

Update on the Acid Drainage Technology Initiative (ADTI), the INAP Global Alliance Member Representing the United States¹

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ABSTRACT. The Acid Drainage Technology Initiative is the regional organization in the United States that is participating in the International Network for Acid Prevention (INAP) Global Alliance, overseeing the continued success of the International Conferences on Acid Rock Drainage (ICARD), held every three years. Earlier reports to ICARDs are referenced and the paper is focused on the activities over the past three years. The recent representation on the ADTI Operations Committee is covered and the statement of mutual intent signed with the Interstate Technology and Regulatory Council is covered.

The coal mining sector (CMS) website and steering committee is described as well as recently completed work on selenium, standardization of a coal overburden kinetic column test and hydrological studies in underground coal mines. Selenium research continues as well as reviews of passive treatment technologies, application of contaminant transport modeling and development of the Global Acid Rock Drainage (GARD) Guide with INAP.

The metal mining sector (MMS) organization and initial publication of the ADTI-MMS workbook volumes on basics of mining influenced water (MIW) and two additional volumes on mitigation and pit lakes that have completed consensus review for publication are covered. Three additional volumes are being drafted and publication of a standard method appendix is possible. The organization of the initial GARD guide workshop is covered as well as the scientific review team; technical programming, the university network and transfer of the website are reviewed.

Additional Key Words: International network for Acid Prevention, interstate technology and regulator council, coal mining sector, metal mining sector, GARD guide.

INTRODUCTION

The origins and previous activities of the ADTI have been presented at previous International Conferences on Acid Rock Drainage (ICARDs) in Hornberger et. al. (2000) Williams, (2003) and Van Zyl, D. J. A. (2006) and will not be repeated here. This paper will focus on the activities of ADTI since the 7th ICARD in St. Louis, Missouri, USA, in February, 2006. In

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general, the ADTI is organized in a coal mining sector, primarily in the eastern US, a metal mining sector primarily in the western US. The activities are coordinated by a joint Operations Committee including industry, both federal and state government and academic representatives as well as the Chairs of the coal and metal mining sector steering committees. The representation on the Operations Committee during 2006-2009 is summarized in Table 1, followed by discussion of the organization and activities of coal and metal mining sectors over the past three years.

Table 1. Representation on the ADTI Operations Committee for 2006-2009

Level	Representing	Name	Affiliation
Operations Committee	Chairman	Dirk Van Zyl John Craynon Charles H. Bucknam	University of Nevada, Reno Office of Surface Mining Newmont Metallurgical Services
	Secretariat	Dennis Turner Paul Ziemkiewicz	Arizona Department of Environmental Quality West Virginia University
Coal Mining Sector	Steering Committee	Eric Perry	Office of Surface Mining
	National Mining Association	Ken Johnson	Consol Energy
	Federal	John Craynon	Office of Surface Mining
	Interstate Mining Compact Commission	Roger Hornberger Keith Brady	Pennsylvania Department of Environmental Protection
	National Mined Land Reclamation Center	Paul Ziemkiewicz	West Virginia University
Metal Mining Sector	Steering Committee	Charles H. Bucknam Doug Peters	Newmont Metallurgical Services Peters Geosciences
	Industry	Charles H. Bucknam	Newmont Metallurgical Services
	Federal	David Williams	Bureau of Land Management
	State	Dennis Turner	Arizona Department of Environmental Quality
	Academic	Dirk Van Zyl Terry Chatwin Linda Figueroa	University of Nevada, Reno University of Utah Colorado School of Mines

Interstate Technology and Regulatory Council (ITRC)

ADTI signed a statement of mutual intent with the ITRC in August, 2008. The objective is to work with the States in a cooperative partnership to pursue regulatory acceptance of cost-effective treatment technologies for the prevention or minimization of adverse environmental impacts and waste production to protect human health and the environment. Linda Figueroa serves as the single point of contact representing ADTI.

INAP Global Alliance

ADTI continued to actively participate in the INAP Global Alliance in development of the GARD Guide, on conference calls and in periodic meetings with the INAP Operations Committee. Charles H. Bucknam serves as the single point of contact representing ADTI.

