

Edward W. Bolton, Ph.D.
Senior Research Scientist

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EDUCATION

Ph.D. in Geophysics and Space Physics <i>University of California, Los Angeles</i>	1985 Los Angeles, CA
M.S. in Geophysics and Space Physics <i>University of California, Los Angeles</i>	1982 Los Angeles, CA
B.S. in Physics <i>Pacific Union College</i>	1980 Angwin, CA
M.A. in Teaching of Physical Science <i>Pacific Union College</i>	1978 Angwin, CA
B.S. in Physical Science <i>Pacific Union College</i>	1977 Angwin, CA

AREAS OF EXPERTISE

- Numerical Modeling and Computational Fluid Dynamics
- Numerical Simulation of Flow, Reactions, and Transport in Heterogeneous Porous Media
- Hydrocarbon reservoir modeling
- Image processing
- Network analysis
- Database creation and statistical analysis
- Finite Difference, Global-Galerkin, Spectral-Transform, and Particle Tracking Methods
- Experimental Fluid Mechanics: Rotating Convection, Bubble Dynamics, including LABVIEW and Data Acquisition
- Nonlinear Thermal Convection and Stability Analysis
- Wavelet Analysis of Time Series and Climate
- Landform Evolution and Erosion Modeling
- Flow Visualization of Common Fluid Instabilities
- Spherical Shell Basis Functions and Curvilinear Coordinates

UNIVERSITY COURSES TAUGHT (at Yale University)

- Geophysical Fluid Dynamics, 1986-1993, yearly
- Physical Oceanography, 1987-1992, yearly
- Theoretical Fluid Dynamics, 1988
- Applied Mathematics Senior Seminar, 1990
- Pattern Formation in Biological and Physical Systems, 1990
- Computational Fluid Dynamics, 1995.

- Advanced Differential and Partial Differential Equations, 1996

EMPLOYMENT

Senior Research Scientist	2005 - Present
<i>Department of Geology and Geophysics, Yale University</i>	New Haven, CT
Simulations of flow and reactions in porous media: Formulation and code creation; Simulation of subsurface carbon sequestration;	
Convection in hydrocarbon reservoirs; weathering; metamorphism;	
Biophysical modeling of circulation in networks, growth statistics	
Research Scientist	2000 - 2005
<i>Department of Geology and Geophysics, Yale University</i>	New Haven, CT
Formulated, coded, and published simulations of flow, reactions, and transport in heterogeneous porous media	
Associate Research Scientist	1993 - 2000
<i>Department of Geology and Geophysics, Yale University</i>	New Haven, CT
Formulated, coded, and published simulations of flow, reactions, and transport in heterogeneous porous media.	
Developed simulation codes for landform evolution via hydraulic erosion and for water/oil/gas flows relevant to water injection secondary oil recovery with interface motion.	
Lecturer of Mechanical Engineering	Fall 1995 - Spring 1996
<i>Department of Mechanical Engineering, Yale University</i>	New Haven, CT
Lecturer	Fall 1992 - Spring 1993
<i>Department of Geology and Geophysics, Yale University</i>	New Haven, CT
Assistant Professor	Fall 1986 - Spring 1992
<i>Department of Geology and Geophysics, Yale University</i>	New Haven, CT
Postdoctoral Researcher	Winter 1985 - Summer 1986
<i>École Normale Supérieure</i>	Paris, France
Postgraduate Researcher	Fall 1981 - Winter 1985
<i>Institute of Geophysics and Planetary Physics, UCLA</i>	Los Angeles, CA
High School Teacher	Fall 1978 - Spring 1979
<i>Taught Physics, Chemistry, Basic Math, and General Science High School</i>	Honolulu, HI

PUBLICATIONS

- Van Hise, J.R., D.E. Martz, R.A. Jackson, D.Y. Kunihiro and E.W. Bolton (1982) Polonium-218 half-life, *Physical Review C*, 25, 2802-2804.
- Busse, F.H. and E.W. Bolton (1984) Instabilities of convection rolls with stress-free boundaries near threshold, *J. Fluid Mech.*, 146, 115-125.
- Bolton, E.W. and F.H. Busse (1985) Stability of convection rolls in a layer with stress-free boundaries, *J. Fluid Mech.*, 150, 487-498.
- Azouni, M.A., E.W. Bolton and F.H. Busse (1986) Convection driven by centrifugal buoyancy in a rotating annulus, *Geophys. Astroph. Fluid Dyn.*, 34 301-317.

