# REFERENCES

# Some General References

- Brady, K.B.C., Smith, M.W., and Schueck, J., eds., 1998, Coal mine drainage prediction and pollution prevention in Pennsylvania: The Pennsylvania Department of Environmental Protection, 18 chapters. (Available online at http://www.dep.state.pa.us/dep/deputate/minres/districts/cmdp/main.htm)
- Church, S.E., von Guerard, P., and Finger, S.E., eds., in press (2003), Integrated investigations of environmental effects of historical mining in the Animas River watershed, San Juan County, Colorado: U.S. Geological Survey Professional Paper 1651. (Will be available online at http://pubs.usgs.gov/products/books/profpaper.html)
- Ferderer, D.A., 1996, National overview of abandoned mine land sites--utilizing the minerals availability system (MAS) and geographic information system (GIS) technology: U.S. Geological Survey Open-File Report 96-549. (Available online at <u>http://greenwood.cr.usgs.gov/pub/open-file-reports/ofr-96-0549/anchor594454>.</u>)
- Filipek, L.H., and Plumlee, G.S., eds., 1999, The environmental geochemistry of mineral deposits, Part B: case studies and research topics, Reviews in Economic Geology, vol. 6B: Littleton, Colorado, Society of Economic Geologists, Inc., 211 p. (See <u>https://inet2.agiweb.org/seg/pubdetail.html?item=REV06</u>)
- Hudson, T.L., Fox, F.D., and Plumlee, G.S., 1999, Metal mining and the environment, AGI Environmental Awareness Series 3: Alexandria, Virginia, American Geological Institute, 64 p. (See <u>http://www.agiweb.org/pubs/pubdetail.html?item=604002</u>)
- ICARD 2000: Proceedings from the Fifth International Conference on Acid Rock Drainage (Published by Society for Mining, Metallurgy, and Exploration, Inc., 1658 pages, 2 volumes). (See <u>http://www.smenet.org/store/bookstore/ViewProductInfo.cfm?ItemKey=PUBLBO</u> <u>OKICARD</u>)
- ICARD 2003: Proceedings from the Acid Rock Drainage Sixth International Conference, 14 - 17 July 2003, Cairns, North Queensland, Australia (See <u>http://www.acmer.com.au/</u>)
- Jambor, J.L., and Blowes, D.W., eds., 1994, The environmental geochemistry of sulfide mine-wastes, Short Course Handbook Vol. 22: Nepean, Ontario, Mineralogical Association of Canada, 438 p. (See <u>http://www.mineralogicalassociation.ca/</u>)

- Jambor, J.L., Blowes, D.W., and Ritchie, A.I.M., eds., 2003, Environmental aspects of mine wastes, Short Course Handbook Vol. 31: Ottawa, Mineralogical Association of Canada, 430 p. (See <u>http://www.mineralogicalassociation.ca/</u>)
- King, T.V., ed., 1995, Environmental considerations of active and abandoned mine lands: Lessons from Summitville, Colorado: U.S. Geological Survey Bulletin 2220, 38 p. (Available online at <u>http://pubs.usgs.gov/bul/b2220/b2220.html</u>)
- Marcus, J.J., ed., 1997, Mining environmental handbook--effects of mining on the environment and American environmental controls on mining: London, Imperial College Press, 785 p.
- MEND Manual, 2001, summarizes the work completed by Mine Environment Neutral Drainage (MEND) in Canada in a six-volume set. (See http://www.nrcan.gc.ca/mms/canmet-mtb/mmsl-lmsm/mend/mendmanual-e.htm)
- Ministry of Energy and Mines and Ministry of Environment, Lands and Parks, 1998, Policy for metal leaching and acid rock drainage at minesites in British Columbia. (Available online at <u>http://www.em.gov.bc.ca/mining/mineper/ardpolicy.htm</u>)
- Moore, J.N., and Luoma, S.N., 1990, Hazardous wastes from large-scale metal extraction—a case study: Environ. Sci. Technol., v. 24, p. 1278-1285.
- Morin, K.A., and Hutt, N.M., 1997, Environmental geochemistry of minesite drainage: practical theory and case studies: Vancouver, MDAG Publishing, 333 p. (See <u>http://www.mdag.com/index-mine.html</u>)
- Nimick, D.A., Church, S.E., and Finger, S.E., eds., in press (2003), Integrated investigations of environmental effects of historical mining in the Basin and Boulder Mining Districts, Boulder River Watershed, Jefferson County, Montana: U.S. Geological Survey Professional Paper 1652. (Will be available online at <u>http://pubs.usgs.gov/products/books/profpaper.html</u>)
- Plumlee, G.S., and Logsdon, M.J., eds., 1999, The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., 371 p. (See <u>https://inet2.agiweb.org/seg/pubdetail.html?item=REV06</u>)
- Price, W.A., 1997, DRAFT guidelines and recommended methods for the prediction of metal leaching and acid rock drainage at minesites in British Columbia: British Columbia Ministry of Employment and Investment, Energy and Minerals Division, 159 p.
- Price, W.A., and Errington, J.C., 1998, Guidelines for metal leaching and acid rock drainage at minesites in British Columbia: B.C. Ministry of Energy and Mines. (Available online at <u>http://www.em.gov.bc.ca/mining/mineper/ardguide.htm</u>)

- Smith, K.S., Briggs, P.H., Campbell, D.L., Castle, C.J., Desborough, G.A., Eppinger, R.G., III, Fitterman, D.V., Hageman, P.L., Leinz, R.W., Meeker, G.P., Stanton, M.R., Sutley, S.J., Swayze, G.A., and Yager, D.B., 2000, Tools for the rapid screening and characterization of historical metal-mining waste dumps, in Proceedings of the 2000 Billings Land Reclamation Symposium, Billings, Montana, March 20-24, 2000: Bozeman, Montana State University, Reclamation Research Unit Publication No. 00-01 (CD-ROM), p. 435-442. (Available online at http://crustal.usgs.gov/minewaste/pdfs/ksmith\_billings.pdf)
- Smith, K.S., Campbell, D.L., Desborough, G.A., Hageman, P.L., Leinz, R.W., Stanton, M.R., Sutley, S.J., Swayze, G.A., and Yager, D.B., 2002, Toolkit for the rapid screening and characterization of waste piles on abandoned mine lands, in Seal, R.R., II and Foley, N.K., (eds.), Progress on Geoenvironmental Models for Selected Mineral Deposit Types, Chapter C: U.S. Geological Survey Open-File Report 02-0195 (on-line Version 1.0). (Available online at <u>http://pubs.usgs.gov/of/2002/of02-195/</u>)
- U.S. Environmental Protection Agency, 2000, Abandoned mine site characterization and cleanup handbook, EPA Regions 8, 9, 10: EPA 910-B-00-001, 11 chapters. (Available online at http://www.ott.wrcc.osmre.gov/library/hbmanual/epa530c.htm#download)
- U.S. Geological Survey, 1999, The USGS Abandoned Mine Lands Initiative—Protecting and restoring the environment near abandoned mine lands: U.S. Geological Survey Fact Sheet 095-99, 2 p. (Available online at <u>http://www.usgs.gov/themes/factsheet/095-99/index.html</u>

# **Some General Resources**

Rocky Mountain Regional Hazardous Substance Research Center: <u>http://www.engr.colostate.edu/hsrc/</u>

U.S. Geological Survey Mineral Resources Program: <u>http://minerals.usgs.gov/</u>

U.S. Geological Survey Mine Waste Characterization: <u>http://crustal.usgs.gov/minewaste/</u>

Hazardous Substance Research Centers (HSRC), a national organization that carries out an active program of basic and applied research, technology transfer, and training: <u>http://www.hsrc.org/</u>

Mining Life-Cycle Center (MLC): <u>http://www.unr.edu/mines/mlc/</u>

National Mine Land Reclamation Center (NMLRC), West Virginia University: <u>http://www.nrcce.wvu.edu/nmlrc/index.htm</u>

Acid Drainage Technology Initiative (ADTI) metals mining group: <u>http://www.unr.edu/mines/adti</u>

MEND, A co-operative research program that is directed by a partnership of the Canadian mining industry, federal and provincial governments, and non-government organizations. The original program and its subsequent initiative MEND2000 have contributed enormously to the understanding of acidic drainage and how to prevent it: <u>http://www.nrcan.gc.ca/mms/canmet-mtb/mmsl-lmsm/mend/default\_e.htm</u>

Australian Center for Mining Environmental Research (ACMER): <u>http://www.acmer.com.au/</u>

The International Network for Acid Prevention: <u>http://www.inap.com.au/inap/homepage.nsf</u>

EnviroMine: Environmental Technology for the Mining Industry: <u>http://www.infomine.com/technology/enviromine/</u>

The Society for Mining, Metallurgy, and Exploration Inc. (SME): <u>http://www.smenet.org/</u>

Society of Economic Geologists: <u>http://www.segweb.org/</u>

Geological Society of America: <u>http://www.geosociety.org/</u>

The Society of Environmental Toxicology and Chemistry (SETAC): <u>http://www.setac.org/</u>

Research on Mining Impacts (National Center for Environmental Research, ORD, EPA): <u>http://es.epa.gov/ncer/publications/topical/mining.html#OTHER\_RESEARCH</u>

Mine Waste Technology Program (National Risk Management Research, ORD, EPA): <u>http://www.epa.gov/ORD/NRMRL/std/mtb/mwtphome.html</u>

U.S. Geological Survey Abandoned Mine Lands: <u>http://amli.usgs.gov/</u>

U.S. Geological Survey Mine Drainage Interest Group (MDIG): <u>http://mine-drainage.usgs.gov/</u>

U.S. Geological Survey Toxic Substances Hydrology Program: <u>http://toxics.usgs.gov/</u>

Bureau of Land Management Abandoned Mine Lands: <u>http://www.blm.gov/aml/</u>

U.S. Office of Surface Mining Abandoned Mine Land Reclamation: <u>http://www.osmre.gov/zintro2.htm</u>

Mining Environment Database: http://www.laurentian.ca/library/medlib.htm

Dictionary of Geologic Terms: <u>http://www.geotech.org/survey/geotech/dictiona.html</u>

# **IB.** Fundamentals of Mine-Drainage Formation and Chemistry

- Alpers, C.N., and Blowes, D.W., eds., 1994, Environmental geochemistry of sulfide oxidation: Washington, D.C., American Chemical Society Symposium Series 550, 681 p.
- Alpers, C.N., Blowes, D.W., Nordstrom, D.K., and Jambor, J.L., 1994, Secondary minerals and acid mine-water chemistry, in Jambor, J.L., and Blowes, D.W., eds., Environmental geochemistry of sulfide mine-wastes, MAC Short Course Handbook Vol. 22: Nepean, Ontario, Mineralogical Association of Canada, p. 247-270.
- Bigham, J.M., and Nordstrom, D.K., 2000, Iron and aluminum hydroxysulfates from acid sulfate waters, in Alpers, C.N., Jambor, J.L., and Nordstrom, D.K., eds., Sulfate minerals: crystallography, geochemistry, and environmental significance, Reviews in Mineralogy and Geochemistry, v. 40: Washington, D.C., Mineralogical Society of America and The Geochemical Society, p. 351-403.
- Cravotta, C.A., III, 1994, Secondary iron-sulfate minerals as sources of sulfate and acidity: The geochemical evolution of acidic ground water at a reclaimed surface coal mine in Pennsylvania, in Alpers, C.N., and Blowes, D.W., eds., Environmental geochemistry of sulfide oxidation: Washington, D.C., American Chemical Society Symposium Series 550, p. 345-364.
- Forstner, U., and Wittmann, G., 1979, Metal pollution in the aquatic environment: Berlin, Springer, 486 p.

- Jambor, J.L., Nordstrom, D.K., and Alpers, C.N., 2000, Metal-sulfate salts from sulfide mineral oxidation, in Alpers, C.N., Jambor, J.L., and Nordstrom, D.K., eds., Sulfate minerals: crystallography, geochemistry, and environmental significance, Reviews in Mineralogy and Geochemistry, v. 40: Washington, D.C., Mineralogical Society of America and The Geochemical Society, p. 305-350.
- Mills, A.L., 1999, The role of bacteria in environmental geochemistry, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 125-132,
- Nordstrom, D.K., 1982, Aqueous pyrite oxidation and the consequent formation of secondary iron minerals, in Kittrick, J.A., Fanning, D.S., and Hossner, L.R., eds., Acid sulfate weathering, SSSA Special Publication No. 10: Madison, Wisconsin, Soil Science Society of America, p. 37-56.
- Nordstrom, D.K., 1999, Some fundamentals of aqueous geochemistry, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 117-123.
- Nordstrom, D.K., and Alpers, C.N., 1999, Geochemistry of acid mine waters, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 133-160.
- Rawlings, D.E., Tributsch, H., and Hansford, G.S., 1999, Reasons why '*Leptospirillum*'like species rather that *Thiobacillus ferrooxidans* are the dominant iron-oxidizing bacteria in many commercial processes for the biooxidation of pyrite and related ores: Microbiology, v. 145, p. 5-13.
- Ritchie, A.I.M., 1994, The waste-rock environment, in Jambor, J.L., and Blowes, D.W., eds., Environmental geochemistry of sulfide mine-wastes, MAC Short Course Handbook Vol. 22: Nepean, Ontario, Mineralogical Association of Canada, p. 133-161.
- Rose, A.W., and Cravotta, C.A., III, 1998, Geochemistry of coal mine drainage, in Brady, K.B.C., Smith, M.W., and Schueck, J., eds., Coal mine drainage prediction and pollution prevention in Pennsylvania: The Pennsylvania Department of Environmental Protection, chapter 1. (Available online at http://www.dep.state.pa.us/dep/deputate/minres/districts/cmdp/chap01.html)
- Salomons, W., and Forstner, U., 1984, Metals in the hydrocycle: Berlin, Springer-Verlag, 349 p.

- Schrenk, M.O., Edwards, K.J., Goodman, R.M., Hamers, R.J., and Banfield, J.F., 1998, Distribution of *Thiobacillus ferrooxidans* and *Leptospirillum ferrooxidans*: Implications for generation of acid mine drainage: Science, v. 279, p. 1519-1522.
- Singer, P.C., and Stumm, W., 1970, Acidic mine drainage: the rate-determining step: Science, v. 167, p. 1121-1123.
- Smith, K.S., and Huyck, H.L.O., 1999, An overview of the abundance, relative mobility, bioavailability, and human toxicity of metals, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 29-70.