COAL MINING SECTOR ACTIVITIES

Organization

The Coal Mining Sector includes members from state and federal regulatory and research agencies, academia, mining companies, consultants and nongovernmental organizations. The group was organized in 1995 with the overall goal of development and use of best science practices for coal mine drainage. The ADTI coal mining sector focuses on technology development and transfer. The program does not address regulatory or policy development, as that task is outside the scope of the Coal Mining Sector's mission. The group maintains a website at www.aciddrainage.com with information on activities, goals and selected publications.

The Coal Mining Sector is guided by a steering committee composed of representatives reflecting the makeup and topical interests of the overall group. Current steering committee membership is shown in table 2.

Table 2. ADTI Coal Mining Sector Steering Committee 2009

Representing	Name	Affiliation
Chair	Eric Perry	US Office of Surface Mining
Academia	Paul Ziemkiewicz	West Virginia University
Federal	Robert Kleinmann	US Dept. of Energy
State	Greg Conrad, Keith Brady	Interstate Mining Compact Commission, Pennsylvania Dept. Environmental Protection
Industry	Ken Johnson	Consol Energy
Coal Combustion Byproducts	Kim Vories	US Office of Surface Mining
Passive Treatment	Art Rose	Retired Academic/Consultant
Technology Transfer	Jeff Skousen	West Virginia University
Underground Mines	Nick Schaer	West Virginia Dept. Environmental Protection
Water Quality	Roger Hornberger	Pennsylvania Dept. Environmental Protection (retired)/ Consultant

The Coal Mining Sector holds an annual meeting, arranged in conjunction with the West Virginia Surface Mine Drainage Task Force Symposium. The meeting is a forum for informal exchange of current activities and issues, updates and discussion of goals.

Completed Activities

After publishing two handbooks on water quality prediction and remediation at surface coal mines (Kleinmann et al, 2000; Skousen et al, 1998), the Coal Mining Sector developed a set of white papers to identify specific topics needing further attention. The white papers included coal combustion byproducts (2 subtopics), passive treatment (5 subtopics), water quality (4 subtopics) and underground mines (5 subtopics). Several projects developed from the white papers, including issues in water quality prediction, sampling and treatment, and underground mine closure. Following are brief descriptions of ADTI Coal Mining Sector related activities completed since 2006.

West Virginia University completed a study of the occurrence and distribution of selenium (Se) in coal bearing rocks in central Appalachia, USA. Selenium concentrations were found in mine drainage at values exceeding recommended exposure for aquatic life. The affected area is limited to middle Pennsylvanian rocks over a few thousand km², but contains numerous operating surface and underground coal mines. Coals and overburden rocks were characterized by total and selective extraction of Se. Selenium was found to be distributed between both sulfide and organic fractions. Coals generally contained highest Se concentrations, while sandstones had the least. Clastic rocks adjacent or near the coalbeds, often organic rich shales, usually had the highest Se content of non-coal units. The study provided characterization data needed to develop remediation and treatment options for managing Se. Details of the Se characterization study are reported by Vesper et al (2008).

The Pennsylvania Dept. of Environmental Protection, in cooperation with ADTI and other organizations, completed the development of ADTI-WP2 Leaching Column Method in 2009. The goal of this 3 phase project was to provide a standardized kinetic test method for coal mine drainage prediction. Simulated weathering tests have not been widely used in coal mine drainage prediction, in part because a variety of humidity cell and column leaching protocols are available. Consequently, uncertainty exists over technique and interpretation.

The initial phases of the leaching project evaluated several different test apparatus and leaching protocols, and ultimately selected a 14 week column leach test. The principal features of the test include a specified mix of particle size fractions, six days of weathering in humidified air, followed by one day of water saturation. The test protocol includes a significant departure from many other procedures by incorporating 10% CO₂ in the column atmosphere. The CO₂ rich atmosphere increased leachate alkalinity to concentrations similar to corresponding field samples. The test protocol and supporting documentation is under review by US EPA as method 1627, Kinetic Test Method for the Prediction of Mine Drainage Quality. A final project report was submitted to the US Office of Surface Mining and is available at <http://www.techtransfer.osmre.gov/NTTMainSite/appliedscience.htm> .

