ROY HAGGERTY

Dean, College of Science
Oregon State University

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EDUCATION & PROFESSIONAL PREPARATION

Stanford University, Stanford, CA; Applied Earth Sciences (Hydrogeology); PhD, 1996
Stanford University, Stanford, CA; Applied Earth Sciences (Hydrogeology); MS, 1993
University of Alberta, Edmonton, Canada; Honors Geology; BSc with First Class Honors, 1990

Registered Geologist, State of Oregon.

ADMINISTRATIVE POSITIONS

Dean, College of Science, Oregon State University. 2017 – Present
Associate Vice President for Research, Oregon State University. 2016 – 2017
Interim Dean, College of Earth, Ocean, and Atmospheric Sci., Oregon State University. 2015 – 2016
Water Resources Science Program Head, Oregon State University, 2008 – 2013
Geology Program Head, College of Science, Oregon State University. 2003 – 2006

ACADEMIC POSITIONS

Professor, Oregon State University, 2009 – present
Hollis M. Dole Professor of Environmental Geology, Oregon State University, 2010 – 2016
Associate Professor, Oregon State University, 2002 – 2009
Assistant Professor, Oregon State University, 1996 – 2002

Visiting Scientist, Centre d'Estudis Avançats de Blanes (CSIC), Blanes, Spain, 2006 – 2007
Visiting Scientist, Royal Technical University (KTH), Stockholm, Sweden, 2000

PROFESSIONAL ACTIVITIES

University Consortium for Atmospheric Research, OSU representative, 2015 – 2017
National Science Foundation, Hydrologic Sciences panel, 2008 – present
US Dept. of Energy, Committee of Visitors, Office of Science, 2016
University of Birmingham, UK, INTERFACES Board of Advisors, 2012 – 2016
American Geophysical Union, Assoc Editor Water Resources Research, 2001 – 2006, 2008 – 2013
UFZ, Leipzig, Germany, Reviewer for Water and Soil Research Program, 2012
OSU Faculty Senate, 2012 – 2015
Lawrence Berkeley National Lab, program review, 2010
US Dept. of Energy, EMSP review panel, 2009
EPSCOR Review Panel, New Mexico, 2002
National Science Foundation, GLOBE panel, 2001

PROFESSIONAL RECOGNITION

Fellow, Geological Society of America, 2014
Hollis M. Dole Professor of Environmental Geology, 2010 - 2016
Loyd Carter Award for Outstanding Graduate Teaching, College of Science, 2010
Outstanding Faculty Member award, OSU Geosciences Club, 2010
Paper on multirate mass transfer selected by IAHS as benchmark groundwater paper, 2008
Spanish Ministry of Science & Education Fellowship, 2006
Editor's Citation for Excellence in Refereeing, AGU, 2001
Outstanding Teaching Assistant award, Stanford University, 1993
"1967" Science and Engineering Scholarship, NSERC (Canada) 4-yr scholarship to fund PhD. 50 awards nation-wide in all fields.

Dean's Silver Medal in Science (2nd-highest cumulative 4-yr GPA in all of Science), U. Alberta, 1990
Undergraduate academic awards: Student-Industry award (1989), Alberta Energy Co. Scholarship (1989), Geological Association of Canada Prize (1989), P.S. Warren Prize in Earth History (1989), Suncor Scholarship in Geology (1988), Bill Elder Scholarship in Geology (1988), Walter Crawford Memorial Bursary in Geology (1987), APEGGA John Allan Memorial Scholarship in Geology (1987)

ADMINISTRATIVE EXPERIENCE

Dean, College of Science, Oregon State University, 2017 – Present

Associate Vice President for Research, Oregon State University, 2016 – 2017

Oregon State University is a Carnegie "R1" land-, sea-, space-, and sun-grant university with ~ 30,000 students and operations in all 36 counties in the state. OSU's research, development, and other sponsored activities awards were $336M in FY2016, with R&D expenditures of approximately $217M and a statewide economic footprint of over $2B. Major programs include the marine, atmospheric, and earth sciences, ecology, forestry, agriculture, engineering, veterinary medicine, and pharmacy.

I was the chief operating officer (COO) for the OSU Research Office, providing leadership, direction, and operational oversight for all of OSU's research enterprise. The Research Office includes research development, sponsored projects (pre- and post-award), research integrity/research compliance, the major university research centers/institutes including Oregon Sea Grant, and corporate/economic development and commercialization.

