

## **ACID DRAINAGE TECHNOLOGY INITIATIVE: CONTINUING PROGRESS IN COAL RELATED TOPICS<sup>1</sup>**

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**Abstract.** In 1995, the U.S. Office of Surface Mining (OSM) and the National Mine Land Reclamation Center (NMLRC) joined with the Interstate Mining Compact Commission, the National Mining Association, academia, and other Federal agencies to form the Acid Drainage Technology Initiative (ADTI). The ADTI partnership seeks to identify, evaluate and develop “best science” based practices to prevent new acid mine drainage sources and eliminate existing sources. The ADTI partnership developed a management structure to oversee the program and developed action plans to address key technical areas. The ADTI organization consists of a coal mining sector, a metal mining sector and a secretariat, overseen by an Operations Committee. The coal mining sector of ADTI is divided into a prediction working group and an avoidance and remediation working group to implement and coordinate the research strategy. This paper summarizes the results of the coal mining sector efforts since the completion of the avoidance and remediation, and prediction handbooks in 1998 and 2000, respectively, and the status of current activities. The activities have included field verification of acid drainage predictions using acid-base accounting, monitoring and follow up evaluation of acid mine drainage passive and in-situ treatment systems, developing standardized kinetic testing protocols, flooded underground mine pools, and issues related to elevated selenium in streams associated with surface mines.

Additional Key Words: acid mine drainage, coal mining sector.

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## **Introduction**

### **Background**

The Acid Drainage Technology Initiative (ADTI) began in December 1995, to bring together State and Federal governments, the mining industry, academia, and others to identify, evaluate and develop cost-effective and practical acid drainage prediction, prevention and remediation technologies. Members included the National Mining Association (representing the mining industry), the Interstate Mining Compact Commission (representing the States), and various Federal agencies, including the Office of Surface Mining (OSM), Bureau of Land Management (BLM), U.S. Geological Survey (USGS), U.S. Environmental Protection Agency (EPA), U.S. Bureau of Mines, the U.S. Army Corps of Engineers (USACOE), and the Department of Energy National Energy Technology Laboratory (NETL). There are two ADTI academic centers: an Eastern University Center for the Coal Mining Sector at the National Mine Land Reclamation Center (NMLRC) at West Virginia University (WVU) and a Western University Center for the Metal Mining Center at the University of Nevada at Reno.

ADTI is an applied science and technology development program with the objective of identifying, evaluating and developing “best science” practices to remediate existing sources of problematic mine drainage and to prevent its occurrence from active and future mining. ADTI does not assume a regulatory or policy development role.

ADTI has focused on scientific and technical solutions to mine drainage quality prediction, sampling, monitoring, modeling, and avoidance and remediation in order to reduce the extent and severity of AMD problems from all sources. As there are many concurrent efforts worldwide aimed at improving the prediction, avoidance and remediation of acid drainage, ADTI seeks to find consensus among all partners on what currently constitutes the best science and technology, to coordinate acid drainage technology development, and to facilitate technology transfer of findings and recommendations.

The initial emphasis of ADTI was on acid drainage issues related to coal mining in Appalachia. However, it soon became clear that there were distinct technical issues related to metal mining in the West and elsewhere. To better address this important issue, in 1999, ADTI restructured itself into a coal mining sector (CMS) and a metal mining sector (MMS) to add a focus on acid drainage and other water quality issues related to metal mining. ADTI MMS deals

with drainage quality issues involving metal mining and related metallurgical operations for abandoned, active and future metal mines. ADTI CMS continues to focus on acid drainage and other water quality issues associated with coal mines. The organization efforts and initial activities of ADTI are discussed more fully discussed in Block et al., (2004).

#### Initial ADTI Publications and Recommendations for Future Work

The ADTI CMS's first effort was to compile the state of knowledge on technologies to predict, and to avoid and remediate mine drainage issues. The results of these efforts are found in two publications. The first, entitled, *A Handbook of Technologies for Avoidance and Remediation of Acid Mine Drainage* was published in 1998 (Skousen et al.). This handbook compiled known technologies and provided general guidance on their application and expected effectiveness. In 2000, the ADTI CMS published the second of the handbooks, *Prediction of Water Quality at Surface Coal Mines* (Kleinmann, Ed.), a compilation of predictive methods for surface mines.

