

JOHN J. MAHONEY, Ph.D.
PRINCIPAL GEOCHEMIST
MAHONEY GEOCHEMICAL CONSULTING LLC

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EDUCATION

Ph.D., Geochemistry, Colorado School of Mines, Golden, Colorado, 1989

M.A., Geology, Boston University, Boston, Massachusetts, 1977

B.A., Geology, Boston University, Boston, Massachusetts, 1975

SUMMARY

Dr. John Mahoney is Principal Geochemist with Mahoney Geochemical Consulting LLC. Dr. Mahoney specializes in Aqueous Environmental Geochemistry and hydrogeochemical modeling as applied to industrial and mining related projects. He has conducted detailed studies and geochemical modeling for various mining operations (in North America, South America, Indonesia and South Africa) and for contaminated sites (fuels spills, chlorinated solvents and metals) primarily in the Western United States.

He conducted detailed laboratory testing and geochemical modeling to reduce the concentrations of soluble arsenic at a tailings management facility for a uranium mine in Saskatchewan. In support of the licensing of the Midwest Uranium Project he performed laboratory testing to develop reducing conditions to manage arsenic in waste rock. He also developed a testing procedure to evaluate the proportion of readily releasable arsenic in tailings.

Other work has included predicting the chemical composition of pit lakes in open pit mines in Nevada (gold mines), Canada (proposed nickel mine and several proposed diamond mines) and South America (copper mines), and predicting the composition of discharges for a copper mine in Indonesia.

He was involved in modeling the chemical composition of discharges from a proposed block cave copper mine in Arizona. Other project activities included design of remediation plan for an open pit uranium mine in New Mexico; development of a kinetic based leaching model for in-situ recovery of uranium, performed waste rock and tailings characterization for copper mines in Peru, evaluated the need for tailings pond liner for a mine in Brazil.

He has conducted numerous soil vapor surveys, and groundwater sampling programs at refineries, service stations, pharmaceutical, aerospace and electronic manufacturing sites. He has also conducted numerous fuel fingerprinting studies, and has developed methods to evaluate and model the natural degradation of organic compounds. He has experience in the analysis and evaluation of the fate of organic compounds including chlorinated solvents, fuel products, and explosives at various sites. He has modeled the degradation of chlorinated solvents in groundwater in sites in California and Oregon. He prepared detailed technical reports demonstrating the

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feasibility of natural degradation of chlorinated solvents. He also has extensive experience in laboratory data validation and data analysis, and laboratory qualifications audits. He served as the Project Manager for the first technical impracticability waiver accepted by the USEPA for a site contaminated with metals (arsenic including organo-arsenical compounds).

Dr. Mahoney commonly uses classical geochemical methods and stable isotope ratio analyses to solve problems related to mining hydrology. These projects have included: evaluating source of chloride-rich brines for a diamond mine in Ontario, Canada; identifying sources of groundwater in an underground gold mine in Nevada; determining nature of discharge from a closed underground mine in southwestern Colorado, identification of water sources for a landslide near Denver, Colorado and identifying chemical nature and origin of waters in diamond mines in Ontario and the Northwest Territories, Canada.

EXPERIENCE

Principal Geochemist, Mahoney Geochemical Consulting LLC - September 2009 to Present

Conducted geochemical modeling and statistical evaluation of lead, zinc and copper data in river water for a litigation driven project. Evaluated acid rock drainage issues and issues related to trace metal mobility in tailings and waste rock at gold mines in Brazil. Evaluated the nature and source of arsenic in mine wastes (gold and arsenic smelter) in Mexico. Modeled reactions (describing uranium dissolution and sorption) between uranium and bicarbonate in a uranium mill tailings management facility. Reviewed the geochemical conditions related to the long term stability of molybdenum in a tailings management facility; work included a review of stability constants for molybdenum bearing minerals and geochemical modeling. Evaluated the behavior of mine discharge waters for an underground mine near Triumph, Idaho.

