

CHARLIE FITTS

Fitts Geosolutions, LLC
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EDUCATION

Ph.D. Civil Engineering, University of Minnesota, Minneapolis, MN, 1990

M.S. Civil Engineering, University of Minnesota, Minneapolis, MN, 1985

M.S. Geological Sciences, Cornell University, Ithaca, NY, 1979

B.A. Geology/Biology, Colby College, Waterville, ME, 1976

EMPLOYMENT AND EXPERIENCE

1991-present: Owner, Fitts Geosolutions, LLC (selected examples)

Participated on a review panel for the EPA regarding analysis of the Gold King Mine release to the Animas River.

Advised numerous consultants, helping them use AnAqSim groundwater flow modeling software to simulate remediation scenarios, coastal interface flow, mine dewatering, construction dewatering, recharge basins, artificial ponds, and regional aquifer flow.

Advised a consulting company about modeling dissolved salt solute transport from a collapsed salt mine into an overlying aquifer in western New York State.

Performed a forensic analysis of pumping tests with a new well in a municipal well field in central Maine, to learn why the new well sand filter failed.

Analyzed aquifer properties and estimated the potential yield of wells near springs in central Maine using 3-D MODFLOW simulations.

Analyzed pumping tests and capture zones for seven different remediation projects for an Indiana environmental consulting firm.

Analyzed two 48-hour pumping tests and created a 3D MODFLOW model to simulate the impacts of proposed groundwater pumping on the sustainability of surface water flows in a sand and gravel aquifer in Fryeburg, ME.

Analyzed the rate of diffusion of radioactivity out of the concrete containment structure at the decommissioned Maine Yankee nuclear power plant in Wiscasset, Maine, to help with decision about whether to remove the structure. Developed both analytic and finite-difference mathematical models of the diffusion.

Helped design educational displays about groundwater for Poland Spring Bottling Co.

Analyzed construction dewatering at a site with a braced excavation and sheet-pile cutoff wall. Used MODFLOW to model 3-D transient flow to sumps inside the cutoff wall. Estimated pump discharges and times to achieve drawdown in stages.

Gave a two-hour short course on non-equilibrium solute transport processes and modeling to geologists and engineers at a Massachusetts groundwater consulting company.

Analyzed the patterns of drawdown near a well field in an anisotropic aquifer, for a consultant in Maryland.

Retained as an expert on groundwater contamination in a class-action law suit regarding MTBE contamination in Maine. Researched the transport and toxicity properties of MTBE relative to other compounds in gasoline and other common organic chemicals.

One of a panel of experts hired by the city of Indianapolis to review mathematical modeling of groundwater flow in the vicinity of three municipal well fields.

Developed mathematical models of seepage beneath a proposed dam in Switzerland for an electric utility.

Provided technical counsel related to a lawsuit involving the timing of gasoline releases and contaminant migration at a site in Waterboro, Maine.

Performed review of geotechnical and geohydrological aspects of a proposed special waste landfill expansion in Norridgewock, Maine.

Analyzed construction dewatering at a site with a braced excavation and sheet-pile cutoff wall. Used MODFLOW to model 3-D transient flow to sumps inside the cutoff wall. Estimated pump discharges and times to achieve drawdown in stages.

Testified as an expert witness in New York DEC hearings regarding a proposed large gravel mining operation in western New York. Testimony was about groundwater flow modeling of potential impacts.

1991-2014: University of Southern Maine, Gorham, ME, Professor of Geoscience (1991-2014), Associate Dean of the College of Science, Technology, and Health (2013-2014), Professor Emeritus (2015-)

Acting Director of Environmental Science and Policy Program 2001-2003, Chair of Geosciences Department, 2007-2011.

Courses taught at USM: *Physical Geology, Oceanography, Floods Glaciers and Changing Climate, Atmospheric Science, Water Resources, Groundwater Flow and Quality, Groundwater Modeling, and Topics in Groundwater Contamination*. Positive student evaluations of teaching: typically 1 to 1.5 on a scale of 1 to 5, 1 being best.

Principal Investigator or Co-PI on research grants: a) develop environmental geophysics capability at USM, b) evaluate groundwater flow in a sand and gravel aquifer near a local water supply well field, c) evaluate the same aquifer geometry with seismic refraction surveys, d) mapping and modeling a glaciofluvial aquifer in Wells, ME. Advised and mentored students on these grants.

Reviewed and continue to review 2-6 journal articles per year for several journals including *Water Resources Research, Ground Water, Advances in Water Resources, Journal of Hydraulic Engineering, and Journal of Hydrology*.

Guest lectured on various groundwater topics at Colorado State U., U. Wyoming, U. Colorado, Colorado State U., U. Maine, U. New Hampshire, Colby College, Tufts U.

1987-1991: GeoTrans, Inc., Harvard, MA. Principal Engineer , groundwater consulting (selected examples)

Responsible for computer operations in the Massachusetts regional office. Responsible for computer hardware and software used for groundwater modeling. Trained others in the use of computers, software, and models.

Provided technical consultation regarding the characterization and remediation of a contaminated industrial site. Recommended and helped design deep bedrock monitoring wells, a ten-day pilot test of the groundwater extraction/treatment system, and laboratory experiments to assess the sorption of chlorinated organic contaminants. Mediated discussions between the present and former landowners regarding the remedy, which included groundwater extraction and treatment, soil excavation, and ex-situ soil venting.

Investigated dissolved TCE and PCE contamination in the vicinity of water supply wells. Used soil gas surveys and micro-well installations in the sand and gravel aquifer to map the distribution of contaminated groundwater and help define the source of contamination.

Helped design and oversee the construction of a passive trench to skim petroleum LNAPL off the water table in an unconfined aquifer.

Evaluated solvent contamination problems and potential remedies at two industrial sites in New Jersey. Defined, as well as possible, the probable sources and timing of contaminant releases to help settle a litigated dispute between the owner and its insurance companies.

Evaluated hydrogeologic conditions at proposed landfill sites for private clients in Maine, Minnesota, and New Jersey. Using analytic and numerical models, analyzed the three-dimensional groundwater flow patterns for pre- and post-construction conditions. Estimated drawdowns and discharges associated with proposed underdrain systems, assessed the contaminant migration patterns for hypothetical failures. Recommended monitoring systems and contingency plans to minimize the potential adverse impacts on groundwater.

Estimated off-site contaminant discharges via groundwater at seven hazardous waste sites in Niagara Falls, for a study of contaminant discharges to the Niagara River.

Set up and monitored a 48 hour pumping test at a landfill site in Minnesota. Used pressure transducers and data loggers to collect data at eight wells. Estimated formation hydraulic conductivity and storativity from the test.

Taught a workshop on the use of the USGS modular three-dimensional groundwater flow model (MODFLOW) to engineers and geologists at a large consulting firm.

Provided technical counsel and expert testimony regarding contaminant migration via groundwater to the Delaware River. Gave testimony in a deposition and in the trial.

1986-1987: CDM, Boston, MA. Water Resources Engineer, groundwater consulting (selected examples)

Evaluated groundwater flow and contaminant transport patterns for the US EPA at two Superfund hazardous waste sites in New Jersey. Used a three-dimensional finite element program for flow simulation and a random-walk particle tracking program for simulation of contaminant transport. Evaluated alternatives for site cleanup, and the effectiveness of an existing slurry-wall barrier.

1979-1983, 1985-1986: GEI Consultants, Winchester, MA., Geologist/Engineer , geotechnical consulting (selected examples)

Investigated groundwater contamination in the vicinity of paper mill waste dewatering lagoons. Field program consisted of borings, well installations, hydraulic testing, surface and groundwater sampling. Did 2-D modeling of groundwater flow and contaminant transport patterns.

Design of a 1500 foot embankment dam in Maine. Soil and rock conditions were mapped in the foundation and borrow areas. Strength and permeability tests were performed on borrow materials. Seepage and stability analyses were performed, a design was recommended, and the dam was constructed.

Evaluated the liquefaction potential of a sand being considered for construction of large offshore oil drilling caissons in the Arctic Ocean. Performed dynamic triaxial strength tests to determine the liquefaction behavior as a function of density.

Simulated groundwater flow beneath a dam in Colorado. The simulated heads were used in stability analyses of the dam.

Field experience includes installation and monitoring of: soil borings, groundwater monitoring wells, dedicated groundwater sampling systems, borehole permeability tests, large-scale pumping tests, gas monitoring wells, pneumatic and electronic piezometers, borehole inclinometers, settlement plates and tiltmeters.

Performed geotechnical lab tests including permeability tests in triaxial cells, triaxial compression tests, cyclic triaxial compression tests, resonant column dynamic triaxial torsion tests, consolidation tests, direct shear tests, compaction tests, and index tests.

COMMERCIAL SOFTWARE

Fitts, C.R., *AnAqSim (Analytic Aquifer Simulator)*. This software is based on the techniques outlined in the 2010 *Water Resources Research* journal article. It simulates groundwater flow analytically and allows multiple layers, anisotropy, heterogeneity, and transient flow. 111 page User Guide. First released in 2011, with 1-3 releases per year since then. See <http://www.fittsgeosolutions.com>.

Fitts, C.R., *AnAqSimEDU (Analytic Aquifer Simulator, free educational version)*. Like *AnAqSim*, but with limited capabilities. Supplement to *Groundwater Science*, 2nd edition. First released in 2012.

Fitts, C.R., *TWODAN*, Two-dimensional analytic groundwater flow model, Windows program and 41 page manual. Over 500 licenses distributed to a wide range of domestic and foreign universities, consulting firms, and public agencies. First released in 1993.

Fitts, C. R., *SOLUTRANS*, a computer program for modeling groundwater contaminant transport using analytic solutions. About 50 licenses have been distributed to universities, consulting firms, and public agencies. First released in 1999.

BOOKS

Fitts, C.R., 2012, *Groundwater Science 2nd ed.*, 672 p., Academic Press (Elsevier), Amsterdam.