Identifying technical areas needing further work is a key component of ADTI Coal Mining Sector activity. The authors of both of the ADTI CMS handbooks identified priority areas that needed to be addressed in future efforts. The priority areas identified in the handbooks have influenced the subsequent work. In the Introduction to the Avoidance and Remediation handbook, Skousen et al., (1998) identified the need for field testing of then-current technologies and the development and testing of new technologies. The authors noted that variable success in treatment was probably caused by the variability found among mines and their associated environmental conditions. An imperfect understanding of the effect of this variability on the effectiveness and applicability of treatment techniques resulted in imperfect criteria for selecting treatment technique. Long-term follow-up monitoring and analysis of water quality from these field installations will help define the limits of applicability of AMD treatment technology.

In the ADTI CMS Prediction handbook, Geidel et al., (2000), made recommendations on the use of kinetic testing methods and recommended that a standard kinetic testing method be established to be used for refined analysis of materials falling in the "gray area" of the acid base accounting (ABA) method. Follow up work in this area is discussed below.

Also in the ADTI CMS Prediction handbook, Perry (2000) identified eight "issues, opportunities and needs" to improve on the "ability to correctly anticipate, prevent, or manage

mine drainage and its effects.” These provide a very useful framework for future efforts by the Coal Mining Sector. His recommendations included:

- Improve quantitative prediction of mine drainage quality.
- Establish a consensus on kinetic test methodology, which supports the recommendation of Geidel et al., (2000).
- Evaluate the effectiveness and limits of applicability of analytical and predictive methods for post-mining and reclamation water quality through field and post-mortem studies of mine sites and water quality.
- Improve and develop technology for underground mine water quality prediction.
- Develop and test new and revised investigative and analytical techniques, such as downhole wireline logging, evolved gas analysis, and other methods.
- Compile and examine existing baseline and monitoring data from ongoing and historical mining available from companies, consultants and government agencies to refine predictive techniques.
- Examine the use of mineralogical data and geochemical modeling techniques to mine drainage prediction, as they are being applied in the hard rock mining industry.
- Evaluate the applicability of analytical tools, such as three-dimensional geologic modeling software to refine overburden volumetric analysis, and geostatistical analysis methods for detailed sampling and analysis.

ADTI CMS activities since the publication of the Prediction and the Avoidance and Remediation handbooks have begun to address a number of these issues, opportunities, and needs and are summarized below.

#### Recent and Current Work

The Coal Mining Sector continues to pursue the original priorities identified when ADTI began as well as issues that have arisen since, such as those identified by Geidel et al., (2000), Kleinmann et al., (2000) and Perry (2000), described above. A vehicle for support of ADTI CMS activities aimed at addressing these priorities is OSM’s funding of a series of cooperative agreements with the National Mine Land Reclamation Center (NMLRC) at West Virginia

University. OSM's funding has been between \$200,000 and \$250,000 per year and this funding remains an important component of support to address ADTI CMS priorities. Cooperative agreement project proposals that address ADTI CMS priorities are given preference for funding. Following is a summary of some of the tasks funded under the cooperative agreements, as well as other activities addressing ADTI CMS priorities.

#### Technical Support for Watershed Projects and Follow Up Evaluations

In order to obtain on-the-ground experience with the effectiveness and applicability of AMD remediation technologies at a variety of sites, the coal mining sector of ADTI works closely with watershed groups and others working to clean up streams and watersheds affected by abandoned mines under the Appalachian Clean Streams Program. The Office of Surface Mining and the NMLRC at West Virginia University are working through a series of annual cooperative funding agreements to:

- Provide technical assistance to watershed groups and others in the design, construction and maintenance of remediation technologies, and
- Evaluate the site conditions, technologies applied, cost of remediation and the resulting quality of water from affected sites.

As part of this task, NMLRC has been conducting an ongoing evaluation of the performance of different methods of passive treatment (e.g., aerobic and anaerobic wetlands, anoxic limestone drains, open limestone channels, limestone leach beds) used for remediation of AMD from abandoned mines. Ziemkiewicz et al., (2003), reported on the results of a comparative evaluation of nine methods. Based on this work, three methods were found to give the best performance, in terms of unit treatment cost, effectiveness of acid load removal and reliability. These were: limestone beds, anoxic limestone drains and open limestone channels (Ziemkiewicz et al., 2003).