Ground water recharge rates to shallow underground mines were investigated as part of ADTI's objectives for contaminant loading and hydrologic budgets. Multi-year discharge and weather data, hydrogeologic and mining variables were evaluated. Annual mine recharge comprised about 15 to 20% of total precipitation. Recharge rates also exhibited distinct seasonality and were similar to distribution of precipitation. An inverse correlation exists between overburden thickness and recharge rate. The recharge relationships are useful for estimating contaminant loads on annual and seasonal bases for underground coal mine drainage.

On-Going Activities

Elevated Se concentration in mine water discharge is an ongoing issue in central Appalachia. Target standards for aquatic life are low, (5 µg/L aqueous, or 5.8 µg/g in fish tissue), and Se is difficult to remove from solution with conventional mine water treatment systems. Laboratory studies are investigating methods for immobilizing selenium in mine backfills. Laboratory and field studies are underway to optimize treatment and removal of Se from mine water. Field demonstration units, using zero valent iron (ZVI), are reducing selenium concentrations from about 20 µg/L to < 5 µg/L. Ongoing work focuses on optimal system residence times, media density, and hydraulics to improve efficiency and longevity of a single ZVI charge.

Other studies are evaluating the changes in drainage chemistry resulting from large mountaintop mining operations, including total dissolved solids (TDS), selenium species, sulfate, and the effects on aquatic life.

The Coal Mining Sector is supporting a comprehensive review of passive treatment technology literature for coal mine drainage. Passive treatment now includes a collection of anaerobic, aerobic, microbiological and limestone based techniques. These technologies have been applied to hundreds of coal mine discharges with a wide range of chemical composition and flow, sometimes with mixed results. The goal of the review is to provide a current analysis of coal mine drainage design criteria and expected performance of passive treatment systems.

An ongoing ADTI project is applying the contaminant transport modeling code TOUGHREACT to flooded underground coal mines. Models have been constructed to simulate the chemistry and discharge characteristics of a mine closed for over 25 years. Modeling efforts include identifying the probable mineral reactions that transformed the mine-pool from initially acidic conditions to net alkaline water, and describing ground water flow in a matrix of open voids and rubble. Calibration work is ongoing. A feasible model could be useful for planning long term management of closed, flooded underground coal mines.

The Coal Mining Sector jointly hosted a workshop introducing the draft GARD Guide to the coal industry. Coal Sector members are also providing review comments and supplemental text specific to coal mine drainage to the GARD Guide project team.

METAL MINING SECTOR ACTIVITIES

Organization

The Acid Drainage Technology Initiative Metal Mining Sector (ADTI-MMS) is a non-profit corporation registered in Colorado and the activities are managed by a steering committee that is represented by industry, federal and state governments, academia, nongovernmental organizations and the chairs and co-chairs of technical and support committees. Steering committee representation during 2006-2009 is summarized in Table 3.

Table 3. Representation on the ADTI-MMS Steering Committee for 2006-2009

Representing	Name	Affiliation
Chair	Doug Peters Charles H. Bucknam	Peters Geosciences Newmont Metallurgical Services
Vice Chair	Linda Figueroa	Colorado School of Mines
Secretary	Dennis Turner	Arizona Department of Environmental Quality
Industry	Charles H. Bucknam	Newmont Metallurgical Services
Federal	David Williams Mark Cowen	Bureau of Land Management US Army Corps of Engineers
State	Dennis Turner David Bird	Arizona Department of Environmental Quality Colorado Department of Natural Resources
Academic	Linda Figueroa Terry Chatwin Dirk van Zyl	Colorado School of Mines University of Utah University of Nevada, Reno
Non Governmental Organization	Glenn Miller Doug Peters	Desert Research Institute Peters Geosciences
Prediction Committee	David Williams Bill White	Bureau of Land Management Retired
Modeling Committee	Andrew Nicholson Rens Verburg	Geomega Golder Associates
Pit Lake Committee	Devin Castendyk Ted Eary	State University of New York MWH Americas, Inc.
Mitigation Committee	Jim Gusek Linda Figueroa	Golder Associates Colorado School of Mines
Sampling and Monitoring Committee	Virginia McLemore Carol Russell Kathy Smith	New Mexico School of Mines and Technology US Environmental Protection Agency US Geological Survey
Review Committee	Charles H. Bucknam Dennis Turner	Newmont Metallurgical Services Arizona Department of Environmental Quality
Technology Transfer Committee	Terry Chatwin	University of Utah/International Network for Acid Prevention