Over 7000 print copies sold, adopted by geology and civil engineering departments at 50+ universities including Colorado State U., Penn State U., Arizona State U., U. Colorado, U. Massachusetts, U. New Mexico, U. Wyoming, U. Wisconsin, Rutgers U., U. Maine, SUNY Buffalo, N. Carolina State U., Harvard U., Texas A&M, U. Alberta (Canada), Manchester U. (U.K.), Delft University of Technology (Netherlands), U. Utrecht (Netherlands), and U. Copenhagen (Denmark).

Fitts, C.R., 2012, *Groundwater Science, 2nd ed. Solutions Manual*, 76 p., Academic Press (Elsevier Science), Amsterdam.

Fitts, C.R., 2002, *Groundwater Science*, 450 p., Academic Press (Elsevier), San Diego.

JOURNAL ARTICLES

Fitts, C.R., J. Godwin, K. Feiner, C. McLane, and S. Mullendore, 2015, Analytic Element Modeling of Steady Interface Flow in Multilayer Aquifers Using AnAqSim, *Groundwater*, 53 (3), 432–439, doi: 10.1111/gwat.12225

Fitts, C.R., 2010, Modeling Aquifer Systems with Analytic Elements and Subdomains, *Water Resources Research*, 46, W07521, doi:10.1029/2009WR008331.

Fitts, C.R., 2006, Exact Solution for Two-Dimensional Flow to a Well in an Anisotropic Domain, *Ground Water*, 44(1), 99-101.

Fitts, C.R., Analytic Modeling of Impermeable and Resistant Barriers, *Ground Water*, 35(2), 312-317, 1997.

Fitts, C.R., Uncertainty in Deterministic Groundwater Transport Models due to the Assumption of Macrodispersive Mixing: Evidence from the Cape Cod and Borden Tracer Tests, *Journal of Contaminant Hydrology*, 23, 69-84, 1996.

Fitts, C.R. and Strack, O.D.L., Analytic Solutions for Unconfined Groundwater Flow Over a Stepped Base, *Journal of Hydrology*, 177, 65-76, 1996.

Fitts, C.R., Well Discharge Optimization Using Analytic Elements, *Ground Water*, 32(4), 547-550, 1994.

Fitts, C.R., Modeling Three-Dimensional Flow about Ellipsoidal Inhomogeneities, with Application to Flow to a Gravel-Packed Well and Flow Through Lens-Shaped Inhomogeneities, *Water Resources Research*, 27(5), 815-824, 1991.

Fitts, C.R., Simple Analytic Functions for Modeling Three-Dimensional Flow in Layered Aquifers, *Water Resources Research*, 25(5), 943-948, 1989.

CONFERENCE PRESENTATIONS (since 2004)

Fitts, C. R., 2013, Response of groundwater/surface water systems to pumping and other stresses, Maine Water Conference, Augusta, ME.

Fitts, C. R., 2011, Analytic Element Modeling with Subdomains and Finite-Difference Time Steps, International Ground Water Modeling Center MODFLOW and More, Golden, CO.

Fitts, C. R., 2010, Engineered Perched Aquifers for Low-Cost Small Water Supplies, National Ground Water Association Ground Water Summit, Denver, CO.

Fitts, C.R., 2007, Analyzing the Sustainability of Groundwater Pumping in the Fryeburg Sand and Gravel Aquifer, Maine Water Conference, Augusta, ME.

Fitts, C.R., 2006, Modeling Groundwater Flow in Layered, Anisotropic, and Heterogeneous Aquifer Systems using Discrete Analytic Domains, Geological Society of America Annual Meeting, Philadelphia, PA.

Fitts, C.R., 2006, Discrete Analytic Domains: A New Technique for Groundwater Flow Modeling in Layered, Anisotropic, and Heterogeneous Aquifer Systems, MODFLOW and More 2006, International Ground Water Modeling Center, Golden, CO.

Fitts, C.R., 2006, Discrete Analytic Domains: A New Method to Model Complex Aquifer Systems with Layers, Anisotropy, and Heterogeneity, 5th International Conference on the Analytic Element Method, Kansas State University, Manhattan, KS.

Fitts, C.R., 2004, Discrete Analytic Domains: A New Technique for Groundwater Flow Modeling in Layered, Anisotropic, and Heterogeneous Aquifer Systems, American Geophysical Union Fall Meeting, San Francisco, CA.

Fitts, C.R., 2004, Discrete Analytic Domains: a New AEM Formulation for Modeling Anisotropy and Heterogeneity, USEPA/NGWA Fractured Rock Conference, Portland, ME.

PROFESSIONAL AFFILIATIONS

Registered Professional Engineer, Maine #5513

Member, National Ground Water Association

CURRICULUM VITAE

MILLER, GLENN C.

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Reno, NV 89557
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email: gcmiller@unr.edu

Born November 17, 1950

Education: University of California, Santa Barbara, CA B.S. Chemistry 1972
University of California, Davis, CA Ph.D. Agricultural Chemistry 1977

Employment:

Univ. of Nevada, Reno	2008-2009	On leave for 11 months serving as Manager, Environmental Exposure Assessment, Valent USA Corporation, Walnut Creek CA
	2007-2008, 2010-present	President UNR Nevada Faculty Alliance
	1995-2006, 2010-2014	Director, Graduate Program in Environmental Sciences and Health
	1998-2004	Director, Center for Environmental Science and Engineering
	1989-present	Professor
	1983-89	Associate Professor
	1979-83	Assistant Professor
	1978-79	Lecturer
Environmental Protection Agency	1977-78	Research Chemist

Professional Societies:

American Chemical Society, Agrochemicals Division and Environmental Chemistry Division
American Association for the Advancement of Science
Society of Environmental Toxicology and Chemistry

Awards:

Thornton Peace Prize (1982)
Junior Faculty Research Award (1982)
UNR Foundation Professor (1991)
Conservationist of the Year, Nevada Wildlife Federation (1995)
College of Agriculture Researcher of the Year (1998)
Friend of the Lake Award, League to Save Lake Tahoe (2001)

Other Professional Activities

Environmental Protection Agency: Competitive Grants Review Panel 1985-1995
Environmental Protection Agency: Advisory Committee on Mining Waste 1991-1993
Environmental Protection Agency: Stakeholder Advisory Committee on Commodity Mercury 2007
Nevada Division of Environmental Protection: Technical Advisory Committee on the Carson River Superfund Site 1991-1994
American Chemical Society, Division of Environmental Chemistry: Chair of the Student Awards Committee 1988-1992
American Chemical Society, Division of Environmental Chemistry: Chair of the Awards Committee 1997-2002
UNR Environmental Studies Board: Chairman 1987-1991
UNR Environmental Science and Health Graduate Program: Director 1995-2006
Consultant to various public interest organizations, companies and law firms
Hydrology/Hydrogeology Graduate Faculty: Member 1989-present
Reviewer for numerous environmental chemistry journals
Co-owner and vice-president: Nevada Environmental Laboratories (Las Vegas and Reno) 1990-1999
Manager, Environmental Exposure Assessment, Valent USA Corporation 8/2008- 8/2009

Courses Taught

Humans and the Environment: Environment 100
Environmental Toxicology: NRES 432/632
Environmental Chemicals: Exposure, Transport and Fate: NRES 433/633
Analysis of Environmental Contaminants: NRES 430/630
Risk Assessment, NRES 793C
Global and Regional Issues in Environmental Science: NRES 467/667

Community and Conservation Service Activities

City of Reno, Charter Review Commission: Chairman 1990-93
Peavine Grade School PTA: Co-President 1990-1992
Sierra Club Mining Committee (national): Co-Chair 1989-1992
League to Save Lake Tahoe Board of Directors: 1986-1999
Mountain and Desert Research Fund: 1987-present
Dupont-Conoco Environmental Leadership Award in Mining Committee: 1989-1994
Nevada Interagency Reclamation Award Committee: 1990-1992
Washoe County School District Science Advisory Board: 1992-2000
Chairman, 1993-94
Earthwords: Board Member 1999-present
Tahoe Baikal Institute: Board Member 1998-present, Chair 2002-2003
Environmental Law Alliance Worldwide Board Member: 2000-present, Chair:2009
Great Basin Mine Watch: Board Member 1994-present, Chair 2001-2006
Center for Science in Public Participation: Board Member 1998-present
Great Basin Institute, Board Member 2000-present, Chair 2001-present
United Nations Environmental Program Committee for Development of a Code for Use of Cyanide in Mining: 2000-2002
Mining, Minerals and Sustainable Development, Assurance Group Committee Member, 2000-2002
National Research Council committee on Methyl Bromide: 1999-2001
National Research Council committee on Mining Technology: 2000-2002
National Research Council committee on USGS Mineral Resources Program, 2000-2003

US Environmental Protection Agency Committee on Management of Mercury Stores in the U.S.
2007

Research Interests: Remediation of mine waste contamination. Mining pit lake water quality. Fate and transport of organic compounds in soils and the atmosphere. Methods of remediation of gasoline contaminated soils; Photochemical transformation of organic contaminants on soil surfaces. Instrumental development of chromatographic systems. Development of arid lands biofuels

Grants Received: (1982-present)

\$ 14,550 "Atmospheric Photolysis of Pesticides," A Junior Faculty Research Award from the UNR Research Advisory Board, 1982.

\$ 3,000 "Photolysis of CGA-41065," CIBA GEIGY Corporation, 1982.

\$ 4,000 "Chemotaxonomy of Sagebrush Using High Performance Liquid Chromatography," Intermountain Research Station USDA, 1984.

\$ 83,000 "Analysis of Bovine Tissue for Chlorinated Hydrocarbons," Environmental Protection Agency, 1984-85.

\$ 18,300 "Photooxidation of Sulfide Containing Pesticides on Soil Surfaces," Western Regional Pesticide Impact Assessment Program, 1984.

\$ 2,500 "Identification of Sagebrush Taxa Based on Liquid Chromatographic Analyses of Phenolics" Research Advisory Board, 1986.

\$235,500 "Factors Affecting the Photolysis of Dioxins on Soil Surfaces," U.S. Environmental Protection Agency, 1986-89.

