Minnesota Ground Water Association
Fall 2005 Conference – November 17, 2005

GeoChemistry for Scientific Investigations

Dr. Laine Vignona, University of Wisconsin, River Falls
Presentation
Geochemistry Refresher & Pollution Study Applications

Scott Alexander, University of Minnesota
Presentation
Non-Contaminant Chemistry of Natural Waters

Geoff Delin, US Geological Survey
Presentation
Use of Environmental Tracers to Age-Date Recently Recharged Ground Water **Overview**

- **Introduction and applications of age dating young ground water**
- **Environmental tracers used for dating young ground water**
- **Example applications of ground-water age dating technology**

Recent scientific advancements have allowed for the use of environmental tracers such as chlorofluorocarbons, sulfur-hexafluoride, and tritium/helium for estimating the mean age of ground-water samples. Analytical methods are now precise enough so that these anthropogenic environmental tracers can be used to estimate ground-water recharge age to within about one year. These environmental tracers are valid for waters recharged within about the past 40-60 years. Interest in measuring the age of recent ground-water recharge is increasing because it has numerous applications including the estimation of ground-water vulnerability to anthropogenic contamination (such as through well-head protection and source-water programs), estimation of long-term changes in ground-water quality due to past or ongoing contamination, and calibration of ground-water flow and transport models. Recent research that applies the new age-dating methods to investigate flow and transport processes is revealing fundamental information about ground-water age and the sustainability of ground-water quality.

Education
Bachelors (Geology), University of Minnesota, 1976

Experience
1979-present, U.S. Geological Survey, Water Resources Discipline (Hydrologist)
1977-1979, E.A. Hickok and Associates (Geologist)

Licenses/Certifications
Certified Professional Hydrogeologist, American Institute of Hydrology
Certified Professional Geologist, Minnesota Board of Architecture, Engineering, Land Surveying, Landscape Architecture, Geoscience and Interior Design

Affiliations
American Geophysical Union (AGU)
American Institute of Hydrology (AIH)
Geological Society of America (GSA)
Minnesota Ground Water Association (MGWA)
National Ground Water Association (NGWA)

Steve Robertson, MN Department of Health

Presentation

Sleuthing for Contaminant Pathways in a Fractured Aquifer Setting

- **Contaminated municipal water supply well**
- **Deep bedrock setting**
- **Use of chemical/isotope tools to identify possible contaminant pathways**

Education

M.A., Geological Sciences, University of Texas, 1987
B.A., Geology, Carleton College, 1983

Experience

Steve works as a hydrogeologist with the Minnesota Department of Health, focusing primarily on wellhead protection activities for public water supply systems in the 7 county Twin Cities metropolitan area. Prior to 1998, when he started with the MDH, Steve worked for several different environmental consulting firms.

Affiliations/Licensure

Minnesota Ground Water Association
National Ground Water Association
Licensed Professional Geologist, State of Minnesota

Jim Walsh, MN Department of Health

Presentation

Isotope Investigations in Wellhead Protection Areas

- **How isotopes can be used in wellhead protection to determine the age and source of recharge water or contaminants**
- **Specific examples**
- **Concluding remarks**

Education

M.S. (geology), University of Michigan, 1985
B.A. (geology), Miami University, 1982

Experience

1989-present, Minnesota Department of Health (hydrogeologist)
1985-1989, Golden Reward Mining Company (geologist)

Affiliations

National Ground Water Association (NGWA)
Minnesota Ground Water Association (MGWA)

Jim Lundy, MN Department of Health

Presentation

Looking for Radium in All the Right Places

- **Why radionuclides are an issue (health effects, EPA rule)**
- **Radionuclides 101--current thoughts on radionuclide occurrence and transport in GW, previous work done in Minnesota and midwest**
- **Our results (progress report, partially complete study)**
- **Further anticipated work**
- **Conclusions**

Education
Master of Science, 1985, University of Minnesota, Minneapolis, structural geology
Bachelor of Arts, 1981, Gustavus Adolphus College, St. Peter, Minnesota, geography and geology
Additional coursework: University of Wisconsin-Madison, Colorado College, University College of North Wales