- Bolton, E.W., F.H. Busse and R.M. Clever (1986) Oscillatory instabilities of convection rolls at intermediate Prandtl numbers, *J. Fluid Mech.*, 164, 469-485.
- Fauve, S., E.W. Bolton and M.E. Brachet (1987) Nonlinear oscillatory convection: A quantitative phase dynamics approach, *Physica*, 29D, 202-214.
- Bolton, E.W. (1993) A simple notation for differential vector operations in orthogonal curvilinear coordinates, *Geophysical Journal International*, 115, 654-666.
- Bolton, E.W. and J. Maurer (1994) A new roll-type instability in an oscillating fluid plane, *J. Fluid Mech.*, 268, 293-313.
- Bolton, E.W., K.A. Maasch and J. M. Lilly (1995), A wavelet analysis of Plio-Pleistocene climate indicators: A new view of periodicity evolution, *Geophysical Research Letters*, 22, 2753-2756.
- Bolton, E.W., A.C. Lasaga and D. Rye, (1996) A model for the kinetic control of quartz dissolution and precipitation in porous media flow with spatially variable permeability: Formulation and examples of thermal convection, *Journal of Geophysical Research*, 101, 22157-22187.
- Bolton, E.W., A.C. Lasaga and D. Rye, (1997) Dissolution and precipitation via forced-flux injection in a porous medium with spatially variable permeability: Kinetic control in two dimensions, *Journal of Geophysical Research*, 102, pp. 12159-12171.
- Bolton, E.W., A.C. Lasaga and D.M. Rye, (1999) Long-term flow/chemistry feedback in a porous medium with heterogeneous permeability: Kinetic control of dissolution and precipitation, *American Journal of Science*, v. 299, pp. 1-68.
- Luttge, A., E.W. Bolton, and A.C. Lasaga, (1999) An interferometric study of the dissolution kinetics of anorthite: The role of reactive surface area, *American Journal of Science*, v. 299, pp. 652-678.
- Seilacher, A., M. Meschede, E.W. Bolton, and H. Luginland, (2000) The Precambrian "fossil" Vermiforma is a tectograph, *Geology*, v. 28, pp. 235-238.
- Lasaga, A.C., A. Luttge, D.M. Rye, and E.W. Bolton, (2000) Dynamic treatment of invariant and univariant reactions in metamorphic systems, *American Journal of Science*, v. 300, pp. 173-221.
- Lasaga, A.C., D.M. Rye, A. Luttge, and E.W. Bolton, (2001) Calculation of fluid fluxes in Earth's crust, *Geochimica et Cosmochimica Acta*, v. 65, No. 7, pp. 1161-1185.
- Breeding, C.M., J.J. Ague, M. Brocker, and E.W. Bolton, (2003) Blueschist preservation in a retrograded, high-pressure, low-temperature metamorphic terrane, Tinos, Greece: Implications for fluid flow paths in subduction zones, *G-cubed*, Vol. 4, No. 1, 22 Jan. 2003.
- Rye, D.M., E.W. Bolton, A. Luttge (2003) Erratum to Antonio C. Lasaga, Danny M. Rye, Andreas Luttge, and Edward W. Bolton (2001) "Calculation of fluid fluxes in the Earth's crust," *Geochimica et Cosmochimica Acta*, Vol. 67, No. 9, p. 1755.
- Luttge, A., E.W. Bolton, and D.M. Rye (2004) A kinetic model of metamorphism: An application to siliceous dolomites, *Contributions to Mineralogy and Petrology*, DOI: 10.1007/s00410-003-0520-8, Vol. 146, No. 5, January 2004 pp. 546 - 565
- Wildman, R. A., Berner, R. A., Petsch, S. T., Bolton, E. W., Eckert, J.O., Mok, U., and Evans, J.B., (2004) The weathering of sedimentary organic matter as a control on atmospheric O₂: I. Analysis of a black shale, *American Journal of Science*, Vol. 304, p. 234-249.
- Bolton, E.W., D.M. Rye, J.J. Ague, and A. Luttge, (2004) Modeling contact metamorphism of siliceous dolomite via kinetic control of overall reactions, *Water-Rock Interaction*, Vol. 1, R.B. Wanty and R.R. Seal II, eds., Proceedings of the 11th International Symposium on Water-Rock Interaction, 27 June -2 July 2004, Saratoga Springs, NY, USA, pp. 269-272.
- Berner, R.A., E.W. Bolton, R.A. Wildman, and S.T. Petsch, (2004) Organic matter weathering and atmospheric oxygen: A field and modeling study of black shale oxidation, *Water-Rock Interaction*, Vol. 1, R.B. Wanty and R.R. Seal II, eds., Proceedings of the 11th International