\$ 15,160 "Vapor Phase Photolysis of Phorate," American Cyanamid Corporation, 1987.

\$ 2,500 "Identification of Sagebrush Taxa Based on Liquid Chromatographic Analyses of Phenolics," UNR Research Advisory Board, 1987.

\$ 48,792 "Upgrading Municipal Wastewater Effluents for Urban Water Reuse through Phytochemical Oxidations: System Development and Operational Criteria," U.S. Geological Survey, State Water Research Institute Program (Co-P.I. with Richard Watts), 1986-88.

\$ 17,200 "Vapor Phase Photolysis of Malathion," American Cyanamid, 1988.

\$ 16,460 "Aging Groundwater: A comparison of the Fluorocarbon Method to the Tritium Method," U.S. Geological Survey, State Water Research Institute Program (Co-P.I. with K. Sertic), 1988-89. (Competitive Grant, State of Nevada) Terminated 6-89.

\$206,000 "In Situ Treatment of Organic Hazardous Wastes in Surface Soils Using Fenton's Reagent." U.S. Environmental Protection Agency (Co-P.I. with Richard Watts), 1988-89. (Competitive Grant, national)

\$ 23,200 "Evaporation of Gasoline from Soils," Nevada Division of Environmental Protection Co-P.I. with Susan Donaldson), (Contract).

\$ 50,000 "Photolysis of Pesticides on Soils," American Cyanamid Corporation (Unrestricted Grant, noncompetitive)

\$ 15,600 "Vapor Phase Photolysis of Diazinon and Methyl Parathion" Western Region Pesticide Impact Assessment Program (USDA) (competitive) 1989-90

\$ 30,000 "Interface for a Capillary electrophoresis Effluent and a Mass Spectrometer" Linear Corporation 1989-90. (Co P.I. with Murray Hackett) (contract)

\$ 15,000 "UV-Gas Chromatographic Dectector" Linear Corporation 1990. (Co P.I. with Murray Hackett) (Noncompetitive grant)

\$153,000 "Enhancement of Photodegradation of Pesticides in Soil by Transport Upward in Evaporating Water" (USGS Competitive) 1991-94

\$ 50,000 "Pit Water from Precious Metal Mines" U.S. Environmental Protection Agency, 1992-94

\$ 91,000 "Remediation of Acid Mine Drainage at Leviathon Mine" Lahontan Water Quality Control Board. (Contract, Co P.I. with Tom Wildman, Colorado School of Mines) 1992-94.

\$159,000 " Ecological Toxicology of Metam Sodium and it Derivatives in the Terrestrial and Riparian Environments of the Sacramento River" California Fish and Game, 1992-1995 (G.C. Miller project, part of a larger project with George Taylor at the Desert Research Institute)

\$43,092 "Atmospheric Transport and Deposition of Organophosphates and Other Pesticides as Input to Sierra Nevada Surface Waters" USDA-NRI. 1995-98. Co-P.I. with P.I. James N. Seiber. Task 2.

\$80,427 "Linked Techniques for Contaminant Removal from Soil in Arid/Semiarid Environments" Dept. of Energy. 1993-96. Co.P.I with James N. Seiber.

\$107,000 "Chemical Environmental Problems Associated with Mining" NIEHS 1993-96. Core B portion. This was a project of a larger Superfund Grant to UNR. James N. Seiber, P.I.

\$36,900 "Protocol for Evaluation of Pesticide Photodegradation" Dow-Elanco. 1995-97. (Contract)

\$45,000 "Photolysis of Pesticides" Dupont Chemical Company. 1995-98. Unrestricted gift to support ongoing research.

\$275,000 "Remediation of Acid Mine Drainage at the Leviathan Mine". Nevada Division of Environmental Protection. 1996-99

\$5000 "Evaluation of Limnology and Water Quality of a Porphyry-Copper Pit Mine Lake" Public Resource Associates 1996.

\$767,000 Geochemical, Biological and Economic Impacts of Arsenic and Related Oxyanions on a Mining-Impacted Watershed" NSF-EPA, 1997-01

\$46,000 "Remediation of Acid Mine Drainage at the Leviathan Mine". Lahontan Regional Water Quality Control Board, 2000-2001

\$30,000 "Use of Sulfate-Reducing Bioreactors to Remove Zinc in Mine Drainage" Placer Dome Corporation. 2000-2001

\$50,000 "Release of Gasoline Constituents from Marine Engines to Lake Tahoe" Lahontan Regional Water Quality Control Board, 1998-1999

\$70,000 "Impact of Marine Engine Exhaust on Pyramid Lake" U.S. Environmental Protection Agency, in cooperation with the Pyramid Lake Paiute Tribe. 2000-2001.

\$570,000 "An Environmental Assessment of the Impacts of Polycyclic Aromatic Hydrocarbons in Lake Tahoe and Donner Lake" California Regional Water Quality Control Board, Lahontan Region. 2001-2003.

\$126,000 "Operation of a Bioreactor at the Leviathan Mine" Contract with ARCO, 2001-2002

\$75,000 Trifluoroacetic Acid in Antarctic Ice, National Science Foundation 2001-2004

\$190,500 "Mercury Deposition Associated with Mining, U.S. Environmental Protection Agency, 2002-2004

\$53,000 Passivation of Acid Generating Rock at the Golden Sunlight Mine, Placer Dome Corporation 2002-2003

\$520,000 "Operation of a Bioreactor at the Leviathan Mine" Contract with ARCO, 2003-2007

\$250,000 "Risk Assessment and Fate of Polyacrylamide and Acrylamide in Irrigation Canals and Receiving Water" A subcontract from the Desert Research Institute on a project from the U.S. Bureau of Reclamation. 2004-2008

\$55,000 Passivation of acid Generating rock, Freeport McMoran, 2009-2010

\$75,000 Biofuel crops on arid lands, Co-P.I. U.S. Department of Energy, 2010-2011

\$104,000 Development of a Good Neighbor Agreement for Mining, P.I. Newmont Mining Corporation 2012-2015

\$498,000 Arid lands biofuels and bioproducts. P.I. USDA NIFA, 2013-2017

\$38,000, Container composting of biosolids. P.I. Nordic Industries, 2015

Publications:

G.C. Miller and D.G. Crosby, "Photodecomposition of Sustar[®] in Water." J. Agric. Food Chem. 26:1316 (1978).

G.C. Miller and R.G. Zepp, "Effects of Suspended Sediments on Photolysis Rates of Dissolved Pollutants." Water Research 13:453 (1979).

G.C., Miller, M.J. Mille, D.G. Crosby, S. Sontum and R.G. Zepp, "Photosolvolysis of 3,4-Dichloroaniline in Water: Evidence for an Aryl Cation Intermediate." Tetrahedron 35:1797 (1979).

G.C. Miller and R.G. Zepp, "Photoreactivity of Pollutants Sorbed on Suspended Sediment." Environ. Sci. Technol. 13:860 (1979).

G.C. Miller, R. Zisook and R.G. Zepp, "Photolysis of 3,4-Dichloroaniline in Natural Waters." J. Agric. Food Chem. 28:1053 (1980).

- G.C. Miller, R.G. Warren, K. Gohre and L. Hanks, "A Gas Chromatographic Method for Determining Strychnine Residues in Alfalfa." J. Assoc. Off. Anal. Chem. 65:901 (1982).
- G.C. Miller and W.W. Miller, Eds. "Effect of Sewage on the Truckee River." A symposium published by the University of Nevada, College of Agriculture (1982).
- G.C. Miller and R.G. Zepp, "Extrapolating Photolysis Rates from the Laboratory to the Environment." Residue Reviews 85:89 (1983).
- G.C. Miller and D.G. Crosby, "Pesticide Photoproducts: Generation and Significance." J. Clin. Toxicol. 19:707 (1983).
- G.C. Miller, W.W. Miller, J.W. Warren and L. Hanks, "Soil Sorption and Alfalfa Uptake of Strychnine Applied as an Agricultural Rodenticide." J. Environ. Quality 12:526 (1983).
- G.C. Miller and D.G. Crosby, "Photooxidation of 4-Chloroaniline and N-(4-Chlorophenyl)-Benzene-sulfonamide to Nitroso- and Nitro-Products." Chemosphere 12:1217-1227 (1983).
- K. Gohre and G.C. Miller, "Singlet Oxygen Generation on Soil Surfaces." J. Agri. and Food Chem. 31:1104-1108 (1983).
- R.G. Zepp, P.F. Schlotzhauer, M.S. Simmons, G.C. Miller, G.L. Baughman and N.L. Wolfe, "Dynamics of Pollutant Photoreactions in the Hydrosphere." J. of Fresenius Z. Anal. Chem. 319:119-125 (1984).
- K. Gohre and G.C. Miller, "Photochemical Generation of Singlet Oxygen on Non-transition Metal Surfaces." J. Chem. Soc. Faraday Trans. I 81:793-800 (1985).
- R.V. Tamma, G.C. Miller and R. Everett, "High-Performance Liquid Chromatographic Analysis of Coumarins and Flavonoids from Section Tridentatae of *Artemisia*." J. Chromatography 322:236-239 (1985).
- K. Gohre, R. Scholl and G.C. Miller, "Singlet Oxygen Reactions on Soil Surfaces." Environ. Sci. Technol. 20:934-938 (1986).
- K. Gohre and G.C. Miller, "Photooxidation of Thioether Pesticides on Soil Surfaces." J. Agric. Food Chem. 34:709-713 (1986).
- B.R. Smith, G.C. Miller, R.W. Mead and R.E.L. Taylor, "Biosynthesis of Asparagine and Taurine in the Freshwater Prawn, *Macrobrachium rosenbergii* (De Man)." Comp. Biochem. Physiol. 87B(4):827-831 (1987).
- B.R. Smith, G.C. Miller and R.W. Mead, "Taurine Tissue Concentrations and Salinity Effect on Taurine in the Freshwater Prawn *Macrobrachium rosenbergii* (De Man)." Comp. Biochem. Physiol. 87A(4):907-909 (1987).
- G.C. Miller and V. Hebert, "Environmental Photodecomposition of Pesticides." In: University of California publication - Fate of Pesticides in the Environment (J.W. Biggar and J.N. Seiber, eds.) Chapt. 8, p. 75-86 (1987).
- G.C. Miller and R.G. Zepp, "2,3,7,8-Tetrachlorodibenzo-p-dioxin: Environmental Chemistry." In: Solving Hazardous Wastes Problems: Learning from Dioxins (J.H. Exner, ed.) American Chemical Society Symposium Series 338, Chapter 6, pp. 82-93 (1987).