ADTI-MMS Workbook Volumes

The major focus of the ADTI-MMS since its inception has been to produce a workbook of technologies for the management of acid rock and metals drainage applicable to sites and operations in the US. ADTI-MMS teamed up with the Society of Mining, Metallurgy and Exploration, Inc. (SME) after the 7th ICARD to publish the work of the steering and technical committees as individual volumes as they complete consensus review in the committees and by the members of ADTI-MMS. To date, one volume has been published and two additional volumes are in final editing prior to publication as summarized in Table 4.

Table 4. Status of ADTI-MMS Workbook Volumes That Have Completed Consensus Review

Committee	Volume Title	Editors	Status
Steering	Basics of Metal Mining Influenced Water	V. T. McLemore	February 2008
Mitigation	Mitigation of Metal Mining Influenced Water	J. J. Gusek and L. A. Figueroa	May 2009
Pit Lakes	Mine Pit Lakes: Characteristics, Predictive Modeling, and Sustainability	D. Castendyk and L. E. Eary	To publish in 2009

The steering committee produced the introductory volume in order to lay the groundwork and tie together the technically focused volumes to follow. Chapters discuss ADTI, mining methods, differences between metal and coal mining and processing, causes of impacts to mining influenced waters, types of mineral deposits, phases of mining in the life cycle, types of metallurgical processing, formation of acid rock drainage, metals transport at alkaline pH and other potential environmental impacts at mining and metal processing sites. The final volume includes a glossary of terms. The volume is 109 pages and is available for \$79 at: <http://www.smenet.org/store/mining-books.cfm/Basics-of-Metal-Mining-Influenced-Water>.

The mitigation volume focuses on the avoidance and mitigation of metal mining drainage. Chapters discuss site characteristics, design and operational planning of mines and process operations, using case studies to demonstrate key aspects of the risk based approach, performance measurement approaches, process solution detoxification methods, aspects of closure and post closure land usage, source and mitigation controls, cover designs, use of amendments, treatment methods for metal mining influenced water, both passive and active, using biological and chemical methods, including examples of cost estimation and case studies. The mitigation volume will be available at <http://www.smenet.org/store/> in May 2009.

Mitigation of Metal Mining Influenced Water embraces two, sometimes overlapping, approaches to resolving environmental issues associated with MIW: *prevention* and *treatment*. There is no single strategy to completely prevent acidic MIW formation; even application of a combination of source control and mitigation techniques may only slow pyrite oxidation to manageable levels. This is the point where *treatment* technology options may be needed. Understanding the “physical environment” of mining and metallurgical processing sites is critical in designing and implementing successful mining influenced water mitigation measures. It is important to understand how the natural and human-made physical environment at mining and metallurgical processing sites in can influence MIW situations. This chapter serves as a checklist of physical elements that designers need to consider to successfully address and implement mitigation strategies after the mining or metallurgical processing site closes. Considering mining influenced water issues during planning and design is more effective than waiting until mine closure is imminent, from both a permitting and cost standpoint.

“Planning and Design Considerations” includes the evaluation of data from site exploration, materials testing, and metallurgical testing to assist in predicting potential MIW issues that could occur during operation and at closure. The issues addressed can vary with the mining method, but some issues are common to all methods. This chapter discusses

design and operational considerations relevant to open pit mining, underground mining, and in situ leaching.