Principal Geochemist, MWH Americas, Inc. Denver and Steamboat Springs, CO - September 2006 to September 2009

Conducted geochemical characterization (waste rock and tailings) and pit lake studies for various mines in Peru. Evaluated the fate of uranium for a former open pit mine in New Mexico and developed a microcosm testing plan to evaluate the remediation of the pit lake through addition of an organic substrate. Designed and conducted laboratory tests to control arsenic concentrations in waste rock by developing reducing conditions through addition of organic substances to a uranium mine pit lake. Prepared detailed tech memo summarizing the geochemical behavior of arsenic for a copper mining operation in the western United States. Evaluated the behavior of barium in tailings and developed possible treatment option for a mine in Brazil.

Evaluated geochemical reactions to update analytical parameter list at the landfills of an Air Force Base in Michigan; performed geochemical modeling to evaluate the proposed lead treatment option at a shooting range for an Air Force Base in Missouri. Designed a laboratory characterization program to measure concentration of hydrous ferric oxide in order to evaluate uranium mobility and extent of sorption in sandstones beneath a tailings facility in Utah.

Other projects while at MWH:

Resolution Copper Mining Limited, Superior Arizona

Developed conceptual geochemical model to predict the chemical composition of discharge of waters from a proposed block cave mining operation. Work involved review of geochemical conditions, sample selection and evaluation of rock testing program results.

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Waste Isolation Pilot Plant (WIPP) Carlsbad, New Mexico

As part of the USEPA's Review Team conducted geochemical modeling using EQ3NR/EQ6 to assess reactions related to the breakdown on cellulose, rubber and plastics in the repository, and to determine if methods to control the pH from these reactions were acceptable. Reactions occur in high ionic strength solutions, and required the use of Pitzer Equations. This work was designed to verify assumptions related to the conceptual models related to the chemical aspects of the repository.

Carson Hill Gold Mine, Angels Falls, California

Directed a geochemical characterization program to demonstrate that material in waste rock dumps was not a source of sulfate and therefore should not be classified as a Group B material. Used geochemical modeling to identify reactions that controlled the release of sulfate from the former leach pads. As part of the detailed hydrogeologic characterization performed additional model and fingerprinting of waters from the site. Designed and directed waste characterization testing involving standard humidity cell tests and specialized barrel scale tests. Presented results to California Regional Water Quality Board.

Senior Geochemist, Hydrologic Consultants Inc. Lakewood CO, - December 1991 to September 2006. (List of Selected Projects)

McClellan Lake Operation in the Athabasca Basin (Saskatchewan), Canada

Performed detailed laboratory studies on the neutralization of uranium mill raffinates, data evaluation and geochemical modeling to evaluate treatment options to reduce arsenic concentrations in pore waters in uranium mill tailings for the McClellan Lake Operation (originally COGEMA Resources Inc., now AREVA Resources, Inc.) in Saskatchewan. Designed and reviewed tests used to evaluate long term performance of arsenic retention in the JEB Tailings Management Facility (TMF). Evaluated annual sampling results and performed geochemical modeling to assess performance of JEB TMF. Participated in Joint Federal and Provincial Public Hearings for Midwest Project (Panel Review).

Environment Public Authority, State of Kuwait

Served on a panel of experts for the Chairman of the Board and Director General of the Environment Public Authority, State of Kuwait. The panel evaluated the origin, distribution and impacts of hydrogen sulfide gas in ground water in Kuwait City.

New Mexico Environmental Department (Ground Water Division)

Served as the state-selected third-party reviewer for the New Mexico Environmental Department (Ground Water Division). Work involved evaluating hydrologic and geochemical models to predict long-term impacts to ground water from pit lakes from three open pit copper mines in southwestern New Mexico.

Bureau of Land Management, Yarnell Gold Mine, Arizona

Participated in third party review of proposed Yarnell Gold Mine in Arizona. Prepared sections for Environmental Impact Statement (EIS) for Bureau of Land Management. Completed detailed appendix describing chemical fate and behavior of cyanide in gold mining operations. Assessed adequacy of waste rock sampling, prepared responses to public comments.

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Echo Bay Minerals, McCoy and Cove Mine, Battle Mountain, Nevada

Performed predictive geochemical modeling to predict the chemical composition of the Cove Pit Lake. Work employed evaluation of testing results, coordination with groundwater modeling results, and geochemical modeling using PHREEQC. Work also evaluated impact to pit lake if waste rock was disposed into the pit lake.