C.R. Blincoe, V.R. Bohman, G.C. Miller, R.L. Scholl, W.W. Sutton and L.R. Williams, "Excretion and Tissue Concentration of Pentachlorophenol Following Controlled Administration to Cattle." J. Animal Sci. 65 Supplement #1 (1987).

G.C. Miller, V.R. Hebert and R.G. Zepp, "Chemistry and Photochemistry of Low-Volatility Organic Chemicals on Environmental Surfaces." Env. Sci. Tech. 21:1164-1167 (1987).

V.R. Bohman, C.R. Blincoe, G.C. Miller, R.L. Scholl, W.W. Sutton and L.R. Williams, "Biological Monitoring Systems for Hazardous Waste Sites." EPA Final Report #CR 809 787 (1988).

F.M. Wilt, G.C. Miller and R.L. Everett, "Monoterpene Concentrations of Litter and Soil of Singleleaf Pinyon Woodlands of the Western Great Basin." Great Basin Naturalist 48:228-231 (1988).

K. Mongar and G.C. Miller, "Vapor Phase Photolysis of Trifluralin in an Outdoor Chamber." Chemosphere 17(11):2183-2188 (1988).

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Ronald L. Schmiermund, Ph.D.
Senior Geochemist

Summary

Dr. Schmiermund has been practicing geochemistry for 40 years with increasing specialization in mining-and mineral processing-related cases. He has worked as a part of multi-service consulting firms providing mining/civil engineering and environmental services, in addition to contract work for both small and multi-national mining companies. He has participated in projects in nearly a dozen countries and on three continents. As of 2006 he has operated as an independent consultant (Economic and Environmental Geochemistry, Inc.) and in collaboration with other independent consultants. Projects included design and implementation of baseline environmental technical programs, interpretation and review of geochemical data necessary for mine design and permit applications, and expert litigation support for abandoned mining operations and a complex, high-profile multi-national RI-FS and NRDA case involving smelting and mining wastes.

Dr. Schmiermund's expertise is based on his combined backgrounds in general geology, economic geology of ore deposits, aqueous environmental geochemistry, and his familiarity with modern and historic mining techniques. His approach is to combine these backgrounds with elements of the scientific method to provide defensible and holistic baseline surveys and environmental impact analyses. He was an early advocate of Geo-Environmental Models (GEMs) as a framework for assessing on-going mining projects and planning new ones. In addition, an intimate familiarity with sampling and analytical practices is used to increase data reliability and reproducibility.

In addition to the analysis of existing conditions at mining facilities, he has applied geochemical methods to tailings disposal and stabilization issues, process waste treatment and management, and mine site remediation. He has considerable experience in performing predictions of long-term waste rock performance for a wide variety of ore deposit types and works in close collaboration with several local laboratories to perform predictive testing. In addition to whole-rock lithogeochemistry, conventional and custom ARD

prediction and leachability testing, recent work has involved solid state analyses including SEM and QEMSCAN and application of stable lead isotopy for identifying sources of contamination

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Education

1991, Ph.D. Geochemistry, Colorado School of Mines

*Solid-State Weathering of Limestone and Marble by Acidic Precipitation
– A Quantitative Laboratory Simulation*

1977, M.Sc. Geochemistry, Pennsylvania State University

*Geology and Geochemistry of Uranium Deposits Nera Penn haven
Junction, Carbon County, Pennsylvania*

1974, B.Sc. Geosciences (Geology), Pennsylvania State University

Affiliations

Society of Economic Geologists (Fellow)

International Association of Geochemistry

International Mine Water Association

Professional Experience

Mining Sector Projects (ordered by country):

ARGENTINA

Veladero Project, San Juan Province, Argentina

High-sulfidation Au

Performed an in-field review of a baseline surface water monitoring program with identification of natural point-source contributions to metal, sulfate, and acidity loading. Participated in the design of a waste rock sampling program for assessment of acid rock drainage potential taking into account nature of supergene alteration and mineralogy. For Homestake/Barrick Mining.

Pirquitas Project, Argentina

Polymetallic Sn vein system

Prepared a feasibility-level waste rock and process waste characterization and predictions of future pit lake chemistry. A sampling plan was developed from a close study of drilling logs. Acid/base accounting and whole-rock chemistry was integrated with compositions of water collected from historic underground workings to anticipate long-term weathering behavior and pit lake chemistry. For Sunshine Mining

Cerro Vanguardia Project, Argentina

Low-sulfidation Au

Conducted a geochemical analysis and developed monitoring programs for the Environmental Baseline Study and the Environmental Impact Study (EIS) in support of the bankable feasibility study and project permitting for a major gold mine development in the Patagonia. For Min-Cruz U.T.E.

BOLIVIA

San Cristobal Project, Bolivia

Ag-Zn vein complex

Environmental Impact Assessment. Analyzed data from surface water and groundwater samples, pit geologic mapping, mineralogic studies of ore, primary and secondary alteration and waste rock, and acid/base accounting data for historic and modern mine rock and pilot-scale tailings. Predicted long-term behavior of mining wastes and impacts of existing features on surface water. For Apex Silver Mines Corporation.

Spent Heap Leach Ore Assessment. Designed preliminary field investigation and final laboratory program to assess acceptability of spent heap leach ore for construction purposes relative to long-term weathering behavior. Used Knight Piésold personnel in an oversight role in the Bolivian laboratory to produce acceptable analytical results. For Apex Silver Mines Corporation.

BRAZIL

Sossego Project, Carajas District, Brazil

Fe-Oxide Cu-Au

Worked on-site with site personnel and other contractors to formulate a sampling plan for assessing acid rock drainage potential from waste rock dumps, low-grade ore stockpiles, pit walls, and tailings. Data interpretation included resolution of extensive analytical inconsistencies and demonstration that chalcopyrite was the principal sulfide, as opposed to pyrite, with appropriate adjustments to standard acid/base accounting interpretation procedures. For Companhia Vale do Rio Doce (CVRD).

Minas Serro Forteleza (MSF) Nickel, Minas Gerias, Brazil

Komatiitic-hosted Ni-Fe massive sulfide

On-site assessment of surface water, groundwater, dump seepage and underground mine water quality, investigation of ARD potential and mechanisms for nickel release from deep lateritic horizons and primary sulfide ore. Designed sampling program to obtain adequate data for a pit lake model necessary for closure. Predicted post-closure underground water quality and executed pit lake model. Compared predicted pit water quality to global occurrences of pit water related to komatiitic-hosted nickel deposits. Worked closely with mine geology staff and presented findings to high-level Rio Tinto review team. Proposed passive in-situ electrolosis system to discourage subaqueous oxidation of sub-ore-grade massive sulfide. For Rio Tinto Brazil

Riacho dos Machados Mine , Minas Gerias, Brazil

Disseminated Au in Pre-Cambrian metasediments

On-site evaluation of post-closure conditions related to potential surface water contamination and pit lake acidification. Designed waste rock sampling program and water quality sampling program to quantify requirements for final closure without increased ARD production. Recommended closure and remediation options for surface and underground

mining facilities and spent cyanidation heap leachpads. For Companhia Vale do Rio Doce (CVRD).

BURKINA FASO

Essakane Project

Birimian-style Au

Reviewed deposit cross sections and participated in selection of samples for waste characterization. Oversight on laboratory humidity cell testing

CAMAROON

Nkamouna Project, central Camaroon

Lataritic Ni-Co-Cu

Reviewed geologic reports and sections, designed confirmatory waste characterization program, coordinated acquisition of remote sensing data and provided recommendations for management of water expected to be affected by mining.

CHILE

Spence Project, Antofagasta Region, Chile (Rio Chiles)

Porphyry Cu with supergene enrichment and exotics

Designed and supervised a sampling scheme and complete laboratory program to assess the potential for acid rock drainage and metal leach-ability. Customized procedures were devised to account for high-salinity groundwater and supergene copper chlorides. A qualitative assessment was made of the potential for acid and metal contributions to any future pit water. Findings were incorporated into the EIA. For Rio Chiles.

DEMOCRATIC REPUBLIC OF CONGO

Tenke Fungurume Mine, Democratic Republic of the Congo

Calcareous sediment-hosted (Zambian), stratabound Cu-Co sulfide-oxide

Participated in the preparation of an independent review of environmental, health, and safety issues related to the project. As part of a third-party advisory team to the President of TFM on environmental issues, was

responsible for reviewing the ongoing waste rock characterization program for TFM. In this capacity, visited the site and reviewed field geology, geologic cross sections and available core before contributing to a sampling and analytical plan to assess acid rock drainage and metal leach-ability potentials for the Kwatebala pit waste rock. Other responsibilities included reviewing and interpreting laboratory data.

EQUADOR

Mirador Project, Marona Santiago province, Ecuador

Porphyry Cu-Au

Review of existing data for EIA, prepared data gap analysis and advised on critical environmental situations related to ARD generation, surface water quality and pit lake water quality. Presented to the Equadorian Ministry of Environment and Mines, the concept of applying existing environmental quality at mine site with close geologic relationships as a preliminary predictor of potential issues.

MEXICO

El Boleo Project, Santa Rosalia, Baja California del Sur, Mexico

Strataform/bound Cu-Co sulfide

Designed and supervised a sampling program to allow assessment of acid rock drainage potential and metal leach-ability from waste rock. In addition, extensive laboratory testing was conducted of the neutralization requirements of pilot-scale tailings along with their reologic properties. Information gained led to important constraints on the design of the tailings storage facility.