Experience
2004-present, Minnesota Department of Health, hydrogeologist
1989-2004, Minnesota Pollution Control Agency, hydrogeologist
1987-1989, ENSR Consulting and Engineering, geologist
1986-1987, Minnesota Pollution Control Agency, pollution control specialist

Affiliations
Minnesota Ground Water Association (MGWA)
American Institute of Hydrology (AIH)
National Ground Water Association (NGWA)

Dr. Melinda Erickson, MN Department of Transportation

Presentation
Geochemical Investigation of Naturally Occurring Arsenic in Upper Midwest Ground Water

Abstract
Arsenic is a widespread, naturally occurring contaminant in upper Midwest ground water. Ground water contamination from naturally occurring processes is fundamentally different than contamination from anthropogenic sources. Therefore, investigating the occurrence and mobility of naturally-occurring contaminants is fundamentally different from investigating anthropogenic contaminants. Defining a source or the extent of a source, in the classic sense, is often not a relevant part of investigating naturally occurring contaminants.
For example, arsenic is already widely present in upper Midwest sediment at concentrations that could cause ground water contamination of concern if the geochemical conditions were conducive to arsenic mobilization from sediment to ground water. Some important factors related to arsenic mobilization are pH, redox, DO, iron, sulfide/sulfate, 3-D geology, well characteristics, well pumping regime, sediment texture, and sediment minerals.
For more information about arsenic in Minnesota and upper Midwest ground water, please visit the following websites:
http://wrs.coafes.umn.edu/students/Alumni/erickson.htm,
http://www.health.state.mn.us/divs/eh/wells/arsenic.html,
http://www.health.state.mn.us/divs/eh/hazardous/topics/arsenicstudy.pdf, and
http://www.pca.state.mn.us/water/groundwater/pubs/arsenic.pdf.

Education
Ph.D., Water Resources Science, University of Minnesota, 2005
M.S., Civil Engineering, University of Minnesota, 1992
Bachelor of Geological Engineering, University of Minnesota, 1990

Experience
Dr. Erickson has been working on research related to arsenic contamination in Minnesota and upper Midwest ground water since 1998, most recently as a graduate student and previously as a hydrologist at the Minnesota Department of Health. Prior to joining MDH, Dr. Erickson worked as a project manager and project engineer for RETEC, a national environmental consulting firm. She is currently a research analyst for the Minnesota Department of Transportation.

Dr. Mike Berndt, MN Department of Natural Resources

Presentation

Use of Halide Tracers to Constrain Hydrology of an Open-Pit Tailings Disposal Site in NE MN

- **Hydrologic complexities associated with in-pit tailings disposal**
- **Use of halides (Br, Cl) to identify flow pathways**
- **Use of halides to constrain underground flow rates**
- **Chemical reactions in the Biwabik Iron Formation**

Education

Ph.D. (Geology), University of Minnesota, 1987
M.S. (Geology), University of Wisconsin, 1983
B.S. (Geology), University of Minnesota, 1980
B.S. (Geophysics), University of Minnesota, 1980

Work Experience

2001-present, DNR-Lands and Minerals: Research Scientist and Senior Project Consultant
1987-2001, University of Minnesota- Twin Cities: Research Associate and Senior Research Associate

Affiliations

Geochemical Society (GC) 1984-present.

Dr. E Calvin Alexander, Jr., University of Minnesota

Presentation

Conduits Rule, Fractures Drool and Pores Suck (Karst and the Nature of Hydrogeologic Reality)

Joe Magner, MN Pollution Control Agency

Presentation

Is There a Role for Geochemical Tools in the Clean Water Legacy?

