by Patrick Williamson, of SRK and ADTI, and into French by Gilles Tremblay, of MEND. Golder Associates and others in Turkey are presently trans-

lating the GARD Guide executive summary into Turkish and are planning to seek membership in the GA.

Beside the Global Alliance, other partners are assisting INAP to promote the GARD Guide. The US Environmental Protection Agency (EPA) has borrowed a large section of the GARD Guide and translated it into Spanish and attached the translation as an appendix to the mining guidance document they prepared for Central America under the Central American Free Trade Act (CAFTA; EPA 2012). EPA also sponsored a webinar focused on technical resources relating to mitigating environmental issues caused by mining. A section of this webinar covered the GARD Guide and was presented on June 13, 2012 by Carol Russell, of EPA and ADTI.

In discussions with International Finance Corporation (IFC), INAP has learned that IFC will be referencing the GARD Guide in their future mining guidance for projects funded by their organization. In the past, INAP has reviewed and commented on IFC mining guidance documents, and we are pleased with this development. INAP is currently in discussions with the US Forest Service (USFS) concerning how INAP might assist the USFS in their training relating to mines on Forest Service land.

In addition, the GARD Guide is also being taught on the internet by EduMine. Over the past two years, the GARD Guide course has been taken by over 300 students. INAP is also discussing with the University of British Columbia and the University of Arizona the possibility that the GARD Guide internet course be included in their mining certificate programs.

### **Path Forward**

INAP is pleased with the reception the on-line GARD Guide has received, but we recognize the need for broader adoption of the practices within the GARD Guide. Our outreach efforts are focused on two diverse populations. First, we want to increase the awareness of the GARD Guide among technical disciplines in

the mining industry. Second, we want to improve the level of understanding in this issue by external stakeholders, such as community leaders, who are interested and concerned about the mine plans and issues but may not have the technical training necessary to fully comprehend the GARD Guide.

### ***Broader technical engagement***

INAP wants broader technical engagement and understanding of the GARD Guide by geologists, materials handling designers, mining engineers and planners. The better engineers, designers and planners understand the GARD Guide and the ARD management plan – the more effectively ARD prevention will be implemented. The ARD management plan, which is the keystone of effective ARD prevention and application of the GARD Guide, is often based on the work of the mine planner.

During exploration, determining the volume, grade and location of the ore are critical, but characterization of the waste is also important. While ore is the first priority, wastes also need to be sampled and available for early characterization to determine potentially acid generating (PAG) materials. During the mine planning and design phase, the mine plan should address how any potentially acid generating (PAG) waste will be managed to mitigate the potential of ARD formation. This should be an integral part of the mine planning activity. It is also important that the costs of ARD management are fully captured in the mine operating budget and continually updated as the mine plan progresses. One suggestion from the GARD Guide is to develop a mine block model including PAG characterization as well as ore grade. In Chapter 9 of the GARD Guide, an illustration, of how this block model was prepared at the Mt. Milligan project, was used as an example.

As well as, geologist, mine planners and engineers, it is important for all mining and mineral processing disciplines to be engaged in addressing ARD issues. Additional processing of waste streams both solid and liquid can

result in reduction of current and future acid and metalliferous drainage. This practice can also have the added advantage of recovering saleable bi-products to mitigate the cost of sulfide waste management.

For the ARD management to be effective, full buy in by the mine operation management and staff is required. This means that during mine operations, the ARD management plan is fully implemented and integrated into the mine operations and the mine wastes are fully characterized. If this buy in occurs, it is unlikely that unidentified PAG wastes and ARD seeps are discovered during mine closure or post closure, when resources are limited and remobilization is very expensive. This situation has occurred at some of the previously closed mine sites with resulting major cost over-runs and long-lasting management commitments. An even more significant problem is that once ARD is observed it is almost assured that there will be a long-lasting and potentially perpetual water treatment effort, unless significant waste re-handling and reclamation efforts are implemented.