- Alpers, C.N., and Nordstrom, D.K., 1999, Geochemical modeling of water-rock interactions in mining environments, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 289-323.
- Bayless, E.R., and Olyphant, G.A., 1993, Acid-generating salts and their relationship to the chemistry of groundwater and storm runoff at an abandoned mine site in southwestern Indiana, USA: Journal of Contaminant Hydrology, v. 12, p. 313-328.
- Bigham, J.M., Schwertmann, U., Traina, S.J., Winland, R.L., and Wolf, M., 1996, Schwertmannite and the chemical modeling of iron in acid sulfate waters: Geochimica et Cosmochimica Acta, v. 60, p. 2111-2121.
- Blowes, D.W., and Jambor, J.L., 1990, The pore-water geochemistry and the mineralogy of the vadose zone of sulfide tailings, Waite Amulet, Quebec, Canada: Applied Geochemistry, v. 5, p. 327-346.
- Brierley, C.L., 1982, Microbiological mining: Scientific American, v. 247, p. 44-53.
- Broshears, R.E., 1996, Reactive solute transport in acidic streams: Water, Air and Soil Pollution, v. 90, p. 195-204.
- Brown, J.G., Bassett, R.L., and Glynn, P.D., 2000, Reactive transport of metal contaminants in alluvium—model comparison and column simulation: Applied Geochemistry, v. 15, p. 35-50.

- Cravotta, C.A., III, Brady, K.B.C., Rose, A.W., and Douds, J.B., 1999, Frequency distribution of the pH of coal-mine drainage in Pennsylvania, in U.S. Geological Survey Toxic Substances Hydrology Program--Proceedings of the Technical Meeting Charleston South Carolina March 8-12,1999--Volume 1 of 3--Contamination From Hard-Rock Mining: U. S. Geological Survey Water-Resources Investigation Report 99-4018A. (Available online at <u>http://toxics.usgs.gov/pubs/wri99-</u> <u>4018/Volume1/sectionD/1507\_Cravotta/index.html</u>)
- Cravotta, C.A., III, and Bilger, M.D., 2001, Water-quality trends for a coal-mined watershed in Eastern Pennsylvania: Geochemistry--Exploration, Environment, Analysis, v. 1, p. 33-50. (Available at <u>http://mine-</u> <u>drainage.usgs.gov/pubs/cravotta/geaa\_final.pdf</u>)
- Drever, J.I., 1997, The geochemistry of natural waters, third edition: Prentice Hall, 436 p.
- Evangelou, V.P., 1995, Pyrite oxidation and its control: CRC Press, 293 p.
- Evangelou, V.P., and Zhang, Y.L., 1995, A review: pyrite oxidation mechanisms and acid mine drainage prevention: Critical Reviews in Environmental Science and Technology, v. 25, p. 141-199.
- Fortescue, J.A.C., 1980, Environmental geochemistry, a holistic approach: New York, Springer-Verlag, 347 p.
- Fuller, C.C., and Davis, J.A., 1989, Influence of coupling of sorption and photosynthetic processes on trace element cycles in natural waters: Nature, v. 340, p. 52-54.
- Fuller, C.C., and Harvey, J.W., 2000, Reactive uptake of trace metals in the hyporheic zone of a mining contaminated stream, Pinal Creek, Arizona: Environmental Science and Technology, v. 34, p. 1150-1155.
- Garrels, R.M., and Christ, C.L., 1965, Solutions, minerals and equilibria: San Francisco, Freeman, Cooper & Company, 450 p.
- Gray, J.E., Crock, J.G., and Fey, D.L., 2002, Environmental geochemistry of abandoned mercury mines in west-central Nevada, U.S.A.: Applied Geochemistry, v. 17, p. 1069-1079.
- Harvey, J.W., and Bencala, K.E., 1993, The effect of streambed topography on surfacesubsurface water exchange in mountain catchments: Water Resources Research, v. 29, no. 1, p. 89-98.
- Hem, J.D., 1989, Study and interpretation of the chemical characteristics of natural water, 3rd Edition: U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Jerz, J.K., 2002, Geochemical reactions in unsaturated mine wastes: Ph.D. Dissertation, Virginia Polytechnic Institute and State University, 94 p.

Langmuir, D., 1997, Aqueous environmental geochemistry: Prentice Hall, 600 p.

- McKnight, D.M., Kimball, B.A., and Bencala, K.E., 1988, Iron photoreduction and oxidation in an acidic mountain stream: Science, v. 240, p. 637-640.
- McKnight, D.M., Kimball, B.A., and Runkel, R.L., 2001, pH dependence of iron photoreduction in a Rocky Mountain stream affected by acid mine drainage: Hydrological Processes, v. 15, p. 1979-1992.
- Moses, C.O., and Herman, J.S., 1991, Pyrite oxidation at circumneutral pH: Geochimica et Cosmochimica Acta, v. 55, p. 471-482.
- Murad, E., Schwertmann, U., Bigham, J.M., and Carlson, L., 1994, Mineralogy and characteristics of poorly crystallized precipitates formed by oxidation of Fe in acid sulfate waters, in: Alpers, C.N., and Blowes, D.W., eds., Environmental geochemistry of sulfide oxidation: Washington, D.C., American Chemical Society Symposium Series 550, p. 190-200.
- Nordstrom, D.K., Alpers, C.N., Ptacek, C.J., and Blowes, D.W., 2000, Negative pH and extremely acidic mine waters from Iron Mountain, California: Environ. Sci. Technol., v. 34, p. 254-258. (Available online at http://pubs.acs.org/hotartcl/est/2000/research/es990646v\_rev.html)
- Plumlee, G.S., Smith, K.S., Montour, M.R., Ficklin, W.H., and Mosier, E.L., 1999, Geologic controls on the composition of natural waters and mine waters draining diverse mineral-deposit types, in Filipek, L.H., and Plumlee, G.S., eds., The environmental geochemistry of mineral deposits, Part B: case studies and research topics, Reviews in Economic Geology, vol. 6B: Littleton, Colorado, Society of Economic Geologists, Inc., p. 373-432.
- Ranville, J.F., and Schmiermund, R.L., 1999, General aspects of aquatic colloids in environmental geochemistry, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 183-199.
- Rimstidt J.D., Chermak J.A., and Gagen P.M., 1994, Rates of reaction of galena, sphalerite, chalcopyrite, and arsenopyrite with Fe(III) in acidic solutions, in Environmental geochemistry of sulfide oxidation: Washington, D.C., American Chemical Society Symposium Series 550, p. 2-13.

- Runkel, R.L., and Kimball, B.A., 2002, Evaluating remedial alternatives for an acid mine drainage stream—Application of a reactive transport model: Environmental Science and Technology, v. 36, p. 1093-1101.
- Schmiermund, R.L., and Drozd, M.A., eds., 1997, Acid mine drainage and other mininginfluenced waters (MIW), in Marcus, J.J., ed., Mining environmental handbook: London, Imperial College Press, Chapter 13, p. 599-617.
- Seal, R.R, II, Alpers, C.N., and Rye, R.O., 1999, Stable isotope systematics of sulfate minerals, in Alpers, C.N., Jambor, J.L., and Nordstrom, D.K., eds., Sulfate minerals: crystallography, geochemistry, and environmental significance, Reviews in Mineralogy and Geochemistry, v. 40: Washington, D.C., Mineralogical Society of America and The Geochemical Society, p. 541-602.
- Sherlock, E.J., Lawrence, R.W., and Poulin, R., 1995, On the neutralization of acid rock drainage by carbonate and silicate minerals: Environmental Geology, v. 25, p. 43-54.
- Smith, K.S., Ranville, J.F., Plumlee, G.S., and Macalady, D.L., 1998, Predictive doublelayer modeling of metal sorption in mine-drainage systems, Chapter 24, in Jenne, E.A., ed., Adsorption of metals by geomedia--variables, mechanisms, and model applications: San Diego, California, Academic Press, p. 521-547.
- Smith, K.S., 1999, Metal sorption on mineral surfaces: an overview with examples relating to mineral deposits, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 161-182.
- Stollenwerk, K.G., 1994, Geochemical interactions between constituents in acidic groundwater and alluvium in an aquifer near Globe, Arizona: Applied Geochemistry, v. 9, no. 4, p. 353--369.
- Stumm, W., and Morgan, J.J., 1996, Aquatic chemistry, 3rd Ed.: New York, John Wiley & Sons, 1022 p.
- Williamson, M.A., and Rimstidt, J.D., 1994, The kinetics and electrochemical rate determining step of aqueous pyrite oxidation: Geochim. Cosmochim. Acta, v. 58, p. 5443-5454.
- Younger, P.L., and Robins, N.S., eds., 2002, Mine water hydrogeology and geochemistry, Geological Society Special Publication No. 198: London, The Geological Society, 396 p. (See http://bookstore.aapg.org/detail.html?cat\_no=678&ticket=8385351905148930&u niqueid=200305061735)

Acid Rock Drainage at EnviroMine: <u>http://technology.infomine.com/enviromine/ard/home.htm</u>

Factors controlling acid mine drainage formation, Office of Surface Mining: <u>http://www.osmre.gov/amdform.htm</u>

The Science of Acid Mine Drainage and Passive Treatment, Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation: <u>http://www.dep.state.pa.us/dep/deputate/minres/bamr/amd/science\_of\_amd.htm</u>

Acid Producing Potential of Mine Overburden, Colorado School of Mines: <u>http://www.mines.edu/fs\_home/jhoran/ch126/app.htm</u>

AMD Chemistry, Colorado School of Mines: <u>http://www.mines.edu/fs\_home/jhoran/ch126/amd.htm</u>

Acid Mine Drainage, West Virginia University: <u>http://wvwri.nrcce.wvu.edu/sidebar/amdoverview.php</u>

# IC. Mining Wastes Overview

- Blowes, D.W., Reardon, E.J., Jambor, J.L., and Cherry, J.A., 1991, The formation and potential importance of cemented layers in inactive sulfide mine tailings: Geochim. Cosmochim. Acta, v. 55, p. 965-978.
- Bunyak, D., 1998, Frothers, bubbles, and flotation: a survey of flotation milling in the twentieth-century metals industry: Denver, Colorado, National Park Service, Intermountain Support Office.
- Chase, C.A., and Kentro, D.M., 1938, Tailings disposal practice of Shenandoah-Dives Mining Company: Mining Congress Journal, v. 24, p. 19-21.
- Goonan, T., 2002, Policy -- a factor shaping minerals supply and demand: U.S. Geological Survey Open-File Report 02-418. (Available online at <u>http://pubs.usgs.gov/of/2002/of02-418/</u>)

Henderson, C.W., 1926, Mining in Colorado, A history of discovery, development and production: U.S. Geological Survey Professional Paper 138, 263 p.

- Herring, J. R., Marsh, S. P., and McLemore, V. T., 1998, Major and trace element concentrations and correlations in mine dump samples from mining districts in Sierra, Socorro, and Otero counties, south-central New Mexico--Mockingbird Gap, Lava Gap, Salinas Peak, Goodfortune Creek, Bearden Canyon, and Sulfur Canyon mining districts of the northern San Andres Mountains, Sierra and Socorro County; Lake Valley mining district of Sierra County; and Tularosa and Orogrande mining districts of Otero County: U.S. Geological Survey Open-File Report 98-486, 21 p.
- Jones, W.R., in press, History of mining and milling practices and production in San Juan County, Colorado 1871-1991, in Church, S.E., von Guerard, P., and Finger, S.E., Integrated investigations of environmental effects of historical mining in the Animas River watershed, San Juan County, Colorado: U.S. Geological Survey Professional Paper 1651-C, 48 manuscript pages.
- Kimball, B.A., Broshears, R.E., Bencala, K.E., and McKnight, D.M., 1994, Coupling of hydrologic transport and chemical reactions in a stream affected by acid mine drainage: Environment Science and Technology, v. 28, p. 2065-73.
- Kimball, B.A., 1997, Use of tracer injections and synoptic sampling to measure metal loading from acid mine drainage: U.S. Geological Survey Fact Sheet FS–245– 96, 4 p. (Available online at <u>http://ut.water.usgs.gov/usgsabout/fs245/245.html</u>)
- Kimball, B.A., Runkel, R.L., Walton-Day, K., and Bencala, K.E., 2002, Assessment of metal loads in watersheds affected by acid mine drainage by using tracer injection and synoptic sampling—Cement Creek, Colorado, USA: Applied Geochemistry, v. 17, p. 1183-1207.
- Munroe, E. A. and McLemore, V. T., 1999, Waste rock pile characterization, heterogeneity and geochemical anomalies in the Hillsboro mining district, Sierra County, New Mexico: Journal of Geochemical Exploration, v. 66, p. 389-405.
- Nash, J.T., 2002, Hydrogeochemical Investigations of historic mining areas in the western Humboldt River Basin, Nevada: U.S. Geological Survey Digital Data Series Report DDS-70, 66 p., CD-ROM.
- Nash, J.T., 2002, Hydrogeochemical investigations of historic mining districts, central western slope of Colorado, including influence on surface-water quality: U.S. Geological Survey Digital Data Series 073, 168 p. (Available online at <u>http://pubs.usgs.gov/dds/2002/dds-073/</u>)
- Nuccio, V.F., 2000, Coal-bed methane: Potential and concerns: U.S. Geological Survey Fact Sheet FS-123-00, 2 p. (Available online at <u>http://water.usgs.gov/wid/index-resources.html</u>)