Accomplishments –

- Led 80% expansion and reform of OSU's research incentives programs, creating significant increase in internal research funding with focus on generation of external support
- Co-lead on 15-year strategic vision to provide roadmap for research distinction and academic excellence that will underpin our next multi-billion $ fundraising campaign
- Developed and began implementing plan to increase OSU's recovery of indirect costs for research, to generate more funds for research infrastructure (equipment, labs)
- Developed plan and began implementing campus-wide electronic research administration system to improve efficiency for managing conflicts of interest, human subjects research, and animal research
- Strong voice for research to OSU president, provost, and external constituents, with message that research is one of the most important human endeavors
- Collaborated with federal and state relations officers to advance OSU research agenda for Regional Class Research Vessel construction, ocean (wave) energy, and postdoctoral research

Interim Dean, College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, 2015 – 2016.

The College (CEOAS, "see-ohss") has an annual operating budget of $15M and external, research-intensive funding of $40M across a diverse portfolio of oceanography, atmospheric sciences, geography, geology, geophysics, and environmental science.

Accomplishments –

- Transformed college philanthropy by intensive focus on fundraising (79 donor visits in 13 months, including 25 out-of-state), staff increase, better partnership with OSU Foundation, and engagement of faculty and alumni, resulting in record year (>$4M)
- Brought one more ship into the college fleet of research vessels, the 84-ft *R/V Pacific Storm* (http://ceoas.oregonstate.edu/pacificstorm/), bringing the number of ships to three and increasing faculty and graduate student access to ocean
- Recognized safety vulnerability of students, staff, and faculty (particularly women) in field and shipboard work, created policy that all student-employees, faculty, and staff must receive sexual harassment prevention training every 3 years. Directed creation of professionally-staffed training program, resulting in more than 50% of employees being trained in first month.
- Led university delegation to China University of Geosciences in Wuhan and negotiated student exchange MOU with largest earth science university in China
- Increased transparency of college decision-making and budgeting through faculty involvement in policy development, consultation with faculty on major decisions, and open communication.
- Authorized several tenure-track faculty searches, resulting in hiring 5 tenure-track faculty
- Brought OSU's research vessel *R/V Oceanus* for 2-day berth on Portland's riverfront to showcase OSU oceanography, resulting in newspaper and TV publicity and an increase in college endowment
- Launched opportunity for all undergraduates in the college, including ocean sciences, to complete a relevant field experience. First complement of ocean sciences undergraduates completed 1-week science cruise on *R/V Oceanus*
- Led successful OSU proposal (NSF) for US national Antarctic sediment core collection
- Initiated $4M building renovation to create 20,000 sq ft of scientific research space that will house national Antarctic sediment core collection,
- Collaborated with Colleges of Engineering, Science, Agriculture, and Forestry on spousal accommodations, faculty retention, equity/diversity issues, renovation of lab space, government relations, startup packages, and fundraising
- In collaboration with OSU's other 10 academic colleges, we launched the OSU Marine Studies Initiative. While closest to CEOAS' mission, all 11 colleges contributed to launching the MSI. We are close to announcing completion of a >$65M fundraising effort for a new MSI building on the Oregon coast
- Promoted ocean, atmospheric, and earth science issues with US senators and representatives, in collaboration with federal relations officer and lobbyists
- Strong voice for earth, ocean, and atmospheric sciences around the US and OSU

Geology Program Head, College of Science, Oregon State University, 2003 – 2006

This position was effectively an Associate Chair in Dept. of Geosciences, with responsibilities in all parts of the department.

Accomplishments –

- Effective organizer and administrator, carrying same duties that were subsequently covered by multiple people after 2006
- Scheduled all classes, negotiated teaching loads
- Led promotion and tenure committee
- Managed all teaching assistants
- Managed graduate admissions
- Assisted with fundraising
- Proxy for department chair at college and university meetings
- Administered all aspects of both undergraduate and graduate geology programs
- Planned, proposed, and developed successful new Earth Sciences degree

Principal Investigator, Willamette Water 2100 project, 2012 – 2016

I led a $4M project to evaluate how climate change, population growth, and economic growth together change the availability, use, and scarcity of water in the Willamette River Basin. Project was a complex, multidisciplinary study with more than 20 faculty and staff.