Other

- Used geochemical modeling techniques and field analytical methods to assess the fate of iron, barium and manganese in discharge waters from coal-bed methane operation in the Powder River Basin, Wyoming. Predicted impact of coal-bed methane discharge waters on the sodium adsorption ratio (SAR) of rivers in Wyoming.
- Course Organizer and Lead Instructor for the Short Course Introduction to Geochemical Modeling Tools held at the Fifth International Conference on Acid Rock Drainage (ICARD 2000), Denver CO, May 22-23, 2000. As part of responsibilities as a collaborator for a Natural Sciences and Engineering Research Council of Canada (NSERC) grant related to the control of arsenic in mining wastes, presented similar course at Department of Mining, Metallurgy and Materials Engineering at McGill University, Montreal, Quebec, Canada (December 2002). Instructor in Short Course in Environmental Geochemistry and Geochemical Modeling (May 2006, May 2008) at the University of Alberta (Edmonton).
- Used geochemical modeling methods to predict the chemical concentrations of mine discharge waters from a copper mine in Irian Jaya (now West Papua), Indonesia. Work was in support of an Environmental Risk Assessment to evaluate impacts to rivers in the area. Instructed mine Hydrology Staff in geochemical methods as they pertain to fingerprinting and identifying sources of ground water and to improving the capture of acid rock drainage. Modeled acid mine drainage potential from gold mines using the geochemical codes *PHREEQE*, and *MINTEQA2*. Used diffuse-layer adsorption model to predict metal availability in surface waters. Conducted intensive (week long) training sessions to Staff of Environmental Department in Environmental Geochemistry as Applied to Mining (2002), and Geochemical Modeling (2005).

Senior Scientist (Geochemist), Geraghty and Miller, Inc., Denver - February 1988 to November 1991. Coordinated laboratory analyses, interpreted and evaluated data involving contamination of soil and ground water by inorganic and organic substances, and modeled fate of contaminants. Conducted field analyses with portable gas chromatograph and trained others in its use. Designed and supervised soil-vapor surveys at numerous sites in the western U.S. As Western Regional Quality Assurance Officer conducted performance evaluation audits at environmental laboratories and supervised data validation efforts. Applied geostatistical methods to various environmental problems. Evaluated geochemical conditions related to mobility of uranium and other metals at uranium mill tailings sites (UMTRA) in Colorado and Texas. Served on Peer Review Team to evaluate proposed remedial design for the Gunnison, Colorado DOE UMTRA Project Site.

Senior Research Scientist, Battelle Pacific Northwest Laboratory, Chemical Systems Analysis Section, Richland, Washington, - December 1985 to January 1988. Evaluated analytical results from Hydrothermal Testing Program of Basalt Waste Isolation Program (BWIP) and used various geochemical computer codes to determine nature of interactions between spent nuclear fuel, water and rock, and to predict fate of uranium, plutonium and other radionuclides in waste-package environment. Modeled degradation of uranium-doped glasses under various conditions to estimate rate of uranium release into the environment. Compared the performance of PHREEQE,

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EQ3NR/EQ6 and MINTEQ on problems related to Aquifer Thermal Energy Storage. Prepared procedure to evaluate the solubility of plutonium in brines. Researched kinetics of sulfate reduction by hydrogen gas and impacts to the proposed nuclear waste repository (Salt Repository Project, Texas). Qualified as fissile material handler. Held DOE L and Q clearances.

Teaching/Research Assistant, Colorado School of Mines, Department of Chemistry and Geochemistry, Golden, Colorado, - August 1983 to November 1985. Research involved determination and modeling of aqueous species in solutions and ground waters to determine effect of high ionic strength solutions (brines) on cation adsorption on clays. Funded by Department of Energy Office of Nuclear Waste Isolation (OWNI) for proposed nuclear waste repository in salt.

Geologist and Manager of Quality Assurance, Weston Geophysical Corp., Westboro, Massachusetts, June 1977 to July 1983. Work involved applications of mineralogy, petrology, and geochemistry. Served as Site Geologist for Angra Nuclear Center in Brazil. Implemented corporate and client specific Quality Assurance Program complying with 10 CFR 50 Appendix B.