Symposium on Water-Rock Interaction, 27 June -2 July 2004, Saratoga Springs, NY, USA, pp. 805-808.

- Bolton, E. W., Berner, R. A., and Petsch, S. T., (2006) The weathering of sedimentary organic matter as a control on atmospheric O₂: II. Theoretical Modeling, to appear in American Journal of Science, October, Vol. 306, pp. 575-615.
- Buss L.W., Anderson C., Bolton E.W. (2013) Muscular Anatomy of the *Podocoryna carnea* Hydorrhiza. PLoS ONE 8(8): e72221. doi:10.1371/journal.pone.0072221
- Bolton, E.W., and A. Firoozabadi, (2014) Numerical modeling of temperature and species distributions in hydrocarbon reservoirs, Journal of Geophysical Research-Solid Earth, Vol. 119, p. 18-31, doi:10.1002/2013JB010043.
- Neogi, S., Bolton, E.W., and Chakraborty, S., (2014) Constraints on timescales of disequilibrium melting in the crust from trace element modeling: A case study of the formation and segregation of melts in the muscovite-sillimanite zone in the lesser Himalayan rocks from Sikkim, Contributions to Mineralogy and Petrology, 168:1020, DOI 10.1007/s00410-014-1020-8.
- Buss, L. W., C. P. Anderson, E. K. Perry, E. D. Buss, and E. W. Bolton (2015) Nutrient distribution and absorption in the colonial hydroid *Podocoryna carnea* is sequentially diffusive and directional. Public Library of Science ONE, PONE-D-15-21037R1.
- Connally, N., Anderson, C.P., Bolton, J.E., Bolton, E.W., Buss, L.W. (2015) The Selective Myosin II Inhibitor Blebbistatin Reversibly Eliminates Gastrovascular Flow and Stolon Tip Pulsations in the Colonial Hydroid *Podocoryna carnea*, Public Library of Science ONE, PONE-D-15-28617R1
- Li, Li, Maher, K., Navarre-Sitchler, A., Bao, C., Biesman, J., Bolton, E.W., Brantley, S., Dietrich, B., Druhan, J., Jin, L., Kocar, B., Kumar, M., Lawrence, C., Mayer, U., McIntosh, J., Meile, C., Moore, J., Perdril, J., Sonnetal, E., Steefel, C.S., Sullivan, P., Thompson, A., Tutulo, B., Valocchi, A., Zachara, J., Barrera, E., Torgerson, T., Lesmes, D., Woodward, N., King, B., a manuscript in preparation summarizing a National Science Foundation sponsored workshop: "Expanding the role of Reactive Transport Modeling (RTM) within the Biogeochemical Sciences", Alexandria, VA, 13-15 April 2014. Submitted to Earth Science Reviews on 13 Dec. 2015.

BOOK REVIEWS

- Bolton, E.W., Review of Buoyancy-induced Flows and Transport, by B. Gebhart, et.al., (Hemisphere, New York, 1988), which appeared in American Scientist, 77, pp. 298-299, 1989.
- Bolton, E.W., Review of Annual Review of Fluid Mechanics, 22, John L. Lumley, et al., editors, published by Annual Reviews, Palo Alto, California 1990, for the Bulletin of the American Meteorological Society, 72, 1399-1400, 1991.