- Rice, C.A., and Nuccio, V.F., 2000, Water produced with coal-bed methane: U.S. Geological Survey Fact Sheet FS-0156-00, 2 p. (Available online at <u>http://water.usgs.gov/wid/index-resources.html</u>)
- Rice, D.D., 1997, Coalbed methane--An untapped energy resource and an environmental concern: U.S. Geological Survey Fact Sheet FS-019-97, 4 p. (Available online at <u>http://energy.usgs.gov/factsheets/Coalbed/coalmeth.html</u>)
- Rickard, T.A., 1932, A history of American mining, AIME series, McGraw-Hill Book Company, Inc., New York and London, 419 p.
- Runkel, R.L., 2000, Using OTIS to model solute transport in streams and rivers: U.S. Geological Survey Fact Sheet 138-99, 4 p. (Available at http://pubs.water.usgs.gov/fac138-99)
- Smith, D.A., 1987, Mining America; The Industry and the Environment, 1800-1980: University Press of Kansas, Development of Western Resources Series, 210 p.
- U.S. Environmental Protection Agency, 1997, Introduction to hard rock mining--a CD-ROM application: U.S. EPA 530-C-97-005, September 1997 (CD-ROM).
- Wagner, R., 1872, A handbook of chemical technology: New York, Charles D. Appleton and Company.
- Walton-Day, Katherine, Rossi, F.J., Gerner, L.J., Evans, J.B., Yager, T.J., Ranville, J.F., and Smith, K.S., 2000, Effects of fluvial tailings deposits on soils and surfaceand ground-water quality, and implications for remediation--Upper Arkansas River, Colorado, 1992-1996: U.S. Geological Survey Water-Resources Investigations Report 99-4273, 100 p.
- Wilburn, D., Goonan, T., and Bleiwas, D., 2001, Technological advancement -- a factor in increasing resource use: U.S. Geological Survey Open-File Report 01-197. (Available at <u>http://pubs.usgs.gov/of/of01-197/</u>)

Mining wastes, U.S. Environmental Protection Agency: <u>http://www.epa.gov/epaoswer/other/mining.htm</u>

Focusing on the problem of mining wastes: www.state.sd.us/denr/documents/amdintro.pdf

Superfund, U.S. Environmental Protection Agency: <u>http://www.epa.gov/superfund/</u>

# **II. Methods to Determine Bioaccessibility of Metals from Waste**

- Allan, R., 1997, Mining and metals in the environment: J. Geochem. Explor., v. 58, p. 95-100.
- Allen, H. E., and Hansen, D. J., 1996, The importance of trace metal speciation to water quality criteria: Water Environ. Res., v. 68, p. 42-54.
- Allen, H.E., ed., 2002, Bioavailability of Metals in Terrestrial Ecosystems: Importance of Partitioning for Bioavailability to Invertebrates, Microbes, and Plants: Pensacola, FL, SETAC Press.
- Allen, H.E., McGrath, S.P., McLaughlin, M.J., Peijnenburg, W.J.G.M., Sauvé, S., 2002, Recommendations for regulatory programs and research, in Allen, H.E., ed., Bioavailability of Metals in Terrestrial Ecosystems: Importance of Partitioning for Bioavailability to Invertebrates, Microbes, and Plants: Pensacola, FL, SETAC Press.
- ASTM, 1997, Standard Guide for Conducting a Laboratory Soil Toxicity Test with Lumbricid Earthworm Eisenia foetida: ASTM E 1676-95, in Annual Book of Standards: Water and Environmental Technology, Volume 11.05: Philadelphia, Pennsylvania.
- ASTM, 2002, Standard guide for conducting acute toxicity tests with fishes, macroinvertebrates, and amphibians, E729-96. American Society for Testing and Materials, West Conshocken, PA, 178-199.
- Basta, N.T.,and Gradwohl, R., 2000, Estimation of heavy metal bioavailability in smelter contaminated soils by a sequential extraction procedure: J. Soil Contam., v. 9, p. 149-164.
- Bennett, J., and Cubbage, J., 1992, Review and Evaluation of Microtox® Test for Freshwater Sediment: Washington State Department of Ecology, Environmental Assessment Program Publication Number 92-e04. Available from <u>http://www.nic.edu/library/superfund/refdocs%5Ccda0164.pdf</u>
- Bitton, G., Garland, E., Kong, I-C., Morel, J.L., Koopman, B., 1996, A Direct Solid-Phase Assay Specific for Heavy Metal Toxicity. I. Methodology: Journal of Soil Contamination, v. 5, no. 4, p. 385-394.
- Brohon, B., and Gourdon, R., 1999, Influence of soil microbial activity level on the determination of contaminated soil toxicity using Lunistox and MetPlate bioassays: Soil Biology & Biochemistry, v. 32, p. 853-857.

- Canadian Council of Ministers of the Environment 1995, Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. [cited 29 April 2003]. Canadian Environmental Quality Guidelines. Available from <u>http://www.ec.gc.ca/ceqg-rcqe/English/Html/sediment\_protocol.cfm</u>
- Dallinger, R., 1993, Strategies of metal detoxification in terrestrial invertebrates, in Dallinger, R., Rainbow, P.S., LaPoint, T., and Greig-Smith, P.W., eds., Ecotoxicology of Metals in Invertebrates: Boca Raton, FL, Lewis Publishers.
- Diamond, J. M., Gerardi, C., Leppo, E., and Miorelli, T., 1997, Using a water-effect ratio approach to establish effects of an effluent-influenced stream on copper toxicity to the fathead minnow. Environ. Toxicol. Chem., 16, 1480-1487.
- Di Toro, D. M, Allen, H. E., Bergman, H. L., Meyer, J. S., and Santore, R. C., 2000, The biotic ligand model: A computational approach for assessing the ecological effects of copper and other metals in aquatic systems. International Copper Association, Ltd.
- Di Toro, D. M., Allen, H. E., Bergaman, H. L., Meyer, J. S., Paquin, P. R., Santore, R. C., 2001, Biotic Ligand Model of the acute toxicity of metals: Technical Basis. Environ. Toxicol. Chem., 20 (10): 2383-2396.
- Dunbar, L. E., 1996, Derivation of s site-specific dissolved copper criteria for selected freshwater streams in Connecticut. Falmouth, MA: Water Toxics Program, Connecticut DEP.
- Erickson, R. J., Benoit, D. A., Mattson, V. R., Nelson, H. P., and Leonard, E. N., 1996, The effects of water chemistry on the toxicity of copper to fathead minnows. Environ. Toxicol. Chem., v. 15, p. 181-193.
- Folsom, Jr., B.L., and Price, R.A., 1991, A Plant Bioassay for Assessing Plant Uptake of Contaminants from Freshwater Soils or Dredged Material, in Gorsuch, J.W., Lower, W.R., Wang, W., Lewis, M.A., eds., Plants for Toxicity Assessment: Second Volume, ASTM STP 1115: American Society for Testing and Materials: Philadelphia, Pennsylvania.
- Gensemer, R. W., Naddy, R. B., Stubblefield, W. A., Hockett, J. R., Santore, R., and Paquin, P., 2002, Evaluating the role of ion composition on the toxicity of copper to Ceriodaphnia dubia in very hard waters. Comp. Biochem. Physiol. C 133, 87-97.
- Greene, J.C., Bartels, C.L., Warren-Hicks, W.J., Parkhurst, B.R., Linder, G.L., Peterson, S.A., Miller, W.E., 1989, Protocols for Short Term Toxicity Screening of Hazardous Waste Sites: EPA 600/3-88/029, February.

- Huang, F., Bitton, G., Kong, I-C., 1999, Determination of the heavy metal binding capacity of aquatic samples using MetPLATE™: a preliminary study: the Science of the Total Environment, v. 234, p. 139-145.
- Janes, N., and Playle, R. C., 1995, Modeling of silver binding to gills of rainbow trout (Oncorhynchus mykiss) Env. Toxicol. Chem., 14, 1847-1858.
- Jung, K., Bitton, G., Koopman, B., 1996, Selective Assay for Heavy Metal Toxicity Using a Fluorogenic Substrate: Environmental Toxicology and Chemistry, v. 15, no. 5, p. 711-714.
- Kinniburg, D., Smedley, P., Ahmad, K.N.U., contacts, Groundwater studies for arsenic contamination in Bangladesh. [cited 30 April 2003]. British Geological Survey, Natural Environment Research Council. Available from <u>http://www.bgs.ac.uk/arsenic/bphase1/B\_find.htm</u>
- Klerks, P.L. and Levinton, J.S., 1993, Evolution of resistance and changes in community composition in metal-polluted environments: A case study on Foundry Cove, in Dallinger, R., Rainbow, P.S., LaPoint, T., and Greig-Smith, P.W., eds., Ecotoxicology of Metals in Invertebrates: Boca Raton, FL, Lewis Publishers.
- Macdonald, A., Silk, L., Schwartz, M., and Playle, R. C., 2002, A lead-gill binding model to predict acute lead toxicity to rainbow trout (Oncorhynuchus mykiss), Comp. Biochem. Physiol. C 133, 227-242.
- MacRae, R. K., Smith, D. E., Swoboda-Colberg, N., Meyer, J. S., and Bergman, H. L., 1999, Copper binding affinity of rainbow trout (Oncorhynuchus mykiss) and brook trout (Salvelinus fontinalis) gills. Environ. Toxicol. Chem. 18, 1180-1189.
- McLaughlin, M.J., 2002, Bioavailability of metals to terrestrial plants, in Allen, H.E., ed., Bioavailability of Metals in Terrestrial Ecosystems: Importance of Partitioning for Bioavailability to Invertebrates, Microbes, and Plants: Pensacola, FL, SETAC Press.
- Meyer, J. S., 1999, A mechanistic explanation for the ln(LC50) vs ln(hardness) adjustment equation for metals. Environ. Sci. Technol., 33, 908-912.
- Meyer, J. S., Santore, R. C., Bobbitt, J. P., Debrey, L., Boese, C., and Paquin, P., 1999, Binding of nickel and copper to fish gills predicts toxicity when water hardness varies but free-ion activity does not. Environ. Sci. Technol. 33, 913-916.
- Naddy, R. B., Stubblefield, W. A., May, J. R., Tucker, S.A., and Hockett, J. R., 2002, The effect of calcium and magnesium ratios on the toxicity of copper to five aquatic species in freshwater. Environ. Toxicol. Chem., 21, 347-352.

- National Academy of Sciences, 2003, Bioavailability of Contaminants in Soils and Sediments: Processes, Tools, and Applications. National Academies Press, Washington DC.
- Nelson, S.M., Roline, R.A., 1998, Evaluation of the Sensitivity of Rapid Toxicity Tests Relative to Daphnid Acute Lethality Test: Bulletin of Environmental Contamination and Toxicology, v. 60, p. 292-299.
- OECD, Test Methods. [revised 2002; cited 13 May 2003]. OECD Guidelines for Testing of Chemicals: Proposal for Updating Guideline 201, Freshwater Alga and Cyanobacteria, Growth Inhibition Test. Available from <u>http://www.oecd.org/pdf/M00033000/M00033169.pdf</u>
- OECD, Test Methods. [revised 2000; cited 13 May 2003]. OECD Guidelines for Testing of Chemicals: Proposal for Updating Guideline 202, Daphnia sp., Acute Immobilization Test. Available from <u>http://www.oecd.org/pdf/M00024000/M00024306.pdf</u>
- OECD, Test Methods. [revised 2000; cited 13 May 2003]. OECD Guidelines for Testing of Chemicals: Proposal for Updating Guideline 208, Terrestrial (Non-Target) Plant Test: 208A: Seedling Emergence and Seedling Growth Test, 208B: Vegetative Vigour Test. Available from http://www.oecd.org/pdf/M00024000/M00024309.pdf
- OECD, Test Methods. [revised 2001; cited 13 May 2003]. OECD Guidelines for Testing of Chemicals: Proposal for a New Guideline 218, Sediment-Water Chironomid Toxicity Test Using Spiked Sediment. Available from <u>http://www.oecd.org/pdf/M00024000/M00024311.pdf</u>
- OECD, Test Methods. [revised 2001; cited 13 May 2003]. OECD Guidelines for Testing of Chemicals: Proposal for a New Guideline 218, Sediment-Water Chironomid Toxicity Test Using Spiked Water. Available from <u>http://www.oecd.org/pdf/M00024000/M00024312.pdf</u>
- Oris, J.T., Winner, R. W., and Moore, M. V., 1991, A four-day survival and reproduction toxicity test for Ceriodaphnia dubia. Environ. Toxicol. Chem. 10, 217-224.
- Pagenkopf, G. K., Russo, R. C., Thurston, R. V., 1974, Effect of complexation on toxicity of copper to fishes. J. Fish. Res. Board Can. 31, 462-465.
- Pagenkopf, G. K., 1983, Gill surface interaction model for trace-metal toxicity to fishes: role of complexation, pH, and water hardness. Environ. Sci. Technol. 17, 342-347.

- Paquin, P. R., Gorsuch, J. W., Apte, S., Bately, G. E., Bowles, K. C., Campbell, P. G. C., Delos, C. G., Di Toro, D. M., Dwyer, R. L., Galvez, F., Gensemer, R. W., Goss, G. G., Hogstrand, C., Janssen, C. R., McGeer, J. C., Naddy, R. B., Playle, R.C., Santore, R. C., Schneider, U., Stubblefield, W. A., Wood, C. M., and Wu, K. B., 2002, The biotic Ligand model: A historical overview. Comp. Biochem. Physiol. C 133, 3-35.
- Pastorok, R.A., and Becker, D.S., 1989, Comparison of Bioassays for Assessing Sediment Toxicity in Puget Sound: EPA 910/9-89-004, May.
- Peijnenburg, W.J.G.M., 2002, Bioavailability of metals to soil invertebrates, in Allen, H.E., ed., Bioavailability of Metals in Terrestrial Ecosystems: Importance of Partitioning for Bioavailability to Invertebrates, Microbes, and Plants: Pensacola, FL, SETAC Press.
- Playle, R. C., Gensemer, R. W., Dixon, D. G., 1992, Copper accumulation on gills of fathead minnows: influence of water hardness, complexation and pH on the gill microenvironment. Environ. Toxicol. Chem, 11, 381-391.
- Playle, R. C., Dixon, D. G., and Burnison, K., 1993a, Copper and cadmium binding to fish gills: modification by dissolved organic carbon and synthetic ligands. Can. J. Fish. Aquatic. Sci. 50, 2667-2677.
- Playle, R. C., Dixon, D. G., and Burnison, K., 1993b, Copper and cadmium binding to fish gills: estimates of metal-gill stability constants and modeling of metal accumulation. Can. J. Fish. Aquatic. Sci. 50, 2678-2687.
- Rainbow, P.S., and Dallinger, R., 1993, Metal uptake, regulation, and excretion in freshwater invertebrates, in Dallinger, R., Rainbow, P.S., LaPoint, T., and Greig-Smith, P.W., eds., Ecotoxicology of Metals in Invertebrates: Boca Raton, FL, Lewis Publishers.
- Rodrigue, D., Mailhiot, K., Hynes, T.P., Wilson, L.J., Blanchette, M., 1995, Aquatic Effects Monitoring in the Mining Industry: Review of Appropriate Technologies. [cited 10 March 2003]. Canada Centre for Mineral and Energy Technology, Natural Resources Canada. Available from <u>http://www.nbiap.vt.edu/brarg/brasym95/rodrigue95.htm</u>
- Santore, R. C., Mathew, R., Paquin, P. R., and Di Toro, D., 2002, Application of the biotic ligand model to predicting zinc toxicity to rainbow trout, fathead minnow, and Daphnia Magna, Comp. Biochem. Physiol. C 133, 271-286.
- Sauvé, S., 2002, Speciation of metals in soils, in Allen, H.E., ed., Bioavailability of Metals in Terrestrial Ecosystems: Importance of Partitioning for Bioavailability to Invertebrates, Microbes, and Plants: Pensacola, FL, SETAC Press.