#### Acid Base Accounting (ABA) for Prediction of Postmining and Reclamation Water Quality

ABA is an important method for predicting postmining and reclamation water quality and evaluating the potential for production of acid mine drainage. The method, developed in the

1960's and 1970's and continuously refined since (Perry, 1998), assesses the potential for the production of acidic drainage at a mine site by balancing the acid-producing and the acid-neutralizing potential of materials at a site to predict the net water quality that can be expected. (Skousen et al., 2002)

The NMLRC has been studying the effectiveness of acid base accounting for predicting postmining and reclamation water quality (Skousen et al., 2002). Overburden analyses, permit maps, and predictions of postmining and reclamation water quality data were collected from regulatory agency permit files from several states in the Appalachian coal region. Data collected from these files was used to calculate mass-weighted acid base accounting for each site. Neutralization potential (NP), maximum potential acidity (MPA) and NP/MPA ratio from each ABA were compared to alkalinity levels in postmining and reclamation water quality data. The results of the ABA analyses were found to be correct in 82% of the cases using the NP/MPA parameter; this indicates that ABA is a good way to predict postmining and reclamation water quality at a mine site (Skousen et al., 2002). More work is planned or is underway to refine this useful analytical tool.

#### In-Situ Underground Mine AMD Treatment Technology

In-situ neutralization is a relatively new concept in the field of passive AMD treatment. The addition of alkaline materials into underground mine voids and ground-water recharge areas may provide an attractive alternative to current treatment practices. These systems require limited land area and, because many of these systems are installed in areas that exclude or limit oxygen, may permit the neutralization of acid without the precipitation of metals in the system. Under this task, three in-situ treatment systems were installed in north-central West Virginia. These sites include a deep mine alkaline injection project, an in-situ limestone portal drain, and ground water alkaline recharge trenches. The performance of these systems with respect to acidity neutralized and metal removed from the discharge is being monitored. The final report on this project is pending.

#### Kinetic Test Methods

ADTI is following up on the recommendations by Geidel et al., (2000) and Perry (2000) to find a consensus on the establishment of kinetic testing protocol for evaluating potentially acid-

generating materials. There are several humidity cell methods and numerous leaching column methods that have been used to predict the quality of drainage from coal and metal mines. However, there are currently no standard methods that are widely used and accepted as accurate predictors of coal mine drainage quality by state and federal regulatory agencies or the coal mining industry. Hornberger and Brady (1998, page 7-5) state — "A tremendous amount of kinetic test information now exists, but the variety of test apparatus and procedures in use is so great that it is very difficult to interpret the results and make meaningful comparisons of data from different studies in similar or different lithologic settings[.] \*\*\* [I]t should be no wonder that mine operator and consultants new to the subject of AMD prediction would shy away from kinetic tests because they don't know which apparatus or procedure to use, nor how to interpret the results." In order to rectify this problem, OSM funded a project to:

- develop standard procedures for a humidity cell test and a leaching column test that will meet the U.S. Environmental Protection Agency (EPA) requirements for performance-based measurement systems (PBMS) methods specifications, and
- improve existing humidity cell and leaching column test methods by maintaining a carbon dioxide enriched gas environment throughout the test to simulate the partial pressure of CO<sub>2</sub> normally found in soils and spoil gas environments. This is needed to optimize carbonate mineral dissolution and the production of significant alkalinity concentrations in ground water, mine drainage discharges, or leachate in laboratory tests used to predict mine drainage quality.

The status and results of this project are discussed in detail in Hornberger et al., (2004) presented at this meeting

### Selenium

Selenium is a naturally occurring widely distributed element, which shows an affinity for sulfide minerals. It combines with metals and non-metals and may form both organic and inorganic compounds. Selenium is the most strongly enriched trace metal in coal, and can occur in several forms in solution. Selenium discharges that exceed water quality standards have been identified in several coal mine watersheds in southern West Virginia. It is suspected that these

Se concentrations are the result of leaching of selenium compounds in coal and overburden exposed to oxidizing conditions during mining activities in this region.

OSM is funding NMLRC to evaluate overburden cores from mined areas within a Se-impacted watershed of southern West Virginia. NMLRC will develop methods for the identification of selenium within the overburden and coal seams in this area and will examine cores for Se sources and mineralogy. In addition, NMLRC researchers will collect high-Se discharges from the affected areas and conduct bench-scale experiments to determine possible methods for avoidance and/or remediation of Se contaminated discharges. Experiments to evaluate potential techniques to avoid or limit Se mobilization will include leaching Se-source geologic materials along with absorptive materials, such as shale or fine-grained soils to determine absorptive potential of Se within the backfill of surface mines.

### **Summary**

The above described ADTI activities continue to address CMS priorities, and progress is being made in most of the priority areas. The CMS has recently met to take stock of the current status of progress in addressing existing priorities and to identify new priority areas. The future direction and priorities of the CMS is discussed in detail by Craynon (2004), a paper in this ADTI session.

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