Water Resources Science Program Head, Oregon State University, 2008 – 2013

A team of four led the Water Resources Graduate Program. As one of the authors of the proposal to establish the degrees, I led the Water Resources Science graduate program. The graduate program grew to more than 50 students during this period.

LANGUAGES: Nearly fluent in Spanish (spoken since teenager); basic French

RESEARCH

Accomplishments –

- More than 60 peer-reviewed and indexed publications; 1995 publication on multirate mass transfer named one of the most important "benchmark" papers in groundwater from 1856 (Darcy's Law) to the present (http://iahs.info/uploads/dms/86.02b-vii-x-Contents-Groundwater.pdf)
- External funded research totaling >$9 Million as PI/co-PI with primary budget authority
- Completed research in the physics of the water-ecosystem interface; mass transfer in porous and fractured media; diffusion in groundwater; groundwater - surface water interactions; development of a "smart tracer" for stream metabolism; fate and transport of nitrate in groundwater, flow and transport in the hyporheic zone of streams; tracer tests; mathematical modeling of solute transport, groundwater flow, and geologic/geophysical problems, integrated modeling of hydrologic and human systems.
- Example projects include
  - Urban Water Innovation Network (U-WIN): Transitioning toward sustainable urban water systems, NSF, $1,100,000. 2015 – 2020
  - How do hydrology and biogeochemistry control carbon flux from headwater streams to the atmosphere?, NSF, $444,943, 2014 – 2017
  - Anticipating water scarcity and informing integrative water system response in the Pacific Northwest. NSF. $4,344,919. 2010 – 2016
  - Mechanisms of impacts and trends over time: Exploring potential climate change influences on stream water temperature, US Forest Service, $227,500. 2010 – 2015
  - Surface transient storage in dead zones: Residence times from stream morphology, velocity and CFD modeling. NSF. $416,936. 2011 – 2015

- A Metabolically Active Transient Storage Model for predicting nutrient retention in streams. NSF. $417,064. 2009 – 2014
- Geoelectrical measurement of multi-scale mass transfer parameters. US Dept. of Energy. $157,558. 2009 – 2013
- Multi-scale mass transfer processes controlling natural attenuation and engineered remediation. US Dept. of Energy via Pacific Northwest National Laboratories. $616,000. 2007 – 2011

TEACHING

Taught at all levels from 100 to 600 and both face-to-face and ecampus (online), with classes ranging from 400 students (GEO 102 in 2 sections) to less than 10 PhD students (GEO 691). Classes in past 10 years include Earth System Science; Heat and Mass Transport in the Environment; Geoscience Communication; Hydrogeology; Intro Earth Sciences; Role of Fluids in Geologic Processes. Typical teaching load was 3-4 classes per year.

Research with undergraduates – Undergraduate thesis advisees have been co-authors on 2 papers in *Geophysical Research Letters* and 1 paper in *Water Resources Research.*

Advised 7 PhD, 23 MS, and 4 post-docs (3 PhD & 2 MS in progress). Former mentees are faculty at University of New Mexico, Colorado State University, Michigan State University, Heriot-Watt University, and many consulting companies and government agencies.

PEER-REVIEWED PUBLICATIONS (*h*-index = 30 [Web of Sci]; *my student & post-doc advisees italicized for work done under my supervision*, view at http://www.researcherid.com/rid/A-5863-2009)

Pennington, R., R. Haggerty, A. Argerich (in review), Measurement of gas exchange rates in streams by the oxygen-carbon method, submitted to *Freshwater Science*.

Jaeger, W.K., A. Amos, D.P. Bigelow, H. Chang, D.R. Conklin, R. Haggerty, C. Langpap, K. Moore, P.W. Mote, A.W. Nolin, A.J. Plantinga, C.L. Schwartz, D. Tullos, and D.P. Turner (2017), Finding water scarcity amid abundance using human-natural system models, *Proc. Nat. Acad. Sci.*, doi: 10.1073/pnas.1706847114.

Day-Lewis, F.D., N. Linde, R. Haggerty, K. Singha, and M. Briggs (2017), Pore-network modeling of the electrical signature of solute transport in dual-domain media, *Geophysical Research Letters*, 44, 4908—4916, doi:10.1002/2017GL073326.

Hester, E. T., M. B. Cardenas, R. Haggerty, and S. V. Apte (2017), The importance and challenge of hyporheic mixing, *Water Resour. Res.*, 53, 3565–3575, doi:10.1002/2016WR020005.