- Timmermans, K.R., 1993, Accumulation and effects of trace metals in freshwater invertebrates, in Dallinger, R., Rainbow, P.S., LaPoint, T., and Greig-Smith, P.W., eds., Ecotoxicology of Metals in Invertebrates: Boca Raton, FL, Lewis Publishers.
- U.S. Army Crops of Engineers Waterways Experiment Station (WES), 1989, A Plant Bioassay for Assessing Plant Uptake of Heavy Metals from Contaminated Freshwater Dredged Material: Technical Note EEDP-04-11, Vicksburg, Mississippi.
- USEPA, 1993, Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms: EPA/600/4-90-027F. Fourth ed., USEPA, Washington, D.C., pp. 246.
- U.S. Environmental Protection Agency, 1996, Ecological Effects Test Guidelines: OPPTS 850.1735 Whole Sediment Acute Toxicity Invertebrates, Freshwater. [cited 13 May 2003]. U.S. Environmental Protection Agency; Prevention, Pesticides, and Toxic Substances, EPA 712-C-96-354. Available from <u>http://www.epa.gov/opptsfrs/OPPTS\_Harmonized/850\_Ecological\_Effects\_Test\_Guidelines/Drafts/850-1735.pdf</u>
- U.S. EPA, 2000, Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates – Second Edition: EPA 600/R-99/064, March.
- USEPA, 2001, Streamlined Water-Effect Ratio Procedure Discharges of Copper. Office of Water, Washington, DC, EPA-822-R001-005. March 2001.
- USEPA, 2002a, Development of a Framework for Metals Assessment and Guidance for Characterizing and Ranking Metals. EPA/630/P-02/003A, June 2002, Draft Action Plan.
- USEPA, 2002b, National Recommended Water Quality Criteria, Office of Water, Washington, DC, EPA/822/R/02/047, November 2002.
- Van Straalen, N.M., 1993, Soil and sediment quality criteria derived from invertebrate toxicity data, in Dallinger, R., Rainbow, P.S., LaPoint, T., and Greig-Smith, P.W., eds., Ecotoxicology of Metals in Invertebrates: Boca Raton, FL, Lewis Publishers.
- Wang, W., 1987, Root Elongation Method for Toxicity Testing of Organic and Inorganic Pollutants: Environmental Toxicology and Chemistry, v. 6, p. 409-414.
- Welsh, P. G., Lipton, J. and Chapman, G. A., 2000a, Evaluation of water-effect ratio methodology for establishing site-specific water quality criteria. Environ. Toxicol. Chem. 19, 1616-1623.

- Welsh, P. G., Lipton, J., Chapman, G. A., and Podrabsky, T. L., 2000a, Relative importance of calcium and magnesium in hardness-based modification of copper toxicity. Environ. Toxicol. Chem. 19, 1624-1631.
- Zitko, V., Carson, W. V., Carson, W. G., 1973, Prediction of incipient lethal levels of copper to juvenile Atlantic salmon in the presence of humic acid by cupric electrode. Bull. Environ. Contam. Toxicol., 10, 265-271.
- Zitko, V., 1976, Structure-activity relations and the toxicity of trace elements to aquatic biota. Proceedings of Toxicity to Biota of Metal Forms in Natural Water. International Joint Commission, 9-32.

- American Society for Testing and Materials (ASTM), 1997, Annual Book of Standards. Water and Environmental Technology, Volume 11.05: Philadelphia, Pennsylvania.
- Besser, J.M., Ingersoll, C.G., and Giesy, J.P., 1996, Effects of spatial and temporal variation of acid-volatile sulfide on the bioavailability of copper and zinc in freshwater sediments: Environmental Toxicology and Chemistry, v. 15, p. 286-293.
- Besser, J.M., Brumbaugh, W.G., May, T.W., Church, S.E., and Kimball, B.A., 2001, Bioavailability of metals in stream food webs and hazards to brook trout (Salvelinus fontinalis) in the Upper Animas River Watershed, Colorado: Archive of Environmental Contamination and Toxicology, v. 40, p. 48-59.
- Boyle, T.P., 2000, Use of risk assessment to evaluate effects and plan remediation of abandoned mines, in Proceedings of the Seventh International Conference on Tailings and Mine Waste: Rotterdam, Netherlands, A.A. Balkema, p. 461-466.
- Boyle, T.P., and Gustina, G.W., 2000, A strategy for use of multivariate methods of analysis of benthic macroinvertebrate communities to assess mine-related ecological stress, in Proceedings of the Fifth International Conference on Acid Rock Drainage, Denver, Colorado, May 21-24, 2000: Littleton, Colorado, Society for Mining, Metallurgy, and Exploration, p. 1425-1432.
- Brumbaugh, W.G., Petty, J.D., Huckins, J.N., and Manahan, S.E., 2002, Stabilized liquid membrane device (SLMD) for the passive, integrative sampling of labile metals in water: Water, Air, and Soil Pollution, v. 133, p. 109-119.
- Clearwater, S.J., Farag, A.M., and Meyer, J.S., 2002, Bioavailability and toxicity of dietborne copper and zinc to fish: Comparative Biochemistry and Physiology, v. 132, p. 269-313.

- Erdman, J.A., Shacklette, H.T. and Keith, J.R., 1976, Elemental composition of selected native plants and associated soils from major vegetation-type areas in Missouri, Geochemical Survey of Missouri: U.S. Geological Survey Professional Paper 954-C, p. 87.
- Erdman, J.A., Smith, K.S., Dillon, M.A., and ter Kuile, M., 1995, Impact of Alamosa River water on alfalfa, southwestern San Luis Valley, Colorado, in Posey, H.H., Pendleton, J.A., and Van Zyl, D., eds., Proceedings: Summitville Forum '95: Colorado Geological Survey Special Publication 38, p. 263-269.
- Farag, A.M., Boese, C.J., Woodward, D.F., and Bergman, H.L., 1994, Physiological changes and tissue metal accumulation in rainbow trout exposed to foodborne and waterborne metals: Environmental Toxicology and Chemistry, v. 13, p. 2021-2029.
- Farag, A.M., Woodward, D.F., Brumbaugh, W.G., Goldstein, J.G., MacConnell, E., Hogstrand, C., and Barrows, F.T., 1999, Dietary effects of metals-contaminated invertebrates from the Coeur d'Alene River, Idaho, on cutthroat trout: Transactions of American Fisheries Society, v. 128, p. 578-592.
- Farag, A.M., Suedkamp, M.J., Meyer, J.S., Barrows, R., and Woodward, D.F., 2000, Distribution of metals during digestion by cutthroat trout fed benthic invertebrates contaminated in the Clark Fork River, Montana and the Coeur d'Alene River, Idaho, USA, and fed artificially-contaminated *Artemia*: Journal of Fish Biology, v. 56, p. 173-190.
- Gough, L.P., Shacklette, H.T., and Case, A.A., 1979, Element concentrations toxic to plants, animals, and man: U.S. Geological Survey Bulletin 1466, 80 p.
- Gough, L.P., Crock, J.G., Day, W.C., and Vohden, J., 2001, Biogeochemistry of arsenic and cadmium, Fortymile River watershed, East-Central Alaska, in Gough, L.P., and Wilson, F.H., eds., Geological studies in Alaska by the U.S. Geological Survey: U.S. Geological Survey Professional Paper 1633, p. 109-126.
- Gulson, B.L., Mizon, K.J., Law, A.J., Korsch, M.J., and Davis, J.J., 1994, Source and pathways of lead in humans from the Broken Hill mining community - An alternative use of exploration methods: Economic Geology, v. 89, no. 4, p. 889-908.
- James, S.M., and Little, E.E., 2003, The effects of chronic cadmium exposure on American toad (*Bufo americanus*) tadpoles: Environmental Toxicology and Chemistry, v. 22, p. 377-380.
- Larison, J.R., Likens, G.E., Fitzpatrick, J.W., and Crock, J.G., 2000, Cadmium toxicity among wildlife in the Colorado Rocky Mountains: Nature, v. 406, p. 181-183.

- Loehr, R.C., and Webster, M.T., 1996, Behavior of Fresh vs. Aged Chemicals in Soil: Journal of Soil Contamination, v. 5, no. 4, p. 361-383.
- Luoma, S.N., and Bryan, G.W., 1981, A statistical assessment of the form of trace metals in oxidized estuarine sediments employing chemical extractants: Science of the Total Environment, v. 17, p. 165-196.
- Luoma, S.N., 1983, Bioavailability of trace metals to aquatic organisms—a review: Science of the Total Environment, v. 28, p. 1-22.
- Luoma, S.N., and Carter, J.L., 1993, Understanding the toxicity of contaminants in sediments—beyond the bioassay-based paradigm: Environmental Toxicology and Chemistry, v. 12, p. 793-796.
- MacDonald, D.D., Ingersoll, C.G., and Berger, T.A., 2000, Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems: Archives of Environmental Contamination and Toxicology, v. 39, p. 20-31.
- Marcus, W.A., Meyer, G.A., and Nimmo, D.R., 2001, Geomorphic control of persistent mine impacts in a Yellowstone Park stream and implications for the recovery of fluvial systems: Geology, v. 29, p. 355-358.
- Miller, W.R, and Sanzolone, R.F., 2003, Investigation of the possible connection of rock and soil geochemistry to the occurrence of high rates of neurodegenerative diseases on Guam and a hypothesis for the cause of the diseases: U.S. Geological Survey Open-File Report 03-126.
- Niyogi, D.K., McKnight, D.M., and Lewis, W.M., Jr., 1999, Influences of water and substrate quality for periphyton in a montane stream affected by acid mine drainage: Limnology and Oceanography, v. 44, p. 804-809.
- Ostrander, G.K.,ed., 1996, Techniques in aquatic toxicology. Boca Raton, Florida, Lewis Publishers.
- Plumlee, G.S., and Ziegler, T.L., 2003 in press, The medical geochemistry of dusts, soils, and other earth materials, in Treatise on Geochemistry, Volume 9, Chapter 7, Elsevier.
- Ruby, M.V., Schoof, R., Brattin, W., Goldade, M., Post, G., Harnois, M., Mosby, D.E., Casteel, S.W., Berti, W., Carpenter, M., Edwards, D., Cragin, D., Chappell, W., 1999, Advances in evaluating the oral bioavailability of inorganics in soil for use in human health risk assessment: Environmental Science and Technology, Volume 33, p. 3697-3705.

- Schmitt, C.J., and Dethloff, G.M., 2000, Biomonitoring of environmental status and trends (BEST) program: selected methods for monitoring chemical contaminants and their effects in aquatic ecosystems: U.S. Geological Survey, ITR--2000-005.
- Shacklette, H.T., and Boerngen, J.G., 1984, Element concentrations in soils and other surficial materials of the conterminous United States: U.S. Geological Survey Professional Paper 1270, 105 p.
- Smith, K.S., and Huyck, H.L.O., 1999, An overview of the abundance, relative mobility, bioavailability, and human toxicity of metals, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 29-70.
- Tidball, R.R., 1976, Chemical variation of soils in Missouri associated with selected levels of the soil classification system, Geochemical Survey of Missouri: U.S. Geological Survey Professional Paper 954-B.

Water Quality Criteria: http://www.epa.gov/waterscience/criteria/ http://www.epa.gov/region7/water/wqs.htm

Water-Effect Ratio: <u>http://www.epa.gov/waterscience/criteria/copper/copper.pdf</u>

Sediment Quality Guidelines: http://www.epa.gov/waterscience/cs/guidelines.htm

Other Topics: <u>http://www.epa.gov/science1/metalspanel.html</u> http://books.nap.edu/books/0309086256/html/R1.html#pagetop

U.S. Environmental Protection Agency, Test Guidelines; Notice of Availability. [updated 1998; cited 1 April 2003]. Federal Register Environmental Documents: <u>http://www.epa.gov/EPA-TOX/1998/August/Day-05/t20898.htm</u>

OECD, Test Methods. [updated 2000; cited 29 April 2003]. OECD Guidelines for Testing of Chemicals: <u>http://www.dicer.org/dicerDB/html/n3main-method-oecd-01.htm</u>

http://www.epa.gov/epaoswer/other/mining.htm

http://cfpub.epa.gov/npdes/indpermitting/mining.cfm

## <u>Suppliers</u>

<u>ORGANISMS</u> Aquatic BioSystems, Inc. Available at <u>http://www.aquaticbiosystems.com</u> Email: info@aquaticbiosystems.com

<u>KITS AND ASSAYS</u> ABOATOX. Available at <u>http://www.aboatox.com/</u> Email: juha.lappalainen@aboatox.com

ASI (Aqua Survey, Inc.). Available at <u>http://www.aquasurvey.com/</u> Email: Mail@AquaSurvey.com

Azur Environmental. Available at <u>http://www.azurenv.com</u> Email: Sales@sdix.com

Department of Environmental Engineering Sciences, University of Florida, Gabriel Bitton, MetPlate. Available at <u>http://www.ees.ufl.edu/homepp/bitton</u> Email: rdagan@ufl.edu

EBPI (Environmental bio-detection products Inc.). Available at <u>http://www.ebpi-kits.com/</u> Email: ebpi@ebpi-kits.com

Environmental Biohidrica Products. Available at <u>http://www.biohidrica.cl/</u> Email: biohidrica@biohidrica.cl

ESG International. Available at <u>http://www.environmental-</u> center.com/consulting/esg/services.htm

Microbiotests Inc. Available at <u>http://www.microbiotests.be/</u> Email: Microbiotests@skynet.be

# **IIIA.** Physical Characterization of Mine-Waste Piles

Herron, J., Stover, B., and Krabacher, P., 1998, Cement Creek reclamation feasibility report, Upper Animas Basin: Colorado Division of Minerals and Geology, Denver, CO, 139 p.