Abstract

The Clean Water Legacy (CWL) is a legislative water initiative aimed at the restoration of Minnesota's impaired waters. Impaired waters are defined as waterbodies not meeting Minnesota water quality standards. A provision of the Clean Water Act (CWA) known as Section 303(d) or TMDL requires states to list impaired waters and then conduct a TMDL study. The TMDL study, unlike a Clean Water Partnership diagnostic study, requires a detailed analysis of pollutant sources and hydrologic pathways. Detail is required to balance the assimilative capacity (AC) equation: AC = defined end-point = WLA + LA + MOS + RC, where, WLA is the waste load allocation from point sources, LA is load allocation from non-point sources, MOS is the margin of safety, and RC is the reserve capacity for future growth. Compliance with water quality standards is measured in a waterbody within a watershed. Various sectors, including natural processes, contribute pollutant loads to a given waterbody; allocating the loads to the various sectors requires a detective-like investigation of processes and pathways. Geochemical and isotopic tools and techniques can be used to build the "weight of evidence" needed to solve the load allocation mystery. To meet the legal demands of the CWA, the Minnesota legislature (both House and Senate) created a bill in 2005 to annually distribute $80 million for the study and restoration of impaired waters. Unfortunately, legislators could not agree on how to fund the bill; due to the tax-fee quandary. Nevertheless, there is optimistic hope for the 2006 legislative session.

Joe Magner is a senior hydrologist with the Minnesota Pollution Control Agency. Upon graduation from the University of Wisconsin and a short tenure with Geotechnical Engineering Corporation, Joe began working for the MPCA in 1979 when he found himself opposite of Calvin Alexander regarding feedlot manure storage ponds in S.E. MN. Joe then began his "real world" education with Calvin and has since become an advocate for basic cation/anion analysis and the use of deuterium and oxygen-18 in watershed studies. In cooperation with Calvin and Scott Alexander, Joe has collected hundreds of geochemical water samples across Minnesota and has co-authored several peer-reviewed papers with Calvin and Scott. Joe is currently researching and developing protocols for Minnesota's TMDL program. In his spare time, he is finishing his PhD in hydrology and watershed management at the University of Minnesota.

Dr. Carol Kendall, US Geological Survey

CSI: Isotope Forensics - How to Use Isotope Fingerprints to Solve Hydrological "who dunnits"

Abstract

Isotope hydrology is one of the fastest growing environmental disciplines. The basic principle is that different sources of materials (such as waters, nitrate, and organic pollutants) and different kinds of biogeochemical sinks (or products) often have distinctively different isotope ratios -- or different isotope fingerprints. There are many "forensic" applications of isotope fingerprints. For example, nitrate isotopes in groundwater samples can be used to determine if the major nitrate source is fertilizer or animal waste, and organic isotopes can be used to determine if an oil spill is from a specific oil company property. This presentation will briefly review the fundamentals of isotope geochemistry, and present several examples of how isotopes are currently being used to solve important water quality and quantify problems.

Education

Ph.D. Geology (geochemistry) 5/93, University of Maryland, College Park.
M.S. Geology 12/76, University of California, Riverside.
B.S. Geology 6/73, University of California, Riverside.

Professional Experience

1990 to Present: Research Hydrologist (Geochemist) in the National Research Program, USGS, WRD. Project Chief of the Isotope Tracers Project, Menlo Park CA; promoted to GS-15 (10/01)
1980-1990: Research Hydrologist, National Research Program, USGS-WRD, Reston VA
1976-1979: Geochemist at the Department of Geology, California Institute of Technology.
1973-1976: Staff research associate at the University of California, Riverside.

Ten Selected Publications:

Kendall, C., and McDonnell, J.J. (Eds) 1998. Isotope Tracers in Catchment Hydrology, Elsevier, Amsterdam, 839 p.

Kendall, C., 1998. Tracing nitrogen sources and cycling in catchments, In: C. Kendall and J.J. McDonnell (Eds.), Isotope Tracers in Catchment Hydrology, Elsevier, Amsterdam, p. 519-576.

Silva, S.R., Kendall, C., Wilkison, D.H., Ziegler, A.C., Chang, C.C., and Avanzino, R.J, 2000. A new method for collection of nitrate from fresh water and the analysis of nitrogen and oxygen isotope ratios, J. of Hydrology, 228: 22-36.

Kendall, C., Silva, S.R., and Kelly, V.J., 2001. Carbon and nitrogen isotopic compositions of particulate organic matter in four large river systems across the United States, Hydrol. Processes: 15, 1301-46.