Corson-Rikert, H.A., S. M. Wondzell, R. Haggerty, M.V. Santelmann (2016), Carbon dynamics in the hyporheic zone of a headwater mountain stream in the Cascade Mountains, Oregon, *Water Resources Research,* doi: 10.1002/2016WR019303.

Argerich, A., R. Haggerty, S. L. Johnson, S. M. Wondzell, *N. Dosch,* H. Corson-Rikert, L.R. Ashkenas, *R. Pennington*, C.K. Thomas (2016), Comprehensive multi-year carbon budget of a temperate headwater stream, *Journal of Geophysical Research – Biogeosciences*, doi: 10.1002/2015JG003050.

González-Pinzón, R., M. Peipoch, R. Haggerty, E. Martí, and J.H. Fleckenstein (2016) Nighttime and daytime respiration in a headwater stream. *Ecohydrol.*, *9*, 93–100. doi: 10.1002/eco.1615.

Maxwell, R. M., L. E. Condon, S. J. Kollet, K. Maher, R. Haggerty, and M. M. Forrester (2016), The imprint of climate and geology on the residence times of groundwater, *Geophysical Research Letters, 43*, 701-708, doi:10.1002/2015GL066916.

González-Pinzón, R., A. S. Ward, C. E. Hatch, A. N. Wlostowski, K. Singha, M. N. Gooseff, R. Haggerty, W. H. Judson, O. A. Cirpka, and J. T. Brock (2015), A field comparison of multiple

techniques to quantify groundwater–surface-water interactions, *Freshwater Science*, *34*(1), 139-160, doi:10.1086/679738.

Zarnetske, J. P., R. Haggerty, and S. M. Wondzell (2015), Coupling multi-scale observations to evaluate hyporheic nitrate removal at the reach scale, *Freshwater Science*, *34*, 172-186, doi:10.1086/680011.

Jackson, T. R., S. V. Apte, R. Haggerty, and R. Budwig (2015), Flow structure and mean residence times of lateral cavities in open channel flows: Influence of bed roughness and shape, *Environmental Fluid Mechanics*, doi:10.1007/s10652-015-9407-2.

Haggerty, R., M. Ribot, G. A. Singer, E. Martí, A. Argerich, G. Agell, and T. J. Battin (2014), Ecosystem respiration increases with biofilm growth and bedforms: Flume measurements with resazurin, *Journal of Geophysical Research - Biogeosciences*, *119*, doi:10.1002/2013JG002498.

Lemke, D., *R. González-Pinzón*, Z. Liao, T. Wöhling, K. Osenbrück, R. Haggerty, and O. A. Cirpka (2014), Sorption and transformation of the reactive tracers resazurin and resorufin in natural river sediments, *Hydrol. Earth Syst. Sci., 18*, 3151--3163, doi:10.5194/hess-18-3151-2014.

González-Pinzón, R., R. Haggerty, and A. Argerich (2014), Quantifying spatial differences in metabolism in headwater streams, *Freshwater Science*, *33(3)*, 798-811, doi:10.1086/677555.

Drost, K. J., S. V. Apte, R. Haggerty, and *T. Jackson* (2014), Parameterization of mean residence times in idealized rectangular dead zones representative of natural streams, *Journal of Hydraulic Engineering*.

Haggerty, R. (2013), Analytical solution and simplified analysis of coupled parent-daughter steady-state transport with multirate mass transfer, *Water Resources Research*, *49*, 635-639, doi:610.1029/2012WR012821.

Arismendi, I., S. L. Johnson, J. B. Dunham, and R. Haggerty (2013), Descriptors of natural thermal regimes in streams and their responsiveness to change in the Pacific Northwest of North America, *Freshwater Biology*, *58*(5), 880-894,doi:810.1111/fwb.12094.

Diabat, M., R. Haggerty, and S. M. Wondzell (2013), Diurnal timing of warmer air under climate change affects magnitude, timing and duration of stream temperature change, *Hydrological Processes*, *27*(16), 2367-2378, DOI: 2310.1002/hyp.9533.

González-Pinzón, R., and R. Haggerty (2013), An efficient method to estimate processing rates in streams, *Water Resources Research*, *49*, doi:10.1002/wrcr.20446.

González-Pinzón, R., R. Haggerty, and M. Dentz (2013), Scaling and predicting solute transport processes in streams, *Water Resources Research*, doi:10.1002/wrcr.20280.