PERU

Quellaveco Project, Moquegua, Peru

Porphyry Cu

Visited the site to resolve issues stemming from a conventional acid rock drainage investigation and to formulate the most realistic pit lake water chemistry model. Samples were collected from the remains of previous exploration programs that helped quantify weathering rates of sulfide minerals under actual site conditions.

Cerro Corona Project (I), Hualgayoc, Peru

Porphyry Cu-Au

Conducted and interpreted a baseline surface water survey in a historic complex mining district occupied by numerous operating and abandoned mines, two types of concentrating plants, ancient smelting operations, and active villages. For Barrick

Cerro Corona Project (II), Hualgayoc, Peru

Porphyry Cu-Au

Updated previous baseline survey for new party and expanded sampling to obtain better understanding of contamination sources from existing surface and underground operations. For RGC

Cerro Corona Project (III), Hualgayoc, Peru

Porphyry Cu-Au

Responsible for greatly expanded waste rock characterization program including prediction of waste rock dump performance, design of dump construction for minimal ARD production, prediction of TSF decant water quality, design of TSF closure program using oxygen-diffusion barrier, performance of pit lake model using limited existing data and data from analogue deposits. Worked closely with geologists to obtain acceptable geologic sections and a block model based on total sulfur. Presented to the Peruvian Ministry of Environment and Mines, the concept of applying existing environmental quality at mine site with close geologic relationships as a preliminary predictor of potential issues. For Gold Fields

Minera Yanacocha (Maqui Maqui Deposit) Cajamarca, Peru

High-sulfidation Au

Designed water and wall rock sampling program to provide necessary data for pit lake water quality predictions. Designed pit lake geochemical model including predictions of lime requirements for neutralization, future spring water quality and recommendations for pit closure. Reviewed and critiqued on-going site-specific waste rock exposure experiments and site-wide water quality data. For Minera Yanacocha S.A.

La Zanja, Cajamarca, Peru

High-sulfidation Au

Collected field observations and water quality data and designed waste rock sampling program based on existing core. Created a custom

analytical program to account for large quantities of alunite and complications to ABA interpretations. For Buenaventura.

CENTROMIN, (National Mining Company of Peru)

Polymetallic veins

Reviewed water quality and other environmental data for eight mines and one smelter complex supplied by government. Provided independent assessment of data as a third-party review for potential buyers

Antamina, Ancash Province, Peru

Zn-Cu Skarn

Reviewed on-site conditions and data related to predictions of future pit lake water quality. Prepared predictions based on very limited experimental data and water quality in the pre-mining lake centered in the ore body. Proposed a comprehensive sampling plan for improved predictions. For Minera Antamina

Cerro Verde Sulfide Expansion, Araquipa, Peru

Porphyry Cu

Worked with site geologists to selected core intervals representative of the major rock waste rock. Reviewed existing data and determined the need for a modified analytical program to account for non-reactive sulfate minerals, Supervised laboratory analytical program prepared an assessment of recommended waste rock disposal methods.

REPUBLIC OF SOUTH AFRICA

Natal Province, Republic of South Africa

Coal

Examined the existing environmental database for recently closed underground coal mining operation. The objective was to provide an opinion on the adequacy of existing data, current sources and future of acid production, and potential remediation technologies. For Client Confidential.

SIERRA LEONE

Sierra Leone Rutile

Heavy-mineral concentrates in recent near-shore fresh water sediments

Provided supervision for field sampling and data-collecting personnel, reviewed laboratory analytical data and prepared an assessment of the source of ARD and geochemical issues associated with proposed mining operations.

UNITED STATES OF AMERICA

Northmet Project, Minnesota

Ultramafic-hosted Cu-Ni-PGE sulfide

Responsible for the geochemical contributions to an EIS document, including review and assimilation of all experimental work conducted by SRK-Vancouver and Minnesota Department of Natural Resources. Kinetic database included a 20-year ongoing program (MnDNR) and three years of current testing of nearly 100 samples.

Montana Tunnels Project, Montana, U.S.A.

Breccia-pipe-controlled Au

Worked in cooperation with Knight Piésold Vancouver to design a predictive model for evolution of the open pit lake water quality. A conservative mass flux model was created and qualitatively adjusted through application of likely geochemical scenarios for attenuation of selected constituents. For Apollo Gold.

Homestake Mine, Lead, South Dakota, U.S.A.

Pre-Cambrian metasediment stratabound arsenopyrite-Au

Responsible for the design of sampling programs for surface water, groundwater, underground mine water, tailings and waste rock, oversight of pit lake modeling subcontractor, and overall interpretation of site-wide environmental geochemistry. Predicted long-term post-closure environmental issues from modern and historic operations. For Homestake Mining.

Mineral Hill Mine, Montana, U.S.A.

Pre-Cambrian metasediment stratabound arsenopyrite-Au

Formulated a field program to evaluate historic waste rock dumps with

respect to future acid production and metal leach-ability. The program included use of roto-sonic drilling and in-field determination of sulfate leach-ability and was negotiated with the Montana DEQ and local stakeholders. Drilling and construction of monitoring wells was performed to investigate the potential for the connection of an underground mine pool with groundwater and surface water. For TVX.

Borealis Mine, Hawthorne, Nevada

High-sulfidation Au w. low-sulfidation overprints

Responsible for waste rock characterization, assessment of surface water, groundwater and pitlake water quality interpretations and predictions in support of a renewed mining permit application. Applied ore deposit models to interpret field observations related to sulfide distribution, production of ARD and metal releases and the distribution of water in pit remaining from previous mining operations.

Tonkin Springs Mine, Eureka, Nevada

Carlin-type Au

Reviewed existing data, proposed additional waste rock characterization, measured field water quality parameters and reviewed the geologic data base to support a prediction of future pit water quality and recommendations for pit closure. Used ore deposit models to interpret litho-chemical observations and infer pit wall rock conditions

**Dairy Syncline Phosphorite Mine Baseline Environmental Study,
Idaho, JBR Environmental (now Stantec) / Simplot (2009-2015)**

Created a plan-of-study / QAPP for, and managed, a large laboratory program to assess the leachability of COPCs from mining waste rock and overburden using down-flow columns. The experimental design included considerable developmental work (E2Geochemistry) to accommodate characteristics of the material to be tested and required custom design of the columns and solution application apparatus. Over 4000 individual samples from 33 drill holes were combined in multiple statistically-defensible composites to allow testing of five lithologies to be produced from four separate pits. Sample preparation was undertaken by the client and a commercial lab (Hazen Research), analytical services provided by another laboratory (Huffman Laboratories). Columns were operated by E2Geochemistry and geostatistical analysis was provided by a third-party

contractor.

The objective of the study was to provide data for source terms to be used in surface and groundwater models. E2Geochemistry produced all interim and final reports in conjunction with JBR Environmental and provided support in negotiations with various governmental agencies

Processing/Remediation Projects:

Voisey's Bay Autoclave Residue Management, Labrador, Canada 10/04 – 6/05

Conducted extensive laboratory investigation of multiple un-neutralized and neutralized residues originating from autoclave processing of Ni-Co-S concentrate, including mineralogical and bulk chemical characterization, leachability and kinetics of elemental sulfur oxidation. Prepared numerous detailed reports and presentations for Inco process metallurgy personnel. Physical nature of residues required design and construction of special humidity cells compatible with very fine-grained materials.

Smokey/Manning Canyon Mines, Idaho Phosphate District, Idaho

Provided critique and review of laboratory and field work done to address prediction of groundwater seepage quality from back-filled pits.

DeLamar Mine Water Management, Oregon, U.S.A.

Updated the existing list of water treatment technologies and evaluated the applicability of each to achieving the client's treatment and operational objectives. Involved a multi-media search for innovative technologies and estimation of efficacy of each. For Kinross.

Ferris Haggarty Copper Mine, Wyoming, U.S.A.

Mapped underground workings and water sources combined with chemical and volumetric analyses of flows led to the formulation of a mass transport model. Further work with geochemical models led to a hypothesis for the acid-generating and copper-liberating processes occurring in inaccessible portions of the mine. Understanding the variability and annual cycles of mine effluent quality led to treatment design constraints. For Wyoming Abandoned Mine Lands Division.

Phosphoric Acid Manufacturing Facility

Investigation of causes and mechanisms for destructive ground heaving utilized trenching and sampling of shallow groundwater and near surface materials in various stages of heave. Mineralogical and chemical analyses were coupled with visual observations and chemical models to arrive at a hypothesis explaining the phenomena. For Client Confidential.

Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Colorado, U.S.A.

Principal Geochemist. Provided geochemical oversight to final and interim interpretation reports and work plans for investigations of the solar

evaporation ponds (including vadose and saturated zone modeling relating to engineering designs). Developed a nitrate brine dilution model to explain aspects of historic groundwater contamination. Provided geochemical oversight to projects involving intrinsic bioremediation of fuel and solvent contamination and field sampling and analytical program design. Principal author of joint proposals (with Colorado School of Mines) to develop innovative, passive down-hole sampling devices and passive in-situ groundwater remediation technologies. For Parsons Engineering Science.

Reno Creek In Situ Uranium Mine, Wyoming

Performed laboratory investigations to support predictions of subsurface migration of leaching contaminants in conjunction with hydrologic predictions of fluid movement under saturated and unsaturated conditions associated with process waste disposal via modified land application. For International Uranium.

Iscaycruz Project, Peru

Senior Geochemist. Performed geochemical modeling of lake water and process water interaction in support of an evaluation of tailings disposal options. For Empresa Minera Iscaycruz S.A.

Monterey Coal, Illinois

Executed and interpreted the laboratory investigation of in situ leaching and oxidation processes in coal refuse heaps in support of predictions of long-term behavior and impacts to groundwaters.

DuPont Specialty Chemicals

Conducted laboratory investigation of proprietary process for passivation of pyrite oxidation during cyanidation for gold leaching.

Oil Field Secondary Recovery Fluid Stability Prediction, Colorado, U.S.A.

Used geochemical modeling techniques to predict the stability of the J-Sand reservoir upon introduction of fresh water for secondary recovery. For City and County of Denver, Colorado.