Herron, J, Jordet, J. A., and Wildeman, T.R., 2001, Reclamation feasibility report: Virginia Canyon: Colorado Division of Minerals and Geology, Denver, CO, 60 p.

- Plumlee, G.S., Ludington, S., Vincent, K.R., Verplanck, P.L., Caine, J.S., and Livo, E., 2003 (in press), Questa baseline and pre-mining ground-water quality investigation, 3. A pictorial record of chemical weathering, erosional processes, and potential debris-flow hazards in scar areas developed on hydrothermally altered rocks: U.S. Geological Survey Open-File Report 03-xxx. (Will be available online at <u>http://pubs.usgs.gov/openfile/</u>)
- Wildeman, T.R., Ranville, J. F., Herron, J., and Robinson, R.H., 2003, Development of a simple scheme to determine the chemical toxicity of mine wastes, in Proceedings, 2003 National Meeting of the American Society of Mining and Reclamation and 9th Billings Land Reclamation Symposium, Billings, MT, June 3-6, 2003: Lexington, Kentucky, American Society of Mining and Reclamation.

# **IIIB. Fate and Transport of Metals and Sediment in Surface Water**

- Clements, W., Carlisle, D., Lazorchak, J., and others, 2000, Heavy metals structure benthic communities in Colorado mountain streams: Ecological Applications, v. 10, no. 2, p. 626-638.
- Johnson, Billy E., 1997, Development of a storm event based two-dimensional upland erosion model, PhD: Fort Collins, CO, Dept. Civil Engr., Colorado State University, Fort Collins, Colorado.
- Johnson, Billy E., Julien, Pierre Y., Molnar, Darcy K., and others, 2000, The twodimensional-upland erosion model CASC2D-SED: J. of the AWRA, v. 36, no. 1, p. 31-42.
- Jorgeson, Jeffrey D., 1999, Peak flow analysis using a two-dimensional watershed model with radar precipitation data, PhD: Fort Collins, CO, Colorado State University.
- Julien, Pierre Y., and Rojas, Rosalia, 2002, Upland erosion modeling with CASC2D-SED: International Journal of Sediment Research, v. 17, no. 4, p. 265-274.
- Julien, Pierre Y., and Saghafian, Bahram, 1991, CASC2D users manual A twodimensional watershed rainfall-runoff model: Fort Collins, CO., Colorado State University, Fort Collins, 66 pp.
- Julien, Pierre Y., Saghafian, Bahram, and Ogden, Fred Lee, 1995, Raster-Based hydrologic modeling of spatially varied surface runoff: Water Resources Bulletin, v. 31, no. 3, p. 523-536.
- Molnar, Darcy K., and Julien, Pierre Y., 2000, Grid size effects on surface runoff modeling: J. Hydrologic Eng., v. 5, no. 1, p. 8-16.

- Rojas, Rosalia, 2002, GIS-based upland erosion modeling, geovisualization and grid size effects on erosion simulations with CASC2D-SED, PhD: Fort Collins, CO, Dept. Civil Engr., Colorado State University, Fort Collins, Colorado.
- Swayze, Gregg A., Smith, Kathleen S., Clark, Roger N., and others, 2000, Using imaging spectroscopy to map acidic mine waste: Environ. Sci. Technol., v. 34, p. 47-54.

# IV. The Importance of Geology

- Bove, D.J., Mast, M.A., Dalton, J.B., Wright, W.G., and Yager, D.B., in press (2003), Major styles of mineralization and hydrothermal alteration and related solid and aqueous-phase geochemical signatures in Church, S., ed., Professional Paper 1651, Chapter E3.
- Bowell, R.J., Rees, S.B., and Parshley, J.V., 2000, Geochemical predictions of metal leaching and acid generation: Geologic controls and baseline assessment in Cluer, J.K., Price, J.G., Struhsacker, E.M., Hardyman, R.F., and Morris, C.L., eds., Geology and Ore Deposits 2000.
- Diehl, S.F., Goldhaber, M.B., Hatch, J.R., Kolker, A., Pashin, J.C., and Koenig, A.E., 2002, Mineralogic residence and sequence of emplacement of arsenic and other trace elements in coals of the Warrior Basin, Alabama: 19th International Pittsburgh Coal Conference, Sept. 27, 14 p., CD-ROM.
- Diehl, S.F., Smith, K.S., Desborough, G.A., White, W.W., III, Lapakko, K., Goldhaber, M.B., and Fey, D.L., 2003, Trace metal sources and release from sulfide-rich mine wastes: Examples from humidity cell test of hard-rock mine waste and from Warrior Basin coal, in Proceedings, 2003 National Meeting of the American Society of Mining and Reclamation and 9th Billings Land Reclamation Symposium, Billings, MT, June 3-6, 2003: Lexington, Kentucky, American Society of Mining and Reclamation.
- du Bray, E.A., ed., 1995, Preliminary compilation of descriptive geoenvironmental mineral deposit models: U.S. Geological Survey Open-File Report 95-831. (Available online at <u>http://pubs.usgs.gov/of/1995/ofr-95-0831/</u>)
- Goldhaber, M.B., Lee, R., Hatch, J., Pashin, J. Treworgy, J., 2002, The Role of Large-Scale-Fluid Flow in Subsurface Arsenic Enrichment; in Arsenic, In Ground Water: Occurrence And Geochemistry; A. Welch and K. Stollenwerk eds., Kluwer Academic Publishers, Chap. 5, p. 123-172.

- Hammarstrom, J.M., and Smith, K.S., 2002, Geochemical and mineralogic characterization of solids and their effects on waters in metal-mining environments: U.S. Geological Survey Open-File Report 02-195, p. 8-54. (Available online at <u>http://pubs.usgs.gov/of/2002/of02-195/</u>)
- Jambor, J.L., Blowes, D.W., and Ptacek, C.J., 2000, Mineralogy of mine wastes and strategies for remediation, in Vaughan, D.J., and Wogelius, R.A., eds., Environmental Mineralogy, EMU Notes in Mineralogy Vol. 2: European Mineralogical Union, p. 255-290.
- Kwong, Y.T.J., 1993, Prediction and prevention of acid rock drainage from a geological and mineralogical perspective: Mine Environment Neutral Drainage (MEND) Project 1.32.1, CANMET, Ottawa, 47 p.
- Lapakko, K.A., 1999, Laboratory drainage quality from siltite-argillite rock (final Appendices for BLM contract J910C82009): Minnesota Department of Natural Resources, Minerals Division, St. Paul, MN 55155-4045, 1 March 1999, 6 Appendices (A1-A6).
- Lapakko, K.A., and White, W.W., III., 2000, Modification of the ASTM 5744-96 kinetic test, in Proceedings of the Fifth International Conference on Acid Rock Drainage, May 20-23, 2000, Denver, Colorado, Society of Mining Engineering, Lakewood, Colo., p. 631-639.
- Plumlee, G.S., and Nash, J.T., 1995, Geoenvironmental models of minerals deposits; fundamentals and applications, in du Bray, E.A., ed., Preliminary compilation of descriptive Geoenvironmental mineral deposit models: U.S. Geological Survey Open-File Report 95-0831, p. 1-9.
- Plumlee, G.S., 1999, The environmental geology of mineral deposits, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 71-116.
- Plumlee, G.S., Smith, K.S., Montour, M.R., Ficklin, W.H., and Mosier, E.L., 1999, Geologic controls on the composition of natural waters and mine waters draining diverse mineral-deposit types, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 373-407.
- Seal, R.R., II, and Hammarstrom, J.M., 2003 (in press), Geoenvironmental models of mineral deposits: examples from massive sulfide and gold deposits, in Jambor, J.L., Blowes, D.W., and Ritchie, A.I.M., eds., Environmental aspects of mine wastes, Short Course Handbook Vol. 31: Ottawa, Mineralogical Association of Canada.

- Seal, R.R., II, and Foley, N.K., eds., 2002, Progress on geoenvironmental models for selected mineral deposit types: U.S. geological Survey Open-File Report 02-0195, 213 p. (Available online at <u>http://pubs.usgs.gov/of/2002/of02-195/</u>)
- Sims, P.K., Drake, A.A., and Tooker, E.W., 1963, Geology and ore deposits of the Central City district, Gilpin County, Colorado: U.S., Geological Survey Professional Paper 359, 231 p.
- Sverdrup, H.U., 1990, The kinetics of base cation release due to chemical weathering: Lund University Press, Lund, 246 p.
- Wanty, R.B., Berger, B.R., and Plumlee, G.S., 1999, Environmental models of mineral deposits; A state of the art: Geologica Hungarica, Serie Geologica, v. 24, p. 97-106.
- White, W.W., III., and Lapakko, K.A., 2000, Preliminary indications of repeatability and reproducibility of the ASTM 5744-96 kinetic test for drainage pH and sulfate release rate, in Proceedings of the Fifth International Conference on Acid Rock Drainage, May 20-23, 2000, Denver, Colorado, Society of Mining Engineering, Lakewood, Colo., p. 621-630.
- Wildeman, T.R., Cain, D., and Ramiriz, A.J., Jr., 1974, The relation between water chemistry and mineral zonation in the Central City mining district, Colorado, in Hadley, R.F., and Snow, D.T., eds., Water resources related to mining: Minneapolis, American Water Resources Association, p. 219-229.

- Alpers, C.N., Jambor, J.L., and Nordstrom, D.K., eds., 2000, Sulfate minerals: crystallography, geochemistry, and environmental significance: Reviews in Mineralogy and Geochemistry, vol. 40: Washington, D.C., Mineralogical Society of America and The Geochemical Society, 608 p.
- Bove, D.J., Wilson, A.B., Barry, T.H., Hon, K., Kurtz, J., Van Loenen, R.E., and Calkin, W.S., 1996, Geology, alteration, and rock and water chemistry of the Iron, Alum, and Bitter Creek areas, Upper Alamosa River, southwestern Colorado: U.S. Geological Survey Open-File Report 96-039.
- Cabri, L.J., and Vaughan, D.J., eds., 1998, Modern approaches to ore and environmental mineralogy, MAC Short Course Seriers Volume 27: Mineralogical Association of Canada, 421 p.
- Cox, D.P., and Singer, D.A., eds., 1986, Mineral deposit models: U.S. Geological Survey Bulletin 1693, 379 p. (Available online at http://pubs.usgs.gov/bul/b1693/)

- Desborough, G.A., Briggs, P.H., and Mazza, N., 1998, Chemical and mineralogical characteristics and acid-neutralizing potential of fresh and altered rocks and soils of the Boulder River headwaters in Basin and Cataract Creeks of northern Jefferson Co., Montana: U.S. Geological Survey Open-File Report 98-40, 21 p. (Available online at <u>http://pubs.usgs.gov/of/1998/ofr-98-0040/</u>)
- Desborough, G.A., Briggs, P.H., Mazza, N., and Driscoll, R., 1998, Acid-neutralizing potential of minerals in intrusive rocks of the Boulder batholith in northern Jefferson, Co., Montana: U.S. Geological Survey Open-File Report 98-364, 21 p. (Available at <u>http://pubs.usgs.gov/of/1998/ofr-98-0364/</u>)
- Desborough, G.A., Leinz, R, Smith, K.S., Hageman, P., Fey, D., and Nash, T., 1999, Acid generation and metal mobility of some metal-mining related wastes in Colorado: U.S. Geological Survey Open-File Report 99-322.
- Desborough, G.A., Leinz, R., Sutley, S., Briggs, P., Swayze, G., Smith, K., and Breit, G., 2000, Leaching studies of schwertmannite-rich precipitates from the Animas River headwaters, Colorado, and Boulder River headwaters: U.S. Geological Survey Open-File Report 00-004, 16 p.
- Downing,B.W., and Giroux,G., 1993, Estimation of a waste rock ARD block model for the Windy Craggy massive sulphide deposit, Northwestern British Columbia: Exploration and Mining Geology, v. 2., no.3, p. 203-215.
- Ficklin, W.H., Plumlee, G.S., Smith, K.S., and McHugh, J.B., 1992, Geochemical classification of mine drainages and natural drainages in mineralized areas in mineralized areas, in Kharaka, Y.K., and Maest, A.S., eds., Water-Rock Interaction, Volume 1, Low Temperature Environments: Proceedings of the 7th International Symposium on Water-Rock Interaction, p. 381-384.
- Filipek, L.H., and Plumlee, G.S., eds., 1999, The environmental geochemistry of mineral deposits, Part B: case studies and research topics, Reviews in Economic Geology, vol. 6B: Littleton, Colorado, Society of Economic Geologists, Inc., 211 p.
- Fleischer, M., 1955, Minor elements in some sulfide minerals: Economic Geology 50th Anniversary Volume, p. 970-1024.
- Hammarstrom, J.M. and Seal, R.R., eds., 2001, Environmental geochemistry and mining history of massive sulfide deposits in the Vermont Copper Belt: Society of Economic Geologists Guidebook Series Vol. 35, Part II: Littleton, Colorado, Society of Economic Geologists, Inc., p. 111-203.