Jackson, T. R., R. Haggerty, and S. V. Apte (2013), A fluid-mechanics based classification scheme for surface transient storage in riverine environments: quantitatively separating surface from hyporheic transient storage, *Hydrology and Earth System Science*, *17*, 2747-2779, doi: 2710.5194/hess-2717-2747-2013.

Jackson, T. R., R. Haggerty, S. V. Apte, and B. L. O'Connor (2013), A mean residence time relationship for lateral cavities in gravel-bed rivers and streams: Incorporating streambed roughness and cavity shape, *Water Resources Research*, *49*, doi:10.1002/wrcr.20272.

González-Pinzón, R., R. Haggerty, and D. D. Myrold (2012), Measuring aerobic respiration in stream ecosystems using the resazurin-resorufin system, *Journal of Geophysical Research*, *117*, G00N06, doi:10.1029/2012JG001965.

Arismendi, I., M. Safeeq, S. L. Johnson, J. B. Dunham, and R. Haggerty (2012), Increasing synchrony of high temperature and low flow in western North American streams: double trouble for coldwater biota?, *Hydrobiologia*, *DOI 10.1007/s10750-012-1327-2*.

Jackson, T. R., R. Haggerty, S. V. Apte, A. Coleman, and K. J. Drost (2012), Defining and Measuring the Mean Residence Time of Lateral Surface Transient Storage Zones in Small Streams, *Water Resources Research*, W10501, doi:10510.11029/12012WR012096.

Stanaway, D., R. Haggerty, S. Benner, A. Flores, and K. Feris (2012), Persistent Metal Contamination Limits Lotic Ecosystem Heterotrophic Metabolism after More Than 100 Years of Exposure: A Novel Application of the Resazurin Resorufin Smart Tracer, *Environmental Science and Technology*, *46*, 9862-9871, doi:9810.1021/es3015666.

Swanson, R. D., K. Singha, F. D. Day-Lewis, A. Binley, K. Keating, and R. Haggerty (2012), Direct geoelectrical evidence of mass transfer at the laboratory scale, *Water Resources Research*, *48*, W10543, doi:10510.11029/12012WR012431.

Zarnetske, J. P., R. Haggerty, S. M. Wondzell, V. A. Bokil, and R. González-Pinzón (2012), Coupled transport and reaction kinetics control the nitrate source-sink function of hyporheic zones, *Water Resources Research*, *48*, W11508, doi:11510.11029/12012WR011894.

Arismendi, I., S. L. Johnson, J. B. Dunham, R. Haggerty, and D. Hockman-Wert (2012), The paradox of cooling streams in a warming world: Regional climate trends do not parallel variable local trends in stream temperature in the Pacific continental United States, *Geophys. Res. Lett.*, doi:10.1029/2012GL051448.

Zarnetske, J. P., R. Haggerty, S. M. Wondzell, and M. A. Baker (2011), Labile dissolved organic carbon supply limits hyporheic denitrification, *J. Geophys. Res.*, *116*, G04036, doi:04010.01029/02011JG001730.

Argerich, A., R. Haggerty, E. Martí, F. Sabater, and *J. P. Zarnetske* (2011), Quantification of metabolically active transient storage (MATS) in two reaches with contrasting transient storage and ecosystem respiration, *J. Geophys. Res.,* 116, doi:10.1029/2010JG001379.

Yin, J., R. Haggerty, D. L. Stoliker, D. B. Kent, J. D. Istok, J. Greskowiak, and J. M. Zachara (2011), Transient groundwater chemistry 1 near a river: Effects on U(VI) transport in laboratory column experiments, *Water Resour. Res.*, *47*, doi:10.1029/2010WR009369.

Argerich, A., E. Martí, F. Sabater, M. Ribot, and R. Haggerty (2011), Influence of transient storage on stream nutrient uptake based on substrata manipulation, *Aquatic Sciences,* doi:10.1007/s00027-011-0184-9.

Zarnetske, J. P., R. Haggerty, S. M. Wondzell, and M. A. Baker (2011), Dynamics of Nitrate Production and Removal as a Function of Residence Time in the Hyporheic Zone, *J. Geophys. Res.*, 116, doi:10.1029/2010JG001356.

Haggerty, R., E. Martí, *A. Argerich*, D. von Schiller, and N. B. Grimm (2009), Resazurin as a “smart” tracer for quantifying metabolically active transient storage in stream ecosystems, *J. Geophys. Res.*, doi:10.1029/2008JG000942.