Miscellaneous Site Investigations

Project and Program Manager. Performed waste site investigations for federal agencies (organic solvent groundwater contamination from USTs), DOE (radioactive site appraisal), and private industry (various CERCLA site investigations and a wood treatment facility contaminated by chromium-copper arsenate and radium contamination in groundwater). Responsible for

proposal preparation, field operations, and final reports for all projects. For NFT, Inc.

Litigation Support Projects:

Energy Fuels

Critical review and assessment of uranium/vanadium mineral resources and mining techniques, including in situ solution mining utilizing alkaline and acidic solutions above and below the water table. Properties and projects investigated were located in Arizona, Utah, Colorado, Wyoming, South Dakota, and Mongolia.

Mobil Oil, Anadarko, Oklahoma, U.S.A.

Participated in a project to develop a defensive database related to co-produced oil-field brine contamination of surface and shallow aquifers. Collected groundwater samples, modeled brine chemistry, investigated brine “fingerprinting,” conducted field investigations, and prepared material for depositions.

Roosevelt Drive-In Chromium Heaving, Jersey City, N.J.

Served as an expert witness for the plaintiff in a civil action involving loss of property use due to heaving of fill material composed of processing wastes from early-mid 1900s chromium ore processing. Depositions addressed the adequacy of existing data, heaving mechanisms, and the chemistry of the heaving process.

Hardage-Criner CERCLA Site, Criner, Oklahoma, U.S.A.

Provided support to a team of experts for the defendant. Designed a field sampling program and designed, built, and operated customized down-hole groundwater sampling equipment for ordinary dissolved constituents, stable and radio-isotopes, and meta-stable field parameters. Provided a verbal deposition to counsel for the plaintiff. For the U.S. Department of Justice.

Pakootas vs. Teck Cominco Metals Ltd., Investigation of Alleged Contamination of Upper Columbia River Sediments from the Trail Smelter. Teck Cominco Metals Ltd. / Pillsbury Winthrop Shaw Pittman LLP (2009-2015)

Details remain privileged and confidential

Provided litigation support in the following areas:

- 1) Historical and process-related background information on local mining and smelting activities
- 2) Identification of critical areas of investigation
- 3) Field sampling methodology and logistics
- 4) Selection of providers of analytical services and interface between labs and client
- 5) Participation in laboratory investigations and real-time data analysis
- 6) Interpretation of whole-sediment geochemistry and mineralogy based on SEM and QEMSCAN
- 7) Interpretation of stable lead isotopic data

Mineral Exploration Projects:

Ouachita Mountains, Arkansas, U.S.A.

Responsible for the design and administration of a large-scale exploration program for massive sulfide deposits including extensive and varied geochemical sampling, data management, computer-assisted data reduction and enhancement, ground and airborne geophysics, basin analysis, prospect generation, and core drilling. For Exxon Minerals Company.

Powder River Basin, Wyoming, U.S.A.

Conducted reconnaissance and detailed exploration for sandstone-type uranium deposits, generated prospects, and was responsible for prospect evaluation in the Powder River Basin and surrounding basins. Methods employed included subsurface mapping with O&G electric logs, surface mapping, extensive airborne radiometric surveys, groundwater sampling, and the use of enhanced LANDSAT images. For Exxon Minerals Company.

Affiliations

Society of Economic Geologists (Fellow)
Geochemical Society
American Chemical Society
International Association of Geochemistry and Cosmochemistry

Publications/Presentations

- Schmiermund, R.L. (2006c.) A modification of ASTM humidity cell apparatus to accommodate very fine-grained mineral processing wastes, 7th ICARD Conference, Denver, Colorado, 2006
- Schmiermund, R.L., Parnow C. and Lazo, C. (2006b) Application of Geo-Environmental models to accelerated EIA and permitting processes for an Andean porphyry Cu-Au deposit, 7th ICARD Conference, Denver, Colorado, 2006
- Schmiermund, R.L. and Ranville, J. (2006a) Geo-Environmental and related models in the life cycle of mine development – A flowchart for integration, , 7th ICARD Conference, Denver, Colorado, 2006
- Schmiermund, R.L., 2000, “Non-Acidic, Sulfate-Poor, Copper-Enriched Drainage from a Precambrian Stratabound Chalcopyrite/Pyrite Deposit, Carbon County, Wyoming,” Proceedings from the Fifth International Conference on Acid Rock Drainage (ICARD 2000), Soc. Mining Metallurgy, and Exploration, Littleton, Colorado, pp. 1059-1070.
- Schmiermund, R.L., and M.A. Drozd, 1997, “Acid Mine Drainage and Other Mining-Influenced Waters (MIW),” Chapter 13 in *Mining Environmental Handbook*, Jerrold J. Marcus (ed.), Imperial College Press, London.
- Ranville, J.F., and R.L. Schmiermund, 1998, “An Overview of Environmental Colloids,” Chapter 2 in *Perspectives in Environmental Chemistry*, Donald Maclady (ed.), Topics in Environmental Chemistry series, Oxford-University Press, London.
- Ranville, J.F., and R.L. Schmiermund, 1993, “Aspects of aquatic colloids in environmental geochemistry,” in *The Environmental Geochemistry of Mineral Deposits, Reviews in Economic Geology*, Plumlee, et al. (eds.), Soc. Econ. Geol. Reviews in Economic Geology 6A, seminar presentation by second author, Denver, Colorado, April 13-15.
- Schmiermund, R.L., R.L. Henry, and P.A. Nixon, 1995, “Application of binary mixing models to the interpretation of nitrate and radionuclide behavior in the vadose and saturated zones beneath the Solar Evaporation

Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado,”
Proceedings, Waste Management ‘95, Tucson, Arizona, February 26-29.

Schmiermund, R.L., G.E. Kishiyama, and D. Langmuir, 1990, “An environmentally controlled laboratory simulation and comprehensive dynamic modeling of acidic precipitation runoff in contact with carbonate building stone,” presented by first author at the International Conference on Acidic Precipitation, Glasgow, Scotland, September 16-21.

Langmuir, D., M. Banes, and R.L. Schmeirmund, 1990, “Weathering of Portland cement and lime mortars,” abstract.

Langmuir, D., R.L. Schmiermund, and G.E. Kishiyama, 1989, “Laboratory Measurement and Modeling of Carbonate Stone Weathering by Acid Rain,” *Annual Report, National Park Service*, November, 77 pp.

Schmiermund, R.L., G.E. Kishiyama, and D. Langmuir, 1988, “Acid Rain Weathering of Carbonate Stone Surfaces: Development of A Dynamic Chemical Model Based of Laboratory Runoff Experiments,” A.C.S. Annual Meeting, Chemical Modeling in Aqueous Systems II, Los Angeles, California, September 25-30.

Langmuir, D., R.L. Schmiermund, and G.E. Kishiyama, 1988, “A Laboratory Study of the Acid Rain Weathering of Salem Limestone and Shelburne Marble,” *Annual Report, National Park Service*, October.

Rose, A.W., R.L. Schmiermund, and D.L. Mahar, 1977, “Geochemical Dispersion of Uranium Near Prospects in Pennsylvania,” U.S. Energy Research and Development Administration, Grand Junction, Colorado, GJO-1659-1, 87 pp.



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MARK A. WILLIAMSON, PhD

PROFILE

Dr. Williamson is an environmental geochemist with over 28 years of experience in consulting, basic/applied research and educational settings. Mark has worked extensively in the mining industry and has been involved in geochemical studies and site evaluations across the United States as well the Philippines, Peru, Australia, Indonesia, Argentina, Canada and Mongolia. Dr. Williamson has extensive experience with acid rock drainage (ARD), which began 28 years ago with his PhD graduate studies in the kinetics of pyrite oxidation. His experience has expanded to include characterization of mine material for potential ARD formation using industry standard methods, prediction of water quality from mine facilities, support for engineered construction design of mine waste facilities, pit lake models, and water treatment design support. In addition to ARD, Mark has extensive experience with metals in aquatic and terrestrial environments, engineering geochemistry (including remedial actions), and the fate and transport of chemicals in the environment. Beyond technical project reports and memoranda, Mark has provided expert testimony regarding litigation matters and has testified before the US Congressional Committee for Science, Space and Technology.

EDUCATION

PhD, Geochemistry, Virginia Polytechnic Institute & State University (Virginia Tech), 1992