“Source and migration control” is the preferred option for mitigation of metal MIW. This chapter focuses on the proven technologies that have been used to mitigate MIW in a wide range of metal mining situations. Technologies include capping and covering of tailings and waste rock, surface water diversion, underground and pit backfilling, and acid rock drainage tetrahedron–disrupting amendments. Source and migration control techniques individually or in combination, comprise the “arsenal” of MIW prevention technologies that should be deployed as the first line of defense. Treatment is the option to consider after all the practical source and migration controls have been implemented at a given site.

“Treatment of Metal Mining Influenced Water” is the longest chapter of the volume. This chapter introduces the array of technologies available as of 2003 to treat residual MIW. Selection of a given technology will depend mostly on the MIW chemistry, flow rate and available land area. These are the key factors which in combination influence the size and cost of the treatment system. The methods for mitigating MIW will continue to evolve as mining companies, regulators, researchers, and engineers publicize their successes and failures at conferences, forums, and in the technical literature. To stay current with the latest developments, practitioners are encouraged to participate in ADTI-MMS sponsored exchange of MIW mitigation experience, and attend conferences that focus on this challenging issue.

Mine Pit Lakes: Characteristics, Predictive Modeling, and Sustainability will also be published by SME in 2009. The objective of this volume is to organize and summarize the major tools, methodologies, and knowledge base necessary to forecast the water quality and hydrologic regime of future pit lakes, and to appropriately manage existing lakes. In order to produce a universal guide, the volume discusses existing pit lakes on 3 continents which have developed under both humid and arid climate regimes, and addresses the needs of both metal-mining and coal-mining operations. Twenty seven authors from Australia, Canada, Germany, and the United States contributed 24 papers to the volume. Castendyk and Eary (2009) summarize the principle findings of the volume elsewhere in the Proceedings of the 8th ICARD.

The workbook volumes that remain to be drafted and undergo ADTI-MMS consensus reviews are summarized in Table 4. The schedule established for publication through SME was approved to submit a volume every six months for completion in 2010. The steering committee is also interested in producing a final companion volume to the series which will include all of the copyrighted ASTM International standard methods and supporting methods that have been developed in cooperation with the ADTI-MMS Prediction Committee members, however a funding source of approximately \$30K will need to be found in order to cover the copyright licensing with ASTM International.

In addition to ADTI-MMS workbook production, members have been involved in the production of the INAP Global Acid Rock Drainage (GARD) Guide, serving on the steering committee, authoring some of the sections as well as helping organize and conduct the first workshop in Denver at the new offices of the US Environmental Protection Agency on October 1, 2008.

Table 5. Remaining ADTI-MMS Workbook Volumes Being Drafted for Consensus Review

Committee	Title	Responsible
Modeling	Geochemical Modeling for Mine Site Characterization and Remediation	A. Nicholson, R. Verburg and K. Nordstrum
Prediction	Techniques for Predicting Metal Mining Influenced Water	David Williams
Sampling and Monitoring	Sampling and Monitoring for the Mine-Life Cycle	V.T. McLemore, K.S. Smith, C.C. Russell, and A.R. Dickens
Steering	Standard Method Appendix	C. H. Bucknam

ADTI-MMS Scientific Review Team

In 2002, Chevron Mining, Inc. (formerly Molycorp) approached the ADTI-MMS for assistance in developing and soliciting a research proposal for the purpose of investigating the potential effects of chemical and physical weathering on the stability of rock piles at the mine. ADTI-MMS volunteers are professionally involved in environmentally sound technical management of metal-mine rock piles, tailing material, mine waters, pit lakes, and other, associated metallurgical materials and the research proposal was in keeping with ADTI's mission. To this end, ADTI – MMS formed an independent science review team that provided technical review on the progress and findings of the effects of weathering on rock pile stability research at the Questa molybdenum mine located near Questa, New Mexico. The goal of this research was to predict long-term physical stability of sulfide-bearing mine rock piles that are subject to weathering, oxidation and acid generation. This investigation was designed to examine and identify these potential effects within the span of 100 years and over geologic time (much greater than 100 years).