Wondzell, S. M., *J. LaNier*, R. Haggerty, Richard D. Woodsmith, and Richard T. Edwards (2009), Estimating changes in hyporheic exchange flow following experimental wood removal in a small, low gradient stream using groundwater flow models, *Water Resour. Res.*, *45*, W05406, doi:10.1029/2008WR007214.

Wondzell, S. M., *J. LaNier,* and R. Haggerty (2009), Reliability of groundwater flow models for simulating hyporheic exchange in small mountain streams*, J. Hydrol.*, 364, 142-151.

Haggerty, R., E. Martí, and A. Argerich (2008), Development of a "smart" tracer for the assessment of microbiological activity and sediment-water interaction in natural waters: The resazurin-resorufin system, *Water Resources Research*, *44*, W00D01, doi:10.1029/2007WR006670.

Burkholder, B. K., G. E. Grant, R. Haggerty, T. Khangaonkar, and P. J. Wampler (2008), Influence of Hyporheic Flow and Geomorphology on Temperature of a Large, Gravel Bed River, Clackamas River, Oregon, USA, *Hydrological Processes*, *22*, 941–953.

Cardenas, M. B., J. L. Wilson, and R. Haggerty (2008), Residence time of bedform-driven hyporheic exchange, *Advances in Water Resources*, *31,* 10.1016/j.advwatres.2008.07.006, 1382-1386.

Crook, N., A. Binley, R. Knight, D.A. Robinson, *J. Zarnetske*, and R. Haggerty (2008), Electrical resistivity imaging of the architecture of sub-stream sediments, *Water Resources Research, 44,* W00D13, doi:10.1029/2008WR0.

McDonnell, J.J., M. Sivapalan, K. Vaché, S. Dunn, G. Grant, R. Haggerty, C. Hinz, R. Hooper, J. Kirchner, M.L. Roderick, J. Selker, and M. Weiler (2007), Moving beyond heterogeneity and process complexity: A new vision for watershed hydrology, *Water Resources Research*, *43*, W07301, doi:10.1029/2006WR005467.

Gooseff, M. N., J. K. Anderson, S. M. Wondzell, *J. LaNier,* and R. Haggerty (2006), A modeling study of hyporheic exchange pattern and the sequence, size, and spacing of stream bedforms in mountain stream networks, Oregon, USA, *Hydrological Processes*, 20, 2443–2457.

Rodriguez, J.M., E. A. Thomann, E. C. Waymire, R. Haggerty and B. Wood (2006), A generalized Taylor-Aris formula and skew diffusion, *SIAM Journal of Multiscale Modelling and Simulation, 5*(3), 786 – 801.

Anderson, J. K., S. M. Wondzell, *M. N. Gooseff*, and R. Haggerty (2005), Patterns in stream longitudinal profiles and implications for hyporheic exchange flow, *Hydrological Processes*, 19, 2931 – 2949.

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Haggerty, R., S. M. Wondzell, and *M. A. Johnson* (2002), Power-law residence time distribution in the hyporheic zone of a 2nd-order mountain stream, *Geophysical Research Letters, 29*(13), DOI 10.1029/2002GL014743.

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Breemer, C. W., P. U. Clark, R. Haggerty (2002), Modeling the subglacial hydrology of the late Pleistocene Lake Michigan Lobe, Laurentide Ice Sheet, *GSA Bulletin, 114*(6), 665 – 674.

Geiger, S., R. Haggerty, J.H. Dilles, M.H. Reed, and S.K. Matthai (2002), New insights from reactive transport modelling: the formation of the sericitic vein envelopes during early hydrothermal alteration at Butte, Montana. *Geofluids 2*(3), 185 – 201.

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Haggerty, R., *S. W. Fleming*, L. C. Meigs, and S. A. McKenna (2001), Tracer tests in a fractured dolomite, 2., Analysis of mass transfer in single-well injection-withdrawal tests, *Water Resources Research, 37*(5), 1129 – 1142.

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Haggerty, R., M. H. Schroth, and J. D. Istok (1998), Simplified method of "push-pull" test data analysis for determining in situ reaction rate coefficients, *Ground Water, 36*(2), 314 – 324.

Haggerty, R., and S. M. Gorelick (1998), Modeling mass transfer processes in soil columns with pore-scale heterogeneity, *Soil Science Society of America Journal*, *62*(1), 62 – 74.

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