MS, Chemistry/Geochemistry, Northern Arizona University, 1990

BS, Chemistry, Old Dominion University, 1983

PROFESSIONAL AFFILIATIONS

Geochemical Society

International Association of Geochemistry and Cosmochemistry

International Mine Water Association

American Chemical Society

Mineralogical Society of America

Sigma Xi, The National Scientific Research Society

PRACTICE AREAS

Environmental Geochemistry

Environmental Forensics

Mining Environmental Geochemistry

Engineering Geochemistry

SELECT PROJECT EXPERIENCE

Mining Environmental Geochemistry and Acid Rock Drainage

- ***Kennecott Utah Copper, Salt Lake City, Utah.*** Investigations into geochemistry of copper heap leach solutions related to plume migration in alluvial aquifer, potential engineered hardpan formation for closure, biological sulfate reduction for removal of metal values, formation of secondary mineral phases on mixing of heap leach solutions and unaffected groundwater.
- ***Newmarket Gold Cosmo/Howley Operations, Darwin Australia.*** Senior Geochemist responsible for geochemical characterization of site materials and development of conceptual site model to quantify and control discharge of TDS impacted mine water.
- ***Rosemont Copper Mine, Pit Lake Modeling and Waste Rock Impact Characterization, Arizona.*** Senior Geochemist responsible for oversight of team investigation of geochemistry of waste rock and potential seepage from same to ground water as well as pit lake model of future water quality.
- ***Bird Mine, Pennsylvania.*** Provided expert review of mechanism and processes related to iron production and well scaling in extraction wells for water control in an abandoned coal mine.
- ***Caldwell Canyon Mine, Idaho.*** Provided senior critical review and communications assistance for mine characterization work related to selenium and other constituents in phosphate mining overburden.
- ***Tailings Geochemistry Investigation, Sulawesi, Indonesia.*** As Senior Geochemist, investigated geochemistry of tailings in subaqueous environments related to potential contaminate release..
- ***Kingking Copper/Gold Mine, Philippines.*** Geochemist responsible for leading characterization of potential ARD waste and construction rock as well as mill tailings. Design and schedule characterization program and work with site personnel to implement plan.
- ***Phoenix Mine Waste Rock Geochemical Evolution Monitoring, Nevada.*** Successfully negotiated modified monitoring plan with state and federal agencies to ensure protection of local water resources. Senior Geochemist for development and design of future monitoring of key parameters regulating geochemical evolution of waste rock, including oxygen, moisture and temperature profiles collected using instrumented borings.
- ***Grassy Mountain Gold Mine, Oregon.*** Geochemist developing approaches to mine rock characterization of copper and gold project in initial stages of permitting. Goal to estimate of future water quality through use of laboratory testing and mineralogical analysis.
- ***Copper Basin Mine Rock Geochemical Characterization, Nevada.*** Geochemist leading mine rock characterization of copper and gold project in initial stages of permitting. Estimates of future water quality through use of laboratory testing and mineralogical analysis.
- ***Mine Pit Lake Geochemical Modeling, Yanacocha, Peru.*** Senior Geochemist responsible for geochemical testing of acid rock drainage potential (ARD) of mine rock to develop source terms for pit lake geochemistry model and team coordination on development of numeric simulation of sequential refill of three pit lakes.
- ***Ortiz Mine, New Mexico.*** Geochemist for team-developed coupled geochemical-hydrologic model for prediction of future water quality associated with potential closure alternatives for the Ortiz Mine pit lake. Results of modeling were used as part of negotiated response to citizen action concerning long-term conditions for site.
- ***Shootaring Uranium Mill, Utah.*** Provided an analysis of background geochemical composition of ground water in support of development of long-term monitoring practices and procedures.
- ***Wharf Mine Waste Rock Characterization, Lead, South Dakota.*** Senior Geochemist responsible for oversight and interpretation of waste rock testing and characterization program in support of a mine expansion permit application. Contributed to waste rock disposal design for management of acid rock

drainage (ARD). Provided expert testimony for county and state hearings on the first permit application in South Dakota to receive unanimous approval at city, county and state levels.

- ***Geochemistry of Selenium Release from Phosphate Mining Overburden, Idaho.*** Conducted comprehensive investigation of techniques employed to characterize selenium release as it pertains to permit development and waste management. Designed and conducted field scale investigations to characterize geochemical conditions within overburden, coupled with column leaching to identify principal release mechanisms and magnitudes.
- ***Phosphate Mining District Geochemical Monitoring of Waste Rock Facilities, Idaho.*** Senior Geochemist responsible for design, installation and monitoring of instrumented boreholes to characterize internal geochemical weathering conditions of waste rock. Investigations included both end-dumped facilities and those constructed in lifts by plug-dumping.
- ***ARD material water balance, Mt Todd, Australia.*** Led team evaluation of effects of ARD loading on mine site water balance associated with pit dewatering.
- ***Vale PRC, Mendoza, Argentina.*** Evaluation of geochemical effects on aquifer stability on injection of waste brine from mineral processing.
- ***State of Virginia Uranium Mining Regulation Development.*** Senior geochemist on team that prepared summary/guidance document to support establishing best practices mining regulatory guidelines for uranium and hardrock mining. Advised on appropriate techniques and their application to mine waste materials.
- ***Haraat Uranium Development, Mongolia.*** Conducted studies associated with mineral processing and potential groundwater effects associated with proposed uranium development.
- ***Tanco Mine, Manitoba, Canada.*** Developed mass-loading mixing cell model for potential chemical loading to tailings storage facility associated with deposition of additional tailings.
- ***Cripple Creek and Victor Mine Waste Rock Investigation, Colorado.*** As Senior Geochemist, conducted acid rock drainage (ARD) laboratory testing and interpreted results for waste rock associated with a proposed mine expansion.
- ***Elkhorn Mining District, Montana, Mine Rock and Tailings Geochemistry.*** Characterization of mine rock and potential produced tailings for environmental concerns related to water quality due to acid rock drainage (ARD). Acid-base accounting, humidity cell testing and other leach laboratory test data developed and interpreted for respective role in potential water quality management decision-making.
- ***Belden Mine, Eagle County Colorado.*** Evaluation of seasonal loading of zinc and other metals from historic waste rock facilities to the Eagle River.
- ***Wharf Mine Spent Ore Disposal, Lead, South Dakota.*** Assessed environmental impact of waste rock disposal due to arsenic release. Constructed numerical model to simulate rate of release as well as fate and transport of arsenic and nitrate. Performed laboratory testing of amendments for arsenic attenuation to achieve reduction of impacts.
- ***Lamefoot Mine Expansion Metal Attenuation Investigation, Echo Bay Minerals, Washington.*** As Senior Geochemist, designed and conducted laboratory investigation of metal attenuation from ARD solutions via precipitation and neutralization in support of mine expansion permit. Used results to develop inputs to water quality fate and transport model.
- ***Crown Jewel Mine Water Quality Characterization and Modeling, Washington.*** As Senior Geochemist, contributed to development of background water quality characterization and modeling.

NEPA (EIS and EA)

- **Resolution Mine Environmental Assessment, Arizona.** Senior Geochemist responsible for an EIS evaluation of data adequacy and water quality impacts associated with mine development, including tailings and underground workings.
- **Rochester Mine Environmental Assessment (EA), Nevada.** Senior Geochemist responsible for an EA evaluation of data adequacy and groundwater quality impacts associated with acid rock drainage (ARD) produced by waste rock dumps.
- **Greens Creek Mine Environmental Assessment (EIS), Nevada.** Senior Geochemist responsible for an EIS evaluation of data adequacy and water quality impacts associated with acid rock drainage (ARD) produced by dry stack tailings.
- **Red Dog Mine Supplemental Environmental Impact Statement (EIS), Alaska.** Senior Geochemist responsible for an EIS evaluation of data adequacy and groundwater quality impacts associated with acid rock drainage (ARD) produced by waste rock.
- **Golden Sunlight Mine Environmental Impact Statement (EIS), Montana.** Senior Geochemist responsible for an EIS evaluation of data adequacy and groundwater quality impacts associated with acid rock drainage (ARD) produced by waste rock.

Remedial Action

- **Technical expert copper source forensics and apportionment, United States.** On-going forensic analysis of copper and other metals in aquatic sediments related to remedial action in an urban setting.
- **Senior Geochemist, Forensics.** Lead impacts from industrial and domestic sources in an urban setting. Performed a forensic assessment of relative timing and extent of environmental impacts in support of cost allocation, insurance settlement and remedial action.
- **Chromium Characterization in Soil and Ground Water, Kansas.** Geochemical support for on-going site investigation of soil and ground water contamination by chromium as lead-in to eventual remediation. Principal focus on geochemical speciation of chromium (trivalent vs. hexavalent) to guide remediation targets and goals, establish extent of ground water contamination requiring remediation, and establish background conditions. Major thrust of activity involved development of materials to educate regulatory representatives and public regarding the influence of chromium speciation of toxicity, risk and clean up targets.
- **Wharf Mine Spent Ore Disposal, Lead, South Dakota.** Assessed environmental impact of waste rock disposal due to arsenic release. Constructed numerical model to simulate rate of release as well as fate and transport of arsenic and nitrate. Performed laboratory testing of amendments for arsenic attenuation to achieve reduction of impacts.
- **Abandoned Mine Laboratory Investigation, California.** Senior Geochemist responsible for investigating the rate of sulfide generation in an engineered upflow wetland as a mechanism of metal removal from ARD at an abandoned mine.

Forensic Geochemistry

- **Technical expert metal source forensics and apportionment, United States.** On-going forensic analysis of copper and other metals in aquatic sediments related to remedial action and source apportionment.
- **Expert witness/forensics Zinc Smelter Impacts, United States.** Worked with Washington DC based legal firm in support of assessment of lead (Pb) and other metal contamination at a confidential former smelting location. Employed use of several geochemical fingerprinting techniques to investigate source of metals (smelter vs. domestic) and pursue allocation of damage costs.

- **Expert witness/forensic, Washington.** Worked with Denver, CO based legal firm in support of insurance litigation for recovery of remediation costs associated with a former uranium mine.
- **Expert Analysis Selenium Geochemistry, Idaho.** Prepared expert opinion report regarding evaluation of environmental impact analysis of selenium release from phosphate mining overburden, focusing on assessment of total modeled chemical loading to receiving groundwater.
- **Expert witness/forensic, New Jersey.** Worked with Newark, NJ based legal firm in support of matter related to alleged sulfide mineral contamination of sand from sand manufacture as related to subsequent alleged damage to production of decorative concrete block via pyrite oxidation/staining.
- **Expert consultant, Canada.** Provided expert report to Washington DC based legal firm on technical history of acid mine drainage formation and management in support of insurance settlement proceeding.
- **Senior Geochemist, Forensics.** Lead impacts from industrial and domestic sources. Performed a forensic assessment of relative timing and extent of environmental impacts in support of cost allocation, insurance settlement and remedial action.
- **Project Geochemist, California.** Chromium geochemistry in sediments and local groundwater, as derived from power generating facilities, to establish/dismiss potential pathways to contaminate groundwater.
- **Senior Geochemist Forensics, Illinois.** Zinc impacts from several industrial sources operating on the same plant site. Evaluated sulfur isotopic systematics to quantify relative impacts in support of remediation cost allocation and remedial action.