The project tasks included characterization (physical, mineralogy, chemistry, texture, geotechnical, hydrologic), accelerated weathering studies (humidity cells testing and modeling), geochemical and weathering rate modeling, unsaturated flow modeling, heat flow modeling, geotechnical stability modeling, and stability risk assessment. The project's overall mission was to develop a method, including modeling, for assessing the long term stability of the rock piles, based on their physical, chemical, mineralogical and weathering characteristics. The ADTI Science Review team is currently reviewing the final report produced by the project (which came to be officially known as the Questa Rock Pile Weathering and Stability Project (QRPWASP).

Twelve university teams expressed interest in the project by responding to the request for Letters of Intent. The University of Utah research consortium was selected to conduct the geologic and geotechnical studies. Utah's team consists of members from the University of Utah, University of British Columbia, University of Saskatchewan, NM Bureau of Geology and Mineral Resources, NM Institute of Mining & Technology, University of Nevada-Reno, Minnesota Department of Natural Resources, Colorado State University and selected mining and environmental consultants.

The weathering investigation project was initiated in July 2003 and funding for the project ended December 2008. Chevron Mining recognized from the start that this project was investigating a complex problem and that the outcome would be uncertain, but a commitment was made to allowing good science and sound engineering practices to develop the results.

The mine is located on the western slope of the Taos Range of the Sangre de Cristo Mountains in northern New Mexico. Elevations at the site vary from 7580 feet to 10,812 feet over an approximately six square mile area. Mining of molybdenum and production of concentrate at Questa started in 1919, first by mining the high-grade lode veins underground, followed by an open pit operation from 1964-1982, and currently by underground methods beginning in 1983. Open pit operations ceased in 1982, leaving 9 mine rock piles, some of which are 1600 ft high. Approximately 320 million tons of mine rock from the open pit operation were placed as valley fills by end dumping. Several years ago, Chevron Mining began to look at various ways to investigate short- and long-term weathering effects of the mine rock piles and slope stability issues.

Participants in the scientific review team are summarized in Table 6.

Table 6. ADTI-MMS Scientific Review Team Participants for the Questa Waste Rock Pile Project

Technical Field	Participant	Affiliation
Geology/ADTI Lead	Dennis Turner	Consultant
Geology	David Williams	Bureau of Land Management
Mineralogy/Geochemistry	Art Rose	Pennsylvania State University
Mineralogy/Geochemistry	Charles Alpers	U.S. Geological Survey
Geotechnical Engineering	Tom Kelly	Telesto Solutions
Geotechnical Engineering	Gordon McKenna	BGC Engineering

On-Going ADTI-MMS Programs

Technical Programming

ADTI-MMS sponsors at least one technical session at the SME Annual Meeting each year, which was organized by David Williams in 2007, Terry Chatwin in 2008 and Linda Figueroa in 2009. Dennis Turner and Charles H. Bucknam are organizing an ADTI session for the 2010 meeting in Phoenix, Arizona, February 28-March 3 following the theme of 100 years of mining research. ADTI-MMS has been holding an annual face-to-face meeting at the SME annual meeting on the Sunday, proceeding the sessions, after the Environmental Division Executive Committee Meeting.

University Network

ADTI-MMS maintains a mailing list of university contacts in the US and around the world to distribute e-mails from ADTI and the Global Alliance, alerting them of pertinent activities. The website has been transferred to the Colorado School of Mines from the University of Nevada, Reno, and is being rebuilt at the following location:

<http://inside.mines.edu/adti/ADTIMAIN.html>. The vision for the new website is to organize the links to university contacts in a structure that parallels the handbook areas of: Mitigation, Pit lakes, Sampling and Monitoring, Modeling and Prediction. ADTI welcomes the addition of new university contacts to ADTI-MMS. Contact Linda Figueroa at the Colorado School of Mines (lfiguero@mines.edu) to provide relevant information.

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