ORGANIZATIONS

American Chemical Society

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PUBLICATIONS/PRESENTATIONS

- Bird, D.A., and *Mahoney, J.J.*, 1994, Estimating post-mining pit lake geochemistry utilizing geochemical and numerical modeling: Reprint of paper presented at 1994 Annual Meeting of Society for Mining, Metallurgy, and Exploration, Albuquerque, New Mexico, 5 p.
- Bird, D.A., and *Mahoney, J.J.*, 2000, Hydrogeochemical tools to define sources of ground-water inflow to surface and underground mines: Proceedings of the XXX IAH Congress on Groundwater: Past Achievements and Future Challenges, Cape Town, South Africa, p. 1091-1097.
- Burse, G.G., *Mahoney, J.J.*, Gale, J.E., Dignard, S.E., Napier, W., Reihm, D., and Downing, B., 1997, Approach used to model pit filling and pit lake chemistry on mine closure - Voisey's Bay, Labrador: Paper presented at Fourth International Conference on Acid Rock Drainage, Vancouver, B.C., Proceedings, vol. 1, p. 255-276.
- Coles, D.G., *Mahoney, J.J.*, and Burnell, J.R., 1986, Observations of selected actinide and fission product chemistry during basalt-repository waste-package hydrothermal experiments containing spent fuel: Paper presented at Northwest Section Meeting of American Chemical Society, Portland, Oregon.
- Emerson, D., Bessler, J., Podolski, M., and *Mahoney, J.*, 2006, Hydrogeologic Characterization of the Gahcho Kué Diamond Project. Presented at 59th Canadian Geotechnical Conference and 7th Joint CGS/IAH-CNC Groundwater Specialty Conference (seatoskygeo.ca), October 2006, Vancouver. Sea to Sky Geotechnique 2006, p. 1723-1728.
- Howell, R.L., Ugorets V.I., and *Mahoney, J.J.*, 2006, Challenges to Hydrogeologic Investigations in the Canadian North. Presented at 59th Canadian Geotechnical Conference and 7th Joint CGS/IAH-CNC Groundwater Specialty Conference (seatoskygeo.ca), October 2006, Vancouver. Sea to Sky Geotechnique 2006, p. 1608-1612.
- Langmuir, D., and *Mahoney, J.J.*, 1984, Chemical equilibrium and kinetics of geochemical processes in ground water studies: in Hitchon, B., and Wallick, E., eds., Practical Applications of Ground Water Geochemistry, National Water Well Association, Dublin, Ohio.
- Langmuir, D., and *Mahoney, J.J.*, 1997, Geochemical controls on arsenic levels in some mine tailings and groundwaters associated with saturated zone tailings disposal: paper presented at International Symposium on Geology and the Environment GeoEnv '97, Istanbul, Turkey, September 1-5.
- Langmuir, D., *Mahoney, J.J.*, MacDonald, A.K., and Rowson, J., 1999, Predicting the arsenic source-term from buried uranium mill tailings: in Proceedings of Tailings and Mine Waste '99, Fort Collins, Colorado, 503-514.
- Langmuir, D., *Mahoney, J.*, MacDonald, A., and Rowson, J., 1999, Predicting arsenic concentrations in the porewaters of buried uranium mill tailings: Geochimica et Cosmochimica Acta, vol. 63, p. 3379-3394.
- Langmuir, D., *Mahoney, J.J.*, Slaughter, M., and Rowson, J.W., 2002, Controlling arsenic concentrations in buried uranium mill tailings: Goldschmidt Conference Abstracts 2002, p. A430.

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Langmuir, D., *Mahoney, J.J.*, and Rowson, J.W., 2002, Arsenic releases from buried uranium mill tailings at McClean Lake: Application of geochemical concepts and license approval by the Canadian Government: Geological Society of America Annual Meeting. Denver. Abstract 201-7.

Langmuir, D., *Mahoney, J.*, and Rowson, J., 2006, Solubility products of amorphous ferric arsenate and crystalline scorodite ($\text{FeAsO}_4 \cdot 2\text{H}_2\text{O}$) and their application to arsenic behavior in buried mine tailings: *Geochimica et Cosmochimica Acta.*, vol. 70, p. 2942-2956.

Liu, H., *Mahoney, J.J.*, and Langmuir, D., 2002, Further refinements of the Davis-Ritchie model of pyrite oxidation in geologic materials associated with mining. Geological Society of America Annual Meeting. Denver. Abstract 84-2.