### ***Business Case for ARD Prevention***

Often, we hear complaints that net present value drives the postponement of the ARD preventative measures until closure because they are cost intensive and not value producing. In response, we need a stronger argument to show that less expensive preventative options could be available if they are integrated into mine operations during early planning and design. As these mitigation options are postponed some of the more effective and less costly options become no longer viable because of prior operational actions.

The ARD Management Plan and preventative actions are site specific to the operation. Hence, each business case for ARD prevention is site specific. Thus we need a general document like the GARD Guide that addresses the concerns of accountants, written so they also grasp the importance of mitigating corporate risk through ARD prevention and understand-

ing the trade offs in early waste characterization and ARD management planning. We also need to engage mine planners to develop computer programs and tools to design the mine plan not only to generate the highest net present value, but do it in a manner that also has the lowest risk profile.

### ***Community engagement***

We understand that the technical issues surrounding ARD can be daunting and misinformation difficult to overcome. For these reasons we are focused on the development of communications and guidance aimed at demystifying ARD for the lay public. We believe that it is important to have a short, simplified version of the GARD Guide that is designed for these stakeholders that explains the issues and actions in terms that are understandable to all regardless of their education or background. INAP is in the process of working with partners to design and publish a guide as described.

Since the publication and success of the GARD Guide, INAP has focused on information and knowledge transfer to match of the momentum of the GARD Guide success. In the immediate future, INAP is planning to prepare GARD Guide supplements to focus on applying its principles to relevant mining planning functions and to enhance its understanding to lay stakeholders. We will also focus on developing a compendium of ARD preventions case studies. Results of a recent strategic planning meeting propose to continue information and knowledge and to expand INAP's collaborative research efforts relating to ARD prevention.

### ***Case Study Compendia***

Generating this compendium of case history requires time as well as the consistent use of best practices by companies to mine sulfide ore bodies. The GARD Guide has only been published for four years and many of these best practices included in that document have only been developed in the past two decades. For a case study of ARD prevention to be con-

sidered of sufficient value, a demonstration of at least 10 years would be expected (Wisconsin 1997). Hence, we are presently at the point where some mining operations are demonstrating ARD prevention of this duration.

Consequently, the mining industry must continue to maintain this highly focused effort to assure that future mining does not result ARD discharges, and publish case studies of these successful operations to demonstrate that this best practice is the common practice of the industry. In addition, it is important to recognize that ARD discharge is limited to mines where potentially acid producing wastes (PAG) are generated. Hence, an ARD management plan is required only in these cases where ARD could be potentially generated and is not a uniform requirement for all mining sites. Most mines do not generate ARD discharges; hence, an ARD management plan is not required

### ***Collaborative Research***

Resulting from INAP's recent strategic planning meeting, our next research project will focus on mine waste cover design. At recent meetings including the Australian AMD Workshop in Darwin in 2011 (SMIKT 2011), the EPA Hard Rock Mining Conference in Denver in April 2012 (EPA 2012), the ICARD in Ottawa in May 2012 and the Path Forward Symposium in May 2012, there was much discussion of on the design of waste covers. A recent publication by MEND addresses waste covers in arctic regions (MEND 2012). This wealth of discussion and thought demonstrates the intense interest in cover design and stability.

### ***Conclusions***

By broadening the awareness and application of the GARD Guide across the mining industry, INAP believes that the industry will be able to demonstrate ARD management, thus lowering the risk of ARD formation and its accompanying impacts. ARD management needs the engagement and commitment of all company technical and financial disciplines for its suc-

cess. By preparing case studies that illustrate successful ARD prevention, we believe that we will be able to help counteract the negative image with which the mining industry has saddled. But this effort will require consistent and committed action by the entire industry. We also believe that a successful ARD prevention plan requires the full engagement of all industry stakeholders. INAP will continue to pursue the involvement of all disciplines and stakeholders by broadening and promoting the principles of ARD prevention presented in the GARD Guide. As stated in the beginning INAP and its members embrace sustainable development. The actions of INAP are designed not only to prevent ARD, but as part of our commitment to sustainable and responsible mining for the benefit of all of our stakeholders.

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