- Jambor, J.L., and Vaughan, D.J., eds., 1990, Advanced microscopic studies of ore minerals, MAC Short Course Servies Volume 17: Mineralogical Association of Canada, 426 p.
- Jambor, J.L., 1994, Mineralogy of sulfide-rich tailings and their oxidation products, in Environmental Geochemistry of Sulfide Mine-wastes, Mineralogical Association of Canada Short Course Vol. 22, p. 59-102.
- Jambor, J.L., and Blowes, D.W., 1998, Theory and application of mineralogy in environmental studies of sulfide-bearing mine wastes, in Cabri, L.J., and Vaughan, D.J., eds., Modern approaches to ore and environmental mineralogy, MAC Short Course Vol. 27: Mineralogical Association of Canada, p. 367-402.
- Jennings, S.R., and Dollhopf, D.J., 1995, Geochemical characterization of sulfide mineral weathering for remediation of acid producing mine wastes: Bozeman, Montana, Montana State University Reclamation Research Unit Publication No. 9502, 140 p.
- Lipin, B.R., 1997, Mineral-Resource Databases: U.S. Geological Survey Fact Sheet 122-00. (Available online at <u>http://pubs.usgs.gov/fs/fs122-00/</u>)
- Miller, W., 2002, Influence of rock composition on the geochemistry of stream and spring waters from mountainous watersheds in the Gunnison, Uncompany, and Grand Mesa National Forests, Colorado: U.S. Geological Survey Professional Paper 1667, 52 p. (Available online at <u>http://pubs.usgs.gov/pp/2002/p1667/</u>)
- Morrison, J.M., 2003, Geochemical processes controlling a coal mine acid mine drainage mixing zone and the impacts on Cane Creek, Alabama: M.S. Thesis, Colorado School of Mines, 206 p.
- Nash, J.T., 2000, Geochemical studies of mines, dumps, and tailings as sources of contamination, upper Animas River watershed, Colorado: U.S. Geological Survey Open Report 00-0104, CD-ROM, 1 disc.
- Plumlee, G.S., Smith, K.S., Ficklin, and Briggs, P.H., 1992, Geological and geochemical controls on the composition of mine drainages and natural drainages in mineralized areas, in Kharaka, Y.K., and Maest, A.S., eds., Water-Rock Interaction, Volume 1, Low Temperature Environments: Proceedings of the 7th International Symposium on Water-Rock Interaction, p. 419-422.
- Plumlee, G.S., and Logsdon, M.J., 1999, An earth-system science toolkit for environmentally friendly mineral resource development, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 1-27.

- Plumlee, G.S., and Logsdon, M.J., eds., 1999, The environmental geochemistry of mineral deposits, Part A: Processes, Techniques, and Health Issues: Reviews in Economic Geology, V. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., 371 p.
- Posey, H.H., Pendleton, J.A., and Van Zyl, D., 1995, Proceedings: Summitville Forum '95: Colorado Geological Survey Special Publication 38, 375 p.
- Roberts, F.I., 1982, Trace element chemistry of pyrite: A useful guide to the occurrence of sulfide base metal mineralization: Journal of Geochemical Exploration, v. 17, p. 49-62.
- Robertson, AM., 1982, Site selection and design options for uranium mine waste and plant tailings, in Glen, H.W., ed., Proceedings, V. II, 12th CMMI Congress, Geological Society of South Africa, p. 861-886.
- Williams, D.J., and Currey, N.A., 2002, Engineering closure of an open pit gold operation in a semi-arid climate, in Inyang, H.I., and Cássia de Brito Galvão, T., eds., Special Issue on Mining and Geoenvironment: International Journal of Surface Mining, Reclamation and Environment, v. 16, no. 4, p. 270-288.
- Yager, D.B., Mast, M.A., Verplanck, P.L., Bove, D.J., Wright, W.G., and Hageman, P.L., 2000, Natural versus mining-related water quality degradation to tributaries draining Mount Moly, Silverton, Colorado: U. S. Geological Survey, Open-File Report: OF 00-0034, p.99-111.
- Yong, R.N., and Thomas, H.R., 2001, Geoenvironmental engineering: Engineering Geology, v. 60, no. 1-4, p. 1-388.

- Lee, G.L.; McCafferty, A.E., Van Gosen, B.S., Bankey, V., Elliott, J.E., Frishman, D., Knepper, D.H., Kulik, D.M., Marsh, S.P., Phillips, J.D., Pitkin, J.A., Smith, S.M., Stoser, D.B., Tysdal, R.G., DiFrancesco, C.A., Bleiwas, D.I., 2001, Montana geoenvironmental explorer: U. S. Geological Survey Digital Data Series, Report: DDS-0065, 1 disc.
- Stoeser, D.B., and Heran, W.D., 2000, USGS mineral deposit models: U.S. Geological Survey, Digital Data Series, Report: DDS-0064, 1 disc.

Petrology and mineralogy in ARD prediction, EnviroMine: <u>http://technology.infomine.com/enviromine/ard/Mineralogy/Petrology%20and%20Mineralogy.htm</u>

# V. Geophysical Applications to Mine-Waste Piles

Remote Sensing Method references have not been completely compiled here. See the following web site and representative papers: http://speclab.cr.usgs.gov/

- Clark, R.N., King, T.V.V., Ager, C., and Swayze, G.A., 1995, Initial vegetation species and senescence/stress mapping in the San Luis Calley, Colorado using imaging spectrometer data. Proceedings: Summitville Forum '95, H.H. Posey, J.A. Pendelton, and D. Van Zyl Eds., Colorado Geological Survey Special Publication 38, p. 64-69.
- Dalton, J.B., T.V.V. King, D.J. Bove, R.F. Kokaly, R.N. Clark, J.S. Vance and G.A. Swayze, Distribution of Acid-Generating and Acid-Buffering Minerals in the Animas River Watershed as Determined by AVIRIS Spectroscopy Proceedings if the ICARD 2000 Meeting, May 21-24, 2000, Denver Colorado.
- King, T.V.V., Clark, R.N., Ager, C., and Swayze, G.A., 1995, Remote mineral mapping using AVIRIS data at Summitville, Colorado and the adjacent San Juan Mountains. Proceedings: Summitville Forum '95, H.H. Posey, J.A. Pendelton, and D. Van Zyl Eds., Colorado Geological Survey Special Publication 38, p. 59-63.
- Swayze, G.A., Smith, K.S., Clark, R.N., Sutley, S.J., Pearson, R.M., Vance, J.S., Hageman, P.L., Briggs, P.H., Meier, A.L., Singleton, M.J., and Roth, S., 2000, Using imaging spectroscopy to map acidic mine waste: Environmental Science and Technology, v. 34, p. 47-54. (Available online at <u>http://speclab.cr.usgs.gov/PAPERS/leadville99/ldv99.html</u>)

The following references supplement those given by

Campbell, D.L., 2000, Annotated bibliography of geophysical methods for characterizing mine waste, late-1994 through early 2000: U.S. Geological Survey Open-File Report 00-428, which can be accessed at: <u>http://crustal.usgs.gov/minewaste/geophysics\_mine\_pubs.html</u>

(Accessed June 2000)

GENERAL GEOPHYSICS SURVEYS AND PRINCIPLES

Sharma, P.Y., 1997 (reprinted 2002), Environmental and engineering geophysics, Cambridge University Press, Cambridge, England, 508p.

Kearey, P., Brooks, M., and Hill, I, 2002, An introduction to geophysical exploration, Blackwell Science.

CASE HISTORIES AND APPLICATIONS

- Campbell, D.V. and Fitterman, D.V., 2000, Geoelectrical Methods for Investigating Mine Dumps; International Conference on Acid Rock Drainage (ICARD2000), May 21-24, 2000, Denver, Colorado, Vol.II, p. 1513-1523
- Campbell, D. L., and Horton, R. J. 2001, Spectral Induced Polarization Studies of Mine Waste Piles in Colorado and New Mexico: Proceedings for the Symposium on the Application of Geophysics to Environmental and Engineering Problems, Denver, March 4-7, 12p.
- Carpenter, P.J., Aizhong Ding, A., Cheng, L., Liu, P., and Chu, F.2003, Geophysical and Geochemical Characterization of Groundwater Contamination Surrounding an Oil Shale Tailings Landfill, Maoming, China: Proceedings for the Symposium on the Application of Geophysics to Environmental and Engineering Problems, San Antonio, April 6-10, p. 938 – 941.
- Custis, K, 1994, Application of geophysics to acid mine drainage investigations, volume 1, literature review and theoretic background: Environmental Protection Agency report 530-R-95-013A, available NTIS PB95-191268, 144p.
- Custis, K, 1994, Application of geophysics to acid mine drainage investigations, volume 2, site investigations: Environmental Protection Agency report 530-R-95-013B, available NTIS PB95-191276, 103p.
- Hammack, R.W., and Mabie, J.S., 2002, Airborne EM and magnetic surveys find faults at the Slufus Bank mercury mine superfund site: The Leading Edge, vol. 21, no. 11, p 1092-1094.
- Hammack, R., Veloski, G., Sams III, J., and Shogren, J., 2002, The Use of Airborne EM Conductivity to Locate Contaminant Flow Paths at the Sulphur Bank Mercury Mine Superfund Site: Proceedings for the Symposium on the Application of Geophysics to Environmental and Engineering Problems, Las Vegas, Feb. 10-14, 16p.
- Hammack R.W., Veloski G.A., Ackman T.E, Love E.I., Harbert W, 2003, The Use of Hem to Delimit the Areal Extent of Contaminated Aquifers at Surface and Underground Coal Mines: Proceedings for the Symposium on the Application of Geophysics to Environmental and Engineering Problems, San Antonio, April 6-10, p. 887-897
- Kaszás, I., and Stickel J., 1999, Environmental examination of tailing ponds by geophysical methods, abstracts 5th meeting, Environmental and Engineering Geophysical Society European Section, September 6-9, Budapest Hungary, 2p.

- Koch, R.R., 1996, Environmental monitoring of uranium mining wastes using geophysical techniques phase 1: a comparison and evaluation of conductivity and resistivity methods to monitor acid mine drainage from uranium waste rock piles and tailings areas: NTIS: MIC-97-06440INZ [microfiche]. 165 p,
- Koch, R.R., Simpson, M., and Giamou P, 1997, Environmental monitoring of uranium mining wastes using geophysical techniques, phase ii: a comparison and evaluation of conductivity, resistivity, gpr and tdem sounding methods to monitor acid mine drainage from uranium waste rock piles and tailings areas: Atomic Energy Control Board, Ottawa, NTIS: MIC-97-07362INZ [microfiche]. 123p.
- Kong,A., Njikam, F., Townes, C., Burbach, G. V.N.,Tang, G., 2003, Geophysical Characterization of an Abandoned Goldmine: Proceedings for the Symposium on the Application of Geophysics to Environmental and Engineering Problems, San Antonio, April 6-10, p. 918-929.
- Mabie J.S., Wilson T., Hammack R.W., 2003, Geophysical Investigations at the T&T Mine Complex, Preston County, West Virginia: Proceedings for the Symposium on the Application of Geophysics to Environmental and Engineering Problems, San Antonio, April 6-10, p. 898-917.
- Malen, F., Wanty R., Viellenave, J.H. and Fontana, J.V., 2000, Probe sampling and geophysics applied to ground water evaluation of Mine dumps: Tailings and Mine Waste '00. Proceedings of the 7th International Conference, January 2000, Fort Collins, CO, p 223-240.
- McDougal, R.R., Cannon, M.R., Smith, B.D., and Ruppert, D.A., 2002, Hydrology of the Boulder River watershed study area, Montana and examination of regional ground-water flow using interpreted fracture mapping from remote sensing data: abstracts Annual meeting of the Geological Society of America, Denver CO, 1 p.
- McCafferty, A.E. and Bradley V.S., 2002, Acid-neutralizing potential of bedrock inferred from whole rock chemistry and high resolution airborne geophysical data: abstracts Annual meeting of the Geological Society of America, Denver CO, 1 p.
- Morris, B., Shang, J., Howarth, P., and Witherly K., 2002, Application of Remote Sensing and Airborne Geophysics to Mine Tailings Monitoring, Copper Cliff, Ontario: Proceedings for the Symposium on the Application of Geophysics to Environmental and Engineering Problems, Las Vegas, 14p.
- Rutley, A., and Fallon, G., 2000, Electromagnetic surveys for environmental applications at mining operations - an Argentinean and Australian perspective: Proceedings of the annual meeting of the Society of Exploration Geophysicists, Calgary, Alberta, Canada, 3p.

- Shemang, E. M., Laletsang, K., Chaoka, T. R., 2003, Geophysical Investigation of the Effect of Acid Mine Drainage on the Soil and Groundwater Near a Mine Dump, Selebi-Phikwe Cu-Ni Mine, NE Botswana: Proceedings for the Symposium on the Application of Geophysics to Environmental and Engineering Problems, San Antonio, April 6-10, p. 930-937.
- Smith, B.D., McCafferty, A.E., and Robert R. McDougal, 2000, Utilization of airborne magnetic, electromagnetic, and radiometric data in abandoned mine land investigations: International Conference on Acid Rock Drainage (ICARD2000), May 21-24, 2000, Denver, Colorado, Vol.II, p. 1524-1538.
- Smith, B. D., Campbell, D. L., and Wright, W. G., 2001, Using Resistivity to Map Acidic Waters at the May Day Mine Dump, Silverton, Colorado: Proceedings for the Symposium on the Application of Geophysics to Environmental and Engineering Problems, Denver, March 4-7, 14p.
- The following are chapters on geophysical interpretations for a USGS Professional Paper on abandoned mine land studies, which is currently (June, 2003) in final review:
- Integrated investigation of environmental effects of historical mining in the Basin and Boulder mining districts, Boulder River watershed, Jefferson County, Montana: Edited by D.A. Nimick, S.E. Church, and S.E. Finger; U.S. Geological Survey Professional Paper 1652
- Chapter D2—Geophysical characterization of geologic features with environmental implications from airborne magnetic and apparent resistivity data, by A.E. McCafferty, B.S. Van Gosen, B.D. Smith, and T.C. Sole.
- Chapter D9—Hydrogeology of the Boulder River watershed study area, and examination of regional ground-water flow using interpreted fracture mapping from remote sensing data, by R.R. McDougal, M.R. Cannon, B.D. Smith, and D.A. Ruppert.
- Chapter E3—Geologic, geophysical, and seismic characterization of the Luttrell pit as a mine-waste repository, by B.D. Smith, R.R. McDougal, and Karen Lund.

# VI. Waste Pile and Water Sampling

- Cosgrove, W.M., Neill, M.P., and Hastie, K.H., eds., 2000, RCRA waste management: planning, implementation, and assessment of sampling activities (ASTM Manual Series, Mnl 42.): American Society for Testing and Materials, ASTM Committee D-34 on Waste Management.
- MEND, 1994, Review of waste rock sampling techniques: Mine Environment Neutral Drainage (MEND) Program Report 4.5.1.