Kendall, C., and Coplen, T.B., 2001. Distribution of oxygen-18 and deuterium in river waters across the United States, Hydrological Processes: 15, 1363-1393.

Kendall, C., McDonnell, J.J., and Gu, W., 2001. A look inside “black box” hydrograph separation models: A study at the Hydrohill artificial catchment, Hydrologic Processes, 15:1877-1902.

Burns, D.A., and Kendall, C., 2002. Sources of NO3- in drainage waters of two Catskill Mountain watersheds differentiated through dual isotope analysis, Water Res. Research 38: 14-1 to 14-11.

Campbell, D.H., Kendall, C., Chang, C.C.Y., Silva, S.R., Tonnessen, K.A., 2002. Pathways for nitrate release from an alpine watershed: determination using δ15N and δ18O, Water Resources Res. 38: 9-1 to 9-11.

Chang, C.C.Y, Kendall, C., Silva, S.R., Battaglin, W.A., and Campbell, D.H., 2002. Nitrate stable isotopes: tools for determining nitrate sources among different land uses in the Mississippi River Basin, Can. J. Fish, Aq. Sci. 59: 1874-85.

McCutchan, J.H., Lewis, W.M. Jr., Kendall, C., and McGrath, C.C. 2003. Variation in trophic shift for stable isotope ratios of carbon, nitrogen, and sulfur, Oikos, 102: 378-390.

Selected Web-based Presentations and Materials

http://water.usgs.gov/nrp/proj.bib/kendall.html
http://wwwrcamnl.wr.usgs.gov/isoig/
http://wwwrcamnl.wr.usgs.gov/isoig/isopubs/itchinfo.html
http://wwwrcamnl.wr.usgs.gov/isoig/projects/Everglades/
http://sofia.usgs.gov/projects/int_geochem_foodweb/
Cyberseminars (click on Kendall links) at:
http://wwwrcamnl.wr.usgs.gov/wrdseminar/pastseminars2005.html
http://www.cuahsi.org/cyberseminars/archive.html
http://www.epa.gov/osp/regions/afo.html

Minnesota Ground Water Association

Fall 2005 Workshop – November 18, 2005

Isotope Hydrology Workshop

Dr. Carol Kendall, US Geological Survey

Presentation

- Fundamentals of Isotope Geochemistry
  - Introduction: terms/definitions
  - Isotopic fractionation: fractionation factors, exchange mechanisms, etc.
  - Radio-isotopes: decay series, half-life, etc
- Isotope Hydrology
  - Hydrologic cycle and the applications of deuterium, oxygen-18, and tritium to tracing water sources
- Isotope Biogeochemistry
  - Applications of solute and organic isotope tracers for determining pollutant sources
- Project Design
  - Sampling strategy, quality assurance of contract laboratories, collection methods

Education

Ph.D. Geology (geochemistry) 5/93, University of Maryland, College Park.
M.S. Geology 12/76, University of California, Riverside.
B.S. Geology 6/73, University of California, Riverside.

Professional Experience

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Chang, C.C.Y, Kendall, C., Silva, S.R., Battaglin, W.A., and Campbell, D.H., 2002. Nitrate stable isotopes: tools for determining nitrate sources among different land uses in the Mississippi River Basin, Can. J. Fish, Aq. Sci. 59: 1874-85.

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http://wwwrcamnl.wr.usgs.gov/isoig/
http://wwwrcamnl.wr.usgs.gov/isoig/isopubs/itchinfo.html
http://wwwrcamnl.wr.usgs.gov/isoig/projects/Everglades/
http://sofia.usgs.gov/projects/int_geochem_foodweb/
Cyberseminars (click on Kendall links) at:
http://wwwrcamnl.wr.usgs.gov/wrdseminar/pastseminars2005.html
http://www.cuahsi.org/cyberseminars/archive.html
http://www.epa.gov/osp/regions/afo.html