Mahoney, J.J., 1989, Adsorption of strontium on kaolinite and montmorillonite at high ionic strengths: Ph.D. Dissertation, Colorado School of Mines.

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Mahoney, J.J., 2000, Geochemistry of Coal Bed Methane Discharge Waters - Powder River Basin, Wyoming. Presented at Office of Surface Mining Bond Release Forum, Billings, Montana, September, 2000.

Mahoney, J.J., 2001, Coprecipitation reactions – verification of computational methods in geochemical models: in Mining Impacted Pit Lakes 2000 Workshop Proceedings: a Multimedia CD Presentation. (Workshop held April 4–6, 2000 Reno, NV) United States Environmental Protection Agency Office of Research and Development. EPA/625/C-00/004. Session 4.

Mahoney, J.J., Cadle, S.A., and Jakubowski, R.T., 2009. Uranyl adsorption onto hydrous ferric oxide – a re-evaluation for the diffuse layer model database. *Environmental Science and Technology*. v. 43, no. 24, p. 9260-9266. DOI 10.1021/es901586w.

Mahoney, J.J., and Coles, D.G., 1986, Examination of spent fuel reactions under hydrothermal conditions: Final Program and Abstracts, 1986 Fall Meeting of Materials Research Society.

Mahoney, J.J., and Jakubowski, R.T., 2008, Assessment of uranyl sorption constants on ferrihydrite – Comparison of model derived constants and updates to the diffuse layer model database. *in* Merkel, B.J. and Hasche-Berger, A., eds., *Uranium, Mining and Hydrogeology*; Springer, Berlin, p. 919 – 928. (Presented at Uranium Mining and Hydrogeology Congress V, Freiberg, Germany - September 2008).

Mahoney, J.J., Jakubowski, R.T. and Cadle, S.A., 2009, Corrections to the diffuse layer model database for uranyl adsorption onto hydrous ferric oxide - Ramifications for solute transport modeling. (Poster presented at U2009 Global Uranium Symposium, May 2009 Keystone, CO.)

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- Mahoney, J., and Langmuir, D., 1991, Adsorption of Sr on kaolinite, illite and montmorillonite at high ionic strengths, Radiochimica Acta, vol. 54, p. 139-144.*
- Mahoney, J., and Langmuir, D., 2002, The corrected solubility product of scorodite and its application to arsenic behavior in buried mine tailings. Geological Society of America Annual Meeting. Denver. Abstract 84-17.*
- Mahoney, J., Langmuir, D., Gosselin, N., and Rowson, J., 2005, Arsenic readily released to pore waters from buried mill tailings. Applied Geochemistry, Vol. 20 (5), p. 947 –959.*
- Mahoney, J., Langmuir, D., and Rowson, J., 2005, A method to measure arsenic readily released to pore waters from uranium mill tailings, in Merkel, B.J. and Hasche-Berger, A., eds., Uranium in the Environment - Mining Impact and Consequences, Springer, Berlin, p. 97 – 106. (Presented at Uranium Mining and Hydrogeology Congress IV, Freiberg, Germany - September 2005.)*
- Mahoney, J., Langmuir, D., Slaughter, M., and Rowson, J., 2005, Raffinate neutralization experiments at the McClean Lake Mill – removal of arsenic and nickel, in Merkel, B.J. and Hasche-Berger, A., eds., Uranium in the Environment - Mining Impact and Consequences, Springer, Berlin, p. 225 – 234. (Presented at Uranium Mining and Hydrogeology Congress IV, Freiberg, Germany - September 2005.)*
- Mahoney, J.J., Liu, H., Warner, J., and Sterrett, R.J., 1996, In-situ measurement of the rate of vinyl chloride degradation in a gravel aquifer: abstract and poster session presentation at the Conference on Intrinsic Remediation of Chlorinated Solvents, Salt Lake City, Utah, April 2.*
- Mahoney, J., Slaughter, M., Langmuir, D., and Rowson, J., 2007, Control of As and Ni releases from a uranium mill tailings neutralization circuit: Solution chemistry, mineralogy, and geochemical modeling of laboratory study results. Applied Geochemistry, Vol. 22, (12) p. 2758 – 2776.*
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