- MEND Manual, 2001, Sampling and analysis, MEND Manual vol. 2: Mine Environment Neutral Drainage (MEND) Program Report 5.4.2b.
- Nimick, D.A., 2001, Diel variation in dissolved trace-element concentrations in streams draining abandoned mine lands: Eos Trans. AGU, v. 82 no. 47, Fall Meet. Suppl., Abstract H11B-0237.
- Nimick, D.A., Gammons, C.H., Cleasby, T.E, Madison, J.P., Skaar, Don, and Brick, C.M., in review, Diel cycles in dissolved metal concentrations in streamsoccurrence and possible causes: submitted to Water Resources Research.
- Pitard, F.F., 1993, Pierre Gy's sampling theory and sampling practice--heterogeneity, sampling correctness, and statistical process control, 2nd edition: Boca Raton, Florida, CRC Press.
- Price, W.A., and Kwong, Y.T.J., 1997, Waste rock weathering, sampling and analysis: Observations from the British Columbia Ministry of Employment and Investment database, in Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, B.C., Canada, May 31-June 6, 1997, p. 31-45.
- Runnells, D.D., Shields, M.J., and Jones, R.L., 1997, Methodology for adequacy of sampling of mill tailings and mine waste rock, in Proceedings of Tailings and Mine Waste 97: Rotterdam, Balkema, p. 561-563.
- Smith, K.S., Ramsey, C.A., and Hageman, P.L., 2000, Sampling strategy for the rapid screening of mine-waste dumps on abandoned mine lands, in Proceedings from the Fifth International Conference on Acid Rock Drainage (ICARD 2000), Denver, Colorado, May 21-24, 2000, Volume II: Littleton, Colorado, Society for Mining, Metallurgy, and Exploration, Inc., p. 1453-1461.

- Brandvold, L.A. and McLemore, V.T., 1999, A study of the analytical variation of sampling and analysis of stream sediments from mining and milling contaminated areas: Journal of Geochemical Exploration, v. 64, p. 185-196.
- British Columbia, 1989. Draft acid rock drainage technical guide, vol.1. British Columbia Acid Mine Drainage Task Force Report.
- Cravotta, C.A., III, 1997, Water, in Marcus, J.J., ed., Mining environmental handbook: London, Imperial College Press, Chapter 12, Section 12.3.2, p. 582-583.
- Filipek, L.H., 1997, Waste, in Marcus, J.J., ed., Mining environmental handbook: London, Imperial College Press, Chapter 12, Section 12.3.3, p. 583-586.

- Gy, P., 1982, Sampling of particulate materials, theory and practice: Amsterdam, Elsevier, 431 p.
- Horowitz, A.J., Rinella, F.A., Lamothe, P.J., Miller, T.L., Edwards, T.K., Roche, R.L., and Rickert, D.A., 1990, Variations in suspended sediment and associated trace element concentrations in selected riverine cross sections: Environ. Sci. Technol., v. 24, p. 1313-1320.
- Horowitz, A.J., Lum, K.R., Garbarino, J.R., Hall, G.E., Lemieux, C., and Demas, C.R., 1996, Problems associated with using filtration to define dissolved trace element concentrations in natural water samples: Environ. Sci. Technol., v. 30, p. 954-963.
- Horowitz, A.J., 1997, Some thoughts on problems associated with various sampling media used for environmental monitoring: Analyst, v. 122, p. 1193-1200.
- Puls, R.W., Eychaner, J.H., and Powell, R.M., 1990, Colloidal-facilitated transport of inorganic contaminants in ground water--Pt. I, Sampling considerations: U.S. Environmental Protection Agency Environmental Research Brief EPA 600/M-90/023, 11 p.
- Schmiermund, R.L., and Drozd, M.A., eds., 1997, Acid mine drainage and other mininginfluenced waters (MIW), in Marcus, J.J., ed., Mining environmental handbook: London, Imperial College Press, Chapter 13, p. 599-617.
- Sketchley, D.A., 1999, Gold deposits: Establishing sampling protocols and monitoring quality control: Exploration and Mining Geology, v. 7, p129-139.
- Smith, K.S., Walton-Day, Katherine, and Ranville, J.F., 1999, Considerations of observational scale when evaluating the effect of, and remediation strategies for, a fluvial tailings deposit in the Upper Arkansas River Basin, Colorado, in Morganwalp, D.W., and Buxton, H.T., eds., U.S. Geological Survey Toxic Substances Hydrology Program--Proceedings of the Technical Meeting, Charleston, South Carolina, March 8-12, 1999--Volume 1 of 3--Contamination from Hardrock Mining: U.S. Geological Survey Water-Resources Investigations Report 99-4018A, p. 131-138. (Available online at <a href="http://toxics.usgs.gov/pubs/wri99-4018/Volume1/sectionB/1304">http://toxics.usgs.gov/pubs/wri99-4018/Volume1/sectionB/1304</a> Smith/index.html)
- U.S. Environmental Protection Agency, 1985, Practical guide for ground-water sampling: EPA 600285104, 169 p.
- U.S. Environmental Protection Agency, 1996. Guidance for data quality assessment. EPA/600/R-96-084.

- U.S. Geological Survey, 1997 to present, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1-A9, 2 v., variously paged. [Also available online at <u>http://pubs.water.usgs.gov/twri9A</u>; Chapters originally were published from 1997-1999; updates and revisions are ongoing and are summarized at: <u>http://water.usgs.gov/owg/FieldManual/mastererrata.html</u>]
- Vallee, Marcel (1999), Sampling quality control: Exploration and Mining Geology, v. 7, nos. 1 and 2.
- Walton-Day, K., Macalady, D.L., Brooks, M.H., and Tate, V.T., 1990, Field methods for the determination of ground-water redox parameters: Ground Water Monitoring Review, v. 10, no. 4, p. 81-89.
- Ward, R. C., Loftis, J. C., and McBride, G. B., 1990, Design of water quality monitoring systems: John Wiley & Sons, 230 p.

ARD sampling and sample preparation, EnviroMine: <a href="http://technology.infomine.com/enviromine/ard/sampling/intro.html">http://technology.infomine.com/enviromine/ard/sampling/intro.html</a>

U.S. Environmental Protection Agency National Water Quality Standards Database: <u>http://www.epa.gov/wqsdatabase/</u>

# VII. Chemical Analysis of Solids, Waters, and Leachates

- Allen, H.E., McGrath, S.P., McLaughlin, M.J., Peijnenburg, W.J.G.M., and Sauvé, S., 2002, Recommendations for regulatory programs and research, in Allen, H.E., ed., Bioavailability of metals in terrestrial ecosystems: importance of partitioning for bioavailability to invertebrates, microbes, and plants: Pensacola, FL, SETAC Press.
- Chao, T.T., and Sanzolone, R.F., 1992, Decomposition techniques: Journal of Geochemical Exploration, v. 44, pp. 65–106.
- Clesceri, L.S., Greenberg, A.E., and Eaton, A.D. (eds.), 1999, Standard methods for the examination of water and wastewater, 20th ed.: Washington, D.C., American Public Health Association.

- Crock, J.G., Arbogast, B.F., and Lamothe, P.J., 1999, Laboratory methods for the analysis of environmental samples, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 265-287.
- Ficklin, W.H., and Mosier, E.L., 1999, Field methods for sampling and analysis of environmental samples for unstable and selected stable constituents, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 249–264.
- MEND Manual, 2001, Sampling and analysis, MEND Manual vol. 2: Mine Environment Neutral Drainage (MEND) Program Report 5.4.2b.
- Price, W.A., 1997, DRAFT Guidelines and recommended methods for the prediction of metal leaching and acid rock drainage at minesites in British Columbia: British Columbia Ministry of Employment and Investment, Energy and Minerals Division, Smithers, BC, (April), 143 p.
- Price, W.A., and Kwong, Y.T.J., 1997, Waste rock weathering, sampling and analysis: Observations from the British Columbia Ministry of Employment and Investment database, in Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, B.C. Canada, May 31-June 6, 1997, p. 31-45.
- Taggart, J.E., Jr. (ed.), 2002, Analytical methods for chemical analysis of geologic and other materials, U.S. Geological Survey: U.S. Geological Survey Open-File Report 02-0223, Version 5.0. (Available online at <u>http://pubs.usgs.gov/of/2002/ofr-02-0223/</u>)
- U.S. Environmental Protection Agency, 1980 to present, Test methods for evaluating solid waste, physical/chemical methods (SW-846). [Available online at <a href="http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm">http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm</a>

- Borsch, L., 1995, Some observations on mineral properties and analytical reproducibility in geochemical samples: Mining Engineering, June, 1995, p. 567-569.
- Calow, R., 1991, Quality control/quality assurance in geochemical laboratories: Explore, no. 72, p. 23-24.
- Helsel, D.R., and Hirsch, R.M., 2002, Statistical methods in water resources: U.S. Geological Survey Techniques of Water Resources Investigations, Book 4, Chapter A3, 510 p. (Available online at <u>http://water.usgs.gov/pubs/twri/twri4a3/</u>)

- Johnson, W. M., 1993, Quality control and quality assurance, in Riddle, C., ed., Analysis of geological materials: New York, Marcel Dekker, Inc., p. 343-376.
- Leinz, R.W., Sutley, S.J., Desborough, G.A., and Briggs, P.H., 2000, An investigation of the partitioning of metals in mine wastes using sequential extractions, in Proceedings from the Fifth International Conference on Acid Rock Drainage (ICARD2000), Denver, Colorado, May 21-24, 2000: Society for Mining, Metallurgy, and Exploration, Inc., v. II, p. 1489-1499. (Available online at http://crustal.usgs.gov/minewaste/pdfs/leinz1.pdf)
- McCarty, Douglas K, Moore, Johnnie N., and Marcus, W. Andrew, 1998, Mineralogy and trace element association in an acid mine drainage iron oxide precipitate: comparison of sequential extractions: Applied Geochemistry, v. 13, p. 165-176.
- McLemore, V.T., 2003, Use of the New Mexico Mines Database in reclamation studies, in Proceedings, 2003 National Meeting of the American Society of Mining and Reclamation and 9th Billings Land Reclamation Symposium, Billings, MT, June 3-6, 2003: Lexington, Kentucky, American Society of Mining and Reclamation.
- Tessier, A., Campbell, P.C.G., and Bisson, M., 1979, Sequential extraction procedure for the speciation of particulate trace metals: Anal. Chem., v. 51, p. 844-851.
- To, T.B., Nordstrom, D.K., Cunningham, K.M., Ball, J.W., and McCleskey, R.B., 1999, New method for the direct determination of dissolved Fe(III) concentration in acid mine waters: Environmental Science and Technology, v. 33, p. 807-813.

STANDARD REFERENCE MATERIALS: U.S. Geological Survey Geochemical Reference Materials and Certificates: <u>http://minerals.cr.usgs.gov/geochem/index.html</u>

U.S. Geological Survey Standard Reference Samples: <u>http://bqs.usgs.gov/srs/</u>

National Institute of Standards and Technology (NIST) Standard Reference Materials: <u>http://ts.nist.gov/ts/htdocs/230/232/</u>

Natural Resources Canada's Canadian Certified Reference Materials: <u>http://www.nrcan.gc.ca/mms/canmet-mtb/mmsl-lmsm/ccrmp/ccrmp-e.htm</u>

Trace element geochemistry, EnviroMine: <a href="http://technology.infomine.com/enviromine/ard/Introduction/Trace.htm">http://technology.infomine.com/enviromine/ard/Introduction/Trace.htm</a>

Quality assurance / quality control, Enviromine: <u>http://technology.infomine.com/enviromine/ard/Acid-Base%20Accounting/Quality.htm</u>

Management and analysis of ARD data, Enviromine: <u>http://technology.infomine.com/enviromine/ard/Case%20Studies/data.html</u>

U.S. Environmental Protection Agency Environmental Test Methods and Guidelines: <u>http://www.epa.gov/epahome/Standards.html</u>

U.S. Environmental Protection Agency National Water Quality Standards Database <u>http://www.epa.gov/wqsdatabase/</u>

# VIIIA. Leaching Studies

- ASTM, Method D6234-98, Standard Test Method for Shake Extraction of Mining Waste by the Synthetic Precipitation Leaching Procedure. American Society for Testing and Materials: <u>http://www.astm.org</u>
- ASTM, Method D5744-96(2000), Standard Test Method for Accelerated Weathering of Solid Materials Using a Modified Humidity Cell. American Society for Testing and Materials: <u>http://www.astm.org</u>
- Bove, D.J., Kurtz, J.P., Wright, W.G., 2002, Geology, mineralization, and hydrothermal alteration and relationships to acidic and metal-bearing surface waters in the Palmetto Gulch Area, Southwestern Colorado: Open-File Report 02-0275, 35 p.
- Crock, J.G. and Severson, R.C., 1980, Four Reference Soil and Rock Samples for Measuring Element-Availability in the Western Energy Regions: USGS Circular 841, 16 pp.
- Hageman, Philip L, and Briggs, Paul H., 2000, A Simple Field Leach for Rapid Screening and Qualitative Characterization of Mine-Waste Dump Material on Abandoned Mine Lands, in ICARD 2000: Proceedings from the Fifth International Conference on Acid Rock Drainage, Denver, Colorado, May 21-24, 2000: Society for Mining, Metallurgy, and Exploration Inc., p. 1463-1475.
- Herron, J, Jordet, J. A., and T. R. Wildeman, 2001, Reclamation Feasibility Report Virginia Canyon. Colorado Div. Of Minerals and Geology, Denver, CO, 60 pp.
- Smith, K. S., Ramsey, C., A., and Hageman, P.L., 2000, Sampling Strategy for the Rapid Screening of Mine-Waste Dumps on Abandoned Mine Lands. Proceedings from the 5th International Conference on Acid Rock Drainage, Society For Mining, Metallurgy, and Exploration, Littleton, CO, p. 1453-1462.

- U.S. Environmental Protection Agency, 2002, Test Methods for Evaluating Solid Wastes, Physical and Chemical Methods, <u>http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm</u>
- Yager, D.B., Mast, A.M., Verplank, P.L., Bove, D.J., Wright, W.G., and Hageman, P.L., 2000, Natural versus mining-related water quality degradation to tributaries draining Mount Moly, Silverton, Colorado, in Proceedings from the 5th International Conference on Acid Rock Drainage: Society for Mining, Metallurgy, and Exploration, Littleton, CO, p.535-547.