Dr. E Calvin Alexander, Jr., University of Minnesota

Presentation

Different Types of Break-Through Curves in Carbonate Aquifers

Dr. Emi Ito, University of Minnesota

Presentation

Hydrology Happens: Effects of Surface-Water Ground-Water Interchange on Oxygen and DIC Carbon Isotopes of Surface-Water Bodies

- **Factors that influence oxygen isotope values of surface-water bodies**
- **Factors that influence DIC carbon isotope values of surface-water bodies**
- **Residence time effects**
- **Groundwater flux - A case study**
- **Lessons for lake-sediment paleoclimatologists**

Education

University of Chicago	Mathematics	B.S.	1971
Princeton University	Geological Sciences	M.A.	1973
University of Chicago	Geophysical Sciences	Ph.D.	1979

Appointments

2002- Director, Limnological Research Center, University of Minnesota
2001- Faculty, Water Resource Sciences, University of Minnesota
1991- Faculty, Quaternary Paleoecology Graduate Minor, University of Minnesota
1982- Faculty, Geology and Geophysics, University of Minnesota
1980-1981 Carnegie Fellow, Dept. Terrestrial Magnetism, Carnegie Inst. of Washington
1973-1975 Earth Sciences and Mathematics Specialist, Calhoun School, Inc., New York, NY

Affiliations

American Geophysical Union (AGU)
American Meteorological Society (AMS)
American Quaternary Association (AMQUA)
American Society for Limnology and Oceanography (ASLO)
Geochemical Society

Dr. Martin O. Saar, University of Minnesota

Presentation

Helium Isotopes As a Natural Tracer in Volcanic and Non-Volcanic Aquifers

Abstract

Regional large-scale groundwater flow rates and patterns are difficult to determine using local pump tests of permeability and/or artificial tracers as permeability is often highly heterogeneous and long-range flow rates may be too small to monitor on reasonable time-scales. However, it is
often this large-scale groundwater flow field that is of interest for studies investigating long-term water resources, regional groundwater contamination, subsurface storage of (radioactive) waste, or geothermal energy resources. To study such problems, natural groundwater flow "tracers" may be employed which may include major elements, stable and unstable isotopes, noble gases, heat, and possibly even fluid induced microseismicity. In this presentation I will focus on noble gas isotopes in volcanic and non-volcanic aquifers and how they may be used to infer groundwater flow patterns. Particular emphasis will be given on how to distinguish between atmospheric, crustal, and mantle Helium contributions to aquifers using all stable noble gases in a joint inversion technique. This approach is often necessary in aquifers that are highly "diluted" in terrestrial noble gases by atmosphere-groundwater interactions.

Education

Ph.D. in Earth and Planetary Science, University of California - Berkeley, 2003
M.S. in Geological Sciences, University of Oregon - Eugene, 1998
B.S. (Vordiplom) in Geology, Albert-Ludwigs University - Freiburg, Germany, 1995

Experience

since January 2005: Assistant Professor and Gibson Chair of Hydrogeology and Geofluids, Department of Geology and Geophysics, University of Minnesota - Twin Cities

2003-2004	Turner Postdoc, Dept. of Geological Sciences, University of Michigan - Ann Arbor
2002-2003	Research Assistant, Lawrence Berkeley National Lab, Berkeley
2001-2003	Research Assistant, University of California, Berkeley, CA
2001	Instructor, University of Oregon, Eugene, OR
1997-2000	Research Assistant, University of Oregon, Eugene, OR
1995-1996	Research Assistant, Albert-Ludwigs University, Freiburg, Germany

Affiliations

International Association of Hydrogeologists (IAH)
Geological Society of America (GSA)
American Geophysical Union (AGU)

Relevant publication for this talk:

Saar, M.O., M.C. Castro, C.M. Hall, M. Manga, and T.P. Rose, Quantifying magmatic, crustal, and atmospheric Helium contributions to volcanic aquifers using all stable noble gases: Implications for magmatism and groundwater flow, Geochem. Geophys. Geosyst., Vol. 6, Nr. 3, Q03008, doi:10.1029/2004GC000828, 2005.

Discussion & Questions with and of Drs. Kendall, Alexander, Ito and Saar