Environmental Geochemistry

- **Chromium Sludge Pond Closure, North Carolina.** Senior scientist and project manager for project to develop closure plan of sludge pond containing water treatment residue from a chromium processing facility. Consideration of geochemical speciation of chromium (trivalent vs. hexavalent) key focus to maintain long-term chemical stability of sludge. Addressed related issue to potential hazardous waste classification of sludge based upon chromium speciation.
- **Chromium Characterization in Soil and Ground Water, Kansas.** Geochemical support for on-going site investigation of soil and ground water contamination by chromium as lead-in to eventual remediation. Principal focus on geochemical speciation of chromium (trivalent vs. hexavalent) to guide remediation targets and goals, establish extent of ground water contamination requiring remediation, and establish background conditions. Major thrust of activity involved development of materials to educate regulatory representatives and public regarding the influence of chromium speciation of toxicity, risk and clean up targets.
- **Ferris-Haggerty Mine, Wyoming, Abandoned Mine Copper Release.** Geochemist for project aimed at understanding the mechanism of copper release from the abandoned mine (collapsed portal) and the the fate and transport of copper downstream from that location.

Engineering Geochemistry

- **Engineering Geochemistry.** Expert due diligence review of confidential in situ copper leach project, metallurgy and environmental geochemistry, related to potential investment.
- **Engineering Geochemistry, Arizona, Dissolution of Chrysocolla.** Laboratory investigation to develop a kinetic rate law for the dissolution of chrysocolla (copper silicate) in acidic lixiviants for the in situ recovery of copper.
- **Engineering Geochemistry, Pennsylvania, Acid Drainage from Road Cuts.** Developed a mitigation program for the avoidance of formation of acid rock drainage from rock produced during road cut construction in pyritic sandstone. Provided characterization procedures, in-field testing, segregation, disposal and monitoring.

- **Engineering Geochemistry, California, Evaporative Disposal.** Constructed dynamic systems model (water balance) for engineered evaporation ponds, linked in series, for purpose of disposal of mill process water. Model accounted for increase in salt (sodium chloride) concentrations, precipitation of salt from solution filling ponds and associated timing for dredging of ponds, and changes in evaporation as a function of increases in salinity.
- **Engineering Geochemistry, Utah, Injection Well Clogging.** As Senior geochemist, evaluated cause of injection well plugging. Determined geochemical mechanism responsible for scaling of well screens (with calcite, calcium carbonate) and produced initial engineering design to modify solution composition prior to injection to avoid future scaling.
- **Engineering Geochemistry, California, Nevada, South Dakota, and Utah.** As Senior Geochemist, participated in various studies to determine parameters germane to engineering design, contaminant migration, waste management, solution mining, engineered wetland construction, and water treatment.
- **Engineering Geochemistry, Utah.** Laboratory investigation of ARD treatment with mineral phosphates to produce chemical hardpans in mine waste rock as a closure opportunity.
- **Engineering Geochemistry.** Investigated an engineered biogenic sulfide treatment system for large-scale treatment of ARD produced during heap leach operations at a copper mine and associated contaminated groundwater.

Oil and Gas

- **Geochemistry of Natural Gas produced waters and environmental consequences.** Expert consultant to natural gas producer on geochemistry related to produced waters and industrial materials as related to potential effects on water resources.
- **Oil Shale Thermal Degradation Evaluation, Colorado.** As Senior Geochemist, performed a geochemical evaluation of oil shale thermal degradation for groundwater remediation. Analyzed organic compound generation and inorganics such as selenium, arsenic, boron and fluoride. Conducted laboratory investigation to characterize attenuation of chemicals of concern through adsorption processes.
- **Engineering Geochemistry, Colorado, Oil Production Waste Injection.** Evaluated observed overpressuring of oil/gas production water injection wells to identify potential geochemical controls on plugging. Differentiated between near- and far-field mechanisms, characterized geochemical features injection waters to develop potential treatment alternatives to alleviate plugging that led to overpressuring.

Other Geochemical Projects

- **Environmental Impacts of Hazardous Waste Disposal, Utah.** Senior Geochemist tasked with determining environmental impacts of hazardous waste disposal. Included numerical modeling, interpretation for regulatory agency personnel, and general permit support.
- **Natural ARD Characterization, Colorado.** Field study of naturally occurring ARD in Colorado, including comparison and contrast with mining ARD in associated districts.
- **Abandoned Mine Laboratory Investigation, California.** Senior Geochemist responsible for investigating the rate of sulfide generation in an engineered upflow wetland as a mechanism of metal removal from ARD at an abandoned mine.
- **Applied Geochemical Research for Oil Exploration, Gulf of Mexico.** As Visiting Research Scientist, performed applied geochemical research on the geochemical systematics in surficial sediments of the Gulf of Mexico as an aid to exploration. Identified sulfur geochemical relationships that significantly increased the percentage of producing wells in an overall exploration program.
- **Kinetics and Rate-Determining Step of Aqueous Pyrite Oxidation.** Basic laboratory research of a rate law describing pyrite kinetics for a wide range of solution compositions. Reconciled lab data from multiple researchers spanning decades of research. Identified electron transfer as the rate determining

step of the process. Published findings in premier research journal, which is a top-cited publication in geosciences.

- ***Kinetics of the Decomposition of the Aqueous Ferric Iron-Thiosulfate Complex.*** Basic laboratory research of a rate law describing the reaction between ferric iron and thiosulfate, postulated as a key intermediate step in the production of sulfate from pyrite during aqueous oxidation.
- ***Thermodynamic Modeling of Aqueous Sulfur.*** Basic computation research correlating the thermodynamic properties of aqueous sulfur ions with their molecular structure.
- ***Diagenesis of Metals in Lake Sediments, Arizona.*** Field and laboratory research into geochemical processes that result in metal accumulation and release from high elevation lake sediments.

PUBLICATIONS

Williamson, Mark A. (2015) Pyrite oxidation in well-constrained humidity cell tests. International Conference for Acid Rock Drainage; proceedings; Santiago, Chile.

Keller, J.M., Busker, L.T., Milczarek, M.A., Rice, R.C. and **Williamson, Mark A.** (2011) Monitoring the geochemical evolution of waste rock at Newmont's Phoenix Mine. Proceedings of the Mine Closure Conference, September 18-21, Lake Louise, Alberta, Canada.

Williamson, Mark A., Kirby CS, Rimstidt JD. (2006) Iron dynamics in acid mine drainage. International Conference for Acid Rock Drainage; proceedings; St. Louis, MO.

Eary TE, **Williamson Mark A.** (2006) Simulations of the neutralizing capacity of silicate rocks in acid mine drainage environments. International Conference for Acid Rock Drainage; proceedings; St. Louis, MO.

Williamson Mark A. (1999) The geochemistry of iron. In: Marshall C, Fairbridge R, editors. The Encyclopedia of Geochemistry. Kluwer Publishers. p 348-53.

Williamson Mark A. (1999) The geochemistry of copper. In: Marshall C, Fairbridge R, editors. The Encyclopedia of Geochemistry. Kluwer Publishers. p 101-02.

Williamson Mark A., Rimstidt JD. (1994) The kinetics and electrochemical rate determining step for aqueous pyrite oxidation. Geochim. Cosmochim. Acta 58: 5443-54.

Williamson Mark A., Parnell RA, Jr. (1994) Partitioning of copper and zinc in the sediments and porewaters of a high-elevation alkaline lake, east-central Arizona, U.S.A. Applied Geochemistry 9:597-608.

Williamson Mark A., Rimstidt JD. (1993) The rate of decomposition of the ferric thiosulfate complex in acidic solutions. Geochim. Cosmochim. Acta 57:3555-61.

Williamson Mark A., Rimstidt JD. (1992) Correlation between structure and thermodynamic properties of aqueous sulfur species. Geochim. Cosmochim Acta 56:3867-80.

Williamson Mark A., Knight CL. (1989) Characterization of authigenic zeolite phases in vapor dominated hydrothermal systems with micro-Raman spectroscopy. In: Russell, PE, editor. Microbeam Analysis. p 574.

Knight CL, **Williamson Mark A.,** Bodnar RJ. (1989) Raman spectroscopy of zeolites: Characterization of natural zeolites with the laser raman microprobe. In: Russell, PE, editor. Microbeam Analysis. p 571.

Williamson Mark A.. (1989) Determination of copper with graphite furnace atomic absorption spectrophotometry: A student exercise in instrumental methods of analysis. J. Chem. Ed. 66:261-63.

PRESENTATIONS

- Williamson, Mark A.** (2015) Pyrite oxidation in well-constrained humidity cell tests. International Conference for Acid Rock Drainage; proceedings; Santiago, Chile.
- Williamson, Mark A.** (2015) Calibrating humidity cell tests. Society for Mining, Metallurgy and Exploration Annual conference. Denver, 2015.
- Williamson, Mark A.** (2014) Pyrite Oxidation in Well-Constrained Humidity Cells. Geological Society of America Program with Abstracts.
- Williamson, Mark A.** (2013) Pyrite Oxidation in Unsaturated Settings. Geological Society of America Program with Abstracts.
- Williamson, Mark A.** (2010) Integrating Field and Laboratory Data to Understand Selenium Geochemistry in the Idaho Phosphate Mining District. Geological Society of America Program with Abstracts.
- Williamson, Mark A.** and Rimelman, R (2010) Avoiding Water Quality Pitfalls In Mine Permitting. Northwest Mining Association Annual Meeting Short Course, December. Spokane, WA.
- Williamson, Mark A.** and Rimelman, R (2009) Avoiding Water Quality Pitfalls In Mine Permitting. Northwest Mining Association Annual Meeting Short Course, December. Reno, NV.
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EXPERIENCE

Principal Geochemist, Geochemical Solutions, LLC, 2010 - present
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Principal Geochemist, Geochemical Solutions, LLC, 2001 to 2003
Principal Geochemist, Adrian Brown Consultants, Inc., 1997 to 2001
Senior Geochemist, Adrian Brown Consultants, Inc., 1992 to 1997
Pre-Doctoral Fellow/PhD Research, Department of Geological Sciences, Virginia Tech, 1988 to 1992
Research Geochemist, ARCO Oil and Gas Company, Geochemical Exploration Group, 1990
Teaching Assistant, Virginia Polytechnic Institute and State University, 1988 to 1992
Chemical Instrumentation Laboratory Supervisor, Northern Arizona University, 1984 to 1988
Chemistry Instructor, Department of Chemistry, Tidewater Community College, 1983 to 1984

AWARDS

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