- Eppinger, R.G., Briggs, P.H., Rosenkrans, D., and Ballestrazze, V., 2000,
  Environmental geochemical studies of selected mineral deposits in Wrangell-St.
  Elias National Park and Preserve, Alaska: U.S. Geological Survey Professional
  Paper 1619, 41 p. (Available online at <a href="http://pubs.usgs.gov/pp/p1619/">http://pubs.usgs.gov/pp/p1619/</a>)
- Nash, J.T., 1999a, Geochemical investigations and interim recommendations for priority abandoned mine sites on U.S.D.A. Forest Service lands, Mineral Creek watershed, San Juan County, Colorado: U.S. Geological Survey Open-File Report 99-170, 40 p.
- Nash, J.T., 1999b, Geochemical investigations and interim recommendations for priority abandoned mine sites, BLM lands, upper Animas River watershed, San Juan County, Colorado: U.S. Geological Survey Open-File Report 99-323, 45 p.
- Nash, J.T., 2000, Geochemical studies of mines, dumps, and tailings as sources of contamination, upper Animas River Watershed, Colorado, U.S. Geological Survey Open-File Report 00-104, CD-ROM.
- Nash, J.T., 2002, Hydrogeochemical investigations of historic mining districts, central Western Slope of Colorado, including influence on surface-water quality, U.S. Geological Survey Digital Data Series DDS-73.
- Nevada Mining Association, 1996, Meteoric water mobility procedure (MWMP), Standardized Column Percolation Test Procedure: Nevada Mining Association, Reno, NV, 5p.
- Price, W.A., Morin, K. and Hutt, N., 1997, Guidelines for the prediction of acid rock drainage and metal leaching for mines in British Columbia: Part II -Recommended procedures for static and kinetic testing, in Proceedings of the 4th International Conference on Acid Rock Drainage, Vancouver, BC, p. 15-30.

Sobek, A.A., Schuller, W.A., Freeman, J.R. and Smith, R.M., 1978, Field and laboratory methods applicable to overburden and minesoils: EPA-600/2-78-054, U.S. National Technical Information Service Report PB-280 495.

#### **Related Resources:**

Metal leaching test procedures, Enviromine: <u>http://technology.infomine.com/enviromine/ard/Acid-Base%20Accounting/metal\_leaching.htm</u>

Kinetic testwork procedures, Enviromine:

http://technology.infomine.com/enviromine/ard/Kinetic%20Tests/kinetic%20procedures. htm

Kinetic testwork interpretation, EnviroMine

http://technology.infomine.com/enviromine/ard/Kinetic%20Tests/kinetic%20examples.ht m

# VIIIB. Assessing the Toxicity of Mine-Waste Piles: Chemical Criteria

- Hageman, P.L., and P.L. Briggs, 2000, A simple field leach test for rapid screening and qualitative characterization of mine waste dump material on abandoned mine lands, in Proceedings from the 5th International Conference on Acid Rock Drainage: Society For Mining, Metallurgy, and Exploration, Littleton, CO, pp.1463-1476.
- Herron, J., Stover, B., and P. Krabacher, 1998, Cement Creek reclamation feasibility report, Upper Animas basin: Colorado Division of Minerals and Geology, Denver, CO, 139 p.
- Herron, J, Jordet, J. A., and T. R. Wildeman, 2001, Reclamation feasibility report: Virginia Canyon: Colorado Div. Of Minerals and Geology, Denver, CO, 60 p.
- Smith, K.S., Ramsey, C.,A., and P.L. Hageman, 2000, Sampling strategy for the rapid screening of mine-waste dumps on abandoned mine lands: Proceedings from the 5th International Conference on Acid Rock Drainage, Society For Mining, Metallurgy, and Exploration, Littleton, CO, pp.1453-1462.
- US Env.. Protection Agency, 2002, Test methods for evaluating solid wastes, physical and chemical methods: http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm

- Winkler, S. Wildeman, T.R., Robinson, R., and J. Herron, 1999, A concise method for mine soil analysis, in Proceedings of 16th Annual Meeting of American Society for Surface Mining and Reclamation: pp. 236-244.
- Wildeman, T.R., Ranville, J. F., Herron, J., and R. H. Robinson, 2003, Development of a simple scheme to determine The chemical toxicity of mine wastes in Proceedings of 20th Annual Meeting of American Society for Mining and Reclamation.

- Clayton, L.D., and T R. Wildeman, 1998, Processes contributing to the removal of manganese from mine drainage by an algal mixture, in Proceedings of 15th Annual Meeting of American Society for Surface Mining and Reclamation: pp.192-201.
- Tessier, A., Campbell, P.C.G., and M. Bisson, 1979, Sequential extraction procedure for the speciation of particulate trace metals: Anal. Chem., Vol. 51, pp 844-851.

# IX. Acid-Base Accounting

- Bucknam, C.H., 1997, Net carbonate value (NCV) for acid-base accounting. (Available online at <u>http://www.bucknam.com/ncv.html</u>)
- Coastech Research, 1989, Investigation of prediction techniques for acid mine drainage, MEND Project Report 1.16.1a: MEND, Ottawa, Ontario.
- Coastech Research, 1991, Acid rock drainage prediction manual, MEND Project Report 1.16.1b: MEND, Ottawa, Ontario.
- Fey, D.L., Desborough, G.A., and Finney, C.J., 2000, Analytical results for totaldigestions, EPA-1312 leach, and net acid production for twenty-three abandoned metal-mining related wastes in the Boulder River watershed, Northern Jefferson County, Montana, U.S. Geological Survey Open-File Report 00-114, 17 p.
- Fey, D.L., Desborough, G.A., and Church, S.E., 2000, Comparison of two leach procedures applied to metal-mining related wastes in Colorado and Montana and a relative ranking method for mine wastes, in Proceedings of the Fifth International Conference on Acid Rock Drainage, May 20-23, 2000, Denver, Colorado, Society of Mining Engineering, Lakewood, Colo., p. 1477-1487.

- Lapakko, K.A., and Lawrence, R.W., 1993, Modification of the net acid production (NAP) test, in Proceedings of the Seventeenth Annual British Columbia Mine Reclamation Symposium, Port Hardy, British Columbia, May 4-7, 1993, p. 145-159.
- MEND Manual, 2000, Prediction, MEND Manual vol. 3: Mine Environment Neutral Drainage (MEND) Program Report 5.4.2c.
- Miller, S., Robertson, A., and Donahue, T., 1997, Advances in acid drainage prediction using the Net Acid Generation (NAG) test, in Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, B.C., Canada, v. !!, p. 533-549.
- Price, W.A., 1997, DRAFT Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia, British Columbia Ministry of Employment and Investment, Energy and Minerals Division, Smithers, BC, (April), 143p.
- Sobek, A.A., Schuller, W.A., Freeman, J.R., and Smith, R.M., 1978, Field and laboratory methods applicable to overburdens and minesoils. EPA-600/2-78-054. U.S. Environmental Protection Agency, Cincinnati, Ohio, 203 p.

- Brady, K.B.C., and Cravotta, C.A., III, 1992, Acid base accounting--An improved method of interpreting overburden chemistry to predict the quality of coal-mine drainage, in Proceedings 13th Annual Meeting West Virginia Surface Mine Drainage Task Force:: Morgantown, W.Va., West Virginia University, 10 p.
- Bruynesteyn, A., and Hackl, R.P., 1984, Evaluation of acid production potential of mining waste materials. Minerals and the Environment, v. 4 (1), p. 5-8.
- Desborough, G.A., and Fey, D.L., 1997, Preliminary characterization of acid-generating potential and toxic metal solubility of some abandoned metal-mining related wastes in the Boulder River headwaters, northern Jefferson County, Montana: U.S. Geological Survey Open-File Report 97-478, 21 p
- Duncan, D.W. and Bruynesteyn, A., 1979, Determination of acid production potential of waste materials: Met. Soc. AIME, paper A79-29, 10 p.
- Fey, D.L., Church, S.E., Unruh, D.M., and Bove, D.J., 2002, Water and sediment study of the Snake River watershed, Colorado, Oct. 9-12, 2001: U.S. Geological Survey Open-File Report 02-330, 41 p.

- Fey, D.L., and Church, S.E., 1998, Analytical results for 42 fluvial tailings cores and 7 stream sediment samples from High Ore Creek, northern Jefferson County, Montana: U. S. Geological Survey Open-File Report 98-215, 49 p.
- Fey, D.L., Church, S.E., and Finney, C.J., 1999, Analytical results for 35 mine-waste tailings cores and six bed-sediment samples, and an estimate of the volume of contaminated material at Buckeye Meadow on upper Basin Creek, northern Jefferson County, Montana: U.S. Geological Survey Open-File Report 99-537, 59 p.
- Fey, D.L., Church, S.E., and Finney, C.J., 2000, Analytical results for Bullion Mine and Crystal Mine waste samples and bed sediments from a small tributary to Jack Creek and from Uncle Sam Gulch, Boulder River watershed, Montana U.S. Geological Survey Open-File Report 00-031, 63 p.
- Filipek, L.H., VanWyngarden, T.J., Papp, C.S.E., and Curry, J., 1999, A multi-phased approach to predict acid production from porphyry copper-gold waste rock in an arid montane environment, in Filipek, L.H., and Plumlee, G.S., eds., The environmental geochemistry of mineral deposits, Part B: case studies and research topics, Reviews in Economic Geology, vol. 6B: Littleton, Colorado, Society of Economic Geologists, Inc., p. 433-445.
- Jambor, J.L., Dutrizac, J.E., and Chen, T.T., 2000, Contribution of specific minerals to the neutralization potential in static tests, in Proceedings of the Fifth International Conference on Acid Rock Drainage, May 20-23, 2000, Denver, Colorado, Society of Mining Engineering, Lakewood, Colo., p. 551-565.
- Lawrence, R.W., and Wang, Y., 1997, Determination of neutralization potential in the prediction of acid rock drainage, in Proceedings of the Fourth International Conference on Acid Rock Drainage, 1997, Vancouver, British Columbia, p. 449-464.
- Li, M.G., 2000, Acid rock drainage prediction for low-sulphide, low neutralization potential mine wastes, in Proceedings of the Fifth International Conference on Acid Rock Drainage, May 20-23, 2000, Denver, Colorado, Society of Mining Engineering, Lakewood, Colo., p. 567-579
- Miller, S.D., Jeffrey, J.J., and Donohue, T.A., 1994, Developments in predicting and management of acid forming mine wastes in Australia and southeast Asia: Paper presented at the International Conference on the Abatement of Acidic Drainage, Pittsburgh, PA, April 24-29, 1994.
- Nash, J.T., 1999a, Geochemical investigations and interim recommendations for priority abandoned mine sites on U.S.D.A. Forest Service lands, Mineral Creek watershed, San Juan County, Colorado: U.S. Geological Survey Open-File Report 99-170, 40 p.

- Nash, J.T., 1999b, Geochemical investigations and interim recommendations for priority abandoned mine sites, BLM lands, upper Animas River watershed, San Juan County, Colorado: U.S. Geological Survey Open-File Report 99-323, 45 p.
- Nash, J.T., 2000, Geochemical studies of mines, dumps, and tailings as sources of contamination, upper Animas River Watershed, Colorado, U.S. Geological Survey Open-File Report 00-104, CD-ROM.
- Nash, J.T., 2002, Hydrogeochemical investigations of historic mining districts, central Western Slope of Colorado, including influence on surface-water quality, U.S. Geological Survey Digital Data Series DDS-73.
- Schafer, W.M., 2000, Use of the net acid generation pH test for assessing risk of acid generation, in Proceedings of the Fifth International Conference on Acid Rock Drainage, May 20-23, 2000, Denver, Colorado, Society of Mining Engineering, Lakewood, Colo., p. 613-618.
- Skousen, J., Renton, J., Brown, H., Evans, P., Leavitt, B., Brady, K., Cohen, L. and Ziemkiewicz, P., 1997, Neutralization potential of overburden samples containing siderite: Journal of Environmental Quality, v. 26, no. 3, p. 673-681.
- White, W.W., III, Lapakko, K.A., and Cox, R.L., 1999, Static-test methods most commonly used to predict acid mine drainage: Practical guidelines for use and interpretation, in Plumlee, G.S., and Logsdon, M.J., eds., The environmental geochemistry of mineral deposits, Part A: processes, techniques, and health issues, Reviews in Economic Geology, vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 325-338.

Acid base accounting, EnviroMine: <u>http://technology.infomine.com/enviromine/ard/Acid-</u> Base%20Accounting/ABAdiscussion.htm

Acid base accounting test procedures, EnviroMine: <u>http://technology.infomine.com/enviromine/ard/Acid-Base%20Accounting/acidbase.htm</u>

# X. Using the Decision Tree

Hageman, P.L., and P.L. Briggs, 2000, A simple field leach test for rapid screening and qualitative characterization of mine waste dump material on abandoned mine lands, in Proceedings from the 5th International Conference on Acid Rock Drainage: Society For Mining, Metallurgy, and Exploration, Littleton, CO, pp.1463-1476.

- Herron, J., Stover, B., and P. Krabacher, 1998, Cement Creek reclamation feasibility report, Upper Animas basin: Colorado Division of Minerals and Geology, Denver, CO, 139 p.
- Herron, J, Jordet, J. A., and T. R. Wildeman, 2001, Reclamation feasibility report: Virginia Canyon: Colorado Div. Of Minerals and Geology, Denver, CO, 60 p.
- Smith, K.S., Ramsey, C.,A., and P.L. Hageman, 2000, Sampling strategy for the rapid screening of mine-waste dumps on abandoned mine lands: Proceedings from the 5th International Conference on Acid Rock Drainage, Society For Mining, Metallurgy, and Exploration, Littleton, CO, pp.1453-1462.
- US Env.. Protection Agency, 2002, Test methods for evaluating solid wastes, physical and chemical methods: http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm
- Winkler, S. Wildeman, T.R., Robinson, R., and J. Herron, 1999, A concise method for mine soil analysis, in Proceedings of 16th Annual Meeting of American Society for Surface Mining and Reclamation: pp. 236-244.
- Wildeman, T.R., Ranville, J. F., Herron, J., and R. H. Robinson, 2003, Development of a simple scheme to determine The chemical toxicity of mine wastes in Proceedings of 20th Annual Meeting of American Society for Mining and Reclamation.

- Clayton, L.D., and T R. Wildeman, 1998, Processes contributing to the removal of manganese from mine drainage by an algal mixture, in Proceedings of 15th Annual Meeting of American Society for Surface Mining and Reclamation: pp.192-201.
- Tessier, A., Campbell, P.C.G., and M. Bisson, 1979, Sequential extraction procedure for the speciation of particulate trace metals: Anal. Chem., Vol. 51, pp 844-851.