SELECTED AWARDS AND ACTIVITIES

- Joliot-Curie Bourse, 1985, at *École Normale Supérieure*, Paris, France, administered by the Commissariat à l'Energie Atomique, France.
- Associate Editor, American Journal of Science, January 2004 - Present.

INVITED LECTURE SERIES

- Modeling Reactive Flows in Earth's Crust (August 3-4, 2001; Institut fuer Geologie, Mineralogie und Geophysik; Ruhr-Universität Bochum, Germany)

SOFTWARE SYSTEMS DEVELOPED

- KINFLOW: Reactive transport in a 2D, non-isothermal, heterogeneous, dynamic permeability, porous media with mineral reactions under kinetic control and numerous aqueous speciation reactions (see also KINFLOW1D below).
- META-KINFLOW: Similar to the above model, but with supercritical fluids (H₂O, CO₂) EOS at metamorphic conditions. 8 minerals used for computation of reactions of siliceous dolomites.

- DIG: Diffusion of isotopes and trace elements in grains during recrystallization (a moving boundary problem), exchanging with moving fluids in porous media.
- OMPYR: Weathering of organic matter and pyrite in eroding soils. The formulation and results are described in Bolton et al., (2006)
- DIGmajorelem: Diffusion of major elements based on nonequilibrium thermodynamics in a 4 mineral set during rapid uplift of kimberlites with applications to thermobarometry (a collaboration with Alex Andrews and Zhengrong Wang).
- KINFLOW1D: Similar to KINFLOW, but for 1D, with 46 minerals under kinetic control, 27 aqueous phase equilibrium reactions, 64 aqueous species, and 2 gases (O₂, CO₂), with accompanying thermodynamic and kinetic rate databases. A 0D version of this model has been implemented for comparison to the geochemical experiments. This models has recently been linked with a 1D geomechanical compaction model, in collaboration with Zhengyu Cai and David Bercovici.
- KINFLOWCO2SEQ: Reactive transport in a 2D, non-isothermal, heterogeneous, dynamic permeability, porous media with mineral reactions under kinetic control and numerous aqueous speciation reactions. The code above was extended to 2D and to include liquid and vapor phases, separate EOS for CO₂-brine phases, with applications to subsurface carbon sequestration.
- CVS 5.0, 6.0: Compositional Variation Software for hydrocarbon reservoir evolution in a two-phase fluid based on non-equilibrium thermodynamics. Prepared in collaboration with A. Firoozabadi. Available to members of the Reservoir Engineering Research Institute. Software package included Bolton's modification of the nearly 17,000 lines of code, manuals (1 CVS5 release, 3 CVS6 releases), example input files and case studies with accompanying figures and descriptions, hydrocarbon property databases, instructions for plotting via R. Bolton implemented dynamic thermal evolution and convection, tilt of the reservoir layers, heterogeneities in tortuosity, separate barycentric reference frames for liquid and vapor phases, multiple injection and extraction wells.
- Diffusion Coefficient Calculations for Hydrocarbon Reservoir Fluids: Created FORTRAN code to implement the diffusion coefficient calculations of Leahy-Dios and Firoozabadi, (2007) Unified Model for Nonideal Multicomponent Molecular Diffusion Coefficients, AIChE Journal, November 2007 Vol. 53, No. 11, p. 2932-2939.
- COLONYCODE: Fluid flow and nutrient circulation driven by an arbitrary number of polyps (as pumps) in an arbitrary network of elastic tubes as a model for the circulation system of the hydrozoan *Podocoryne carnea*.

COMPUTER USAGE EXPERIENCE

- UNIX SYSTEMS: DEC Alphas, SUN Ultras, SGI
- VAX SYSTEMS: Microvax user and administrator
- OTHER SYSTEMS: Macs, PCs, Linux
- LANGUAGES: FORTRAN, C, Mathematica, R, Pascal, LABVIEW
- STATISTICAL ANALYSIS: R, Splus, MS Excel
- GRAPHICS: Splus, UIS, GL, Matlab, CorrelDraw, PowerPoint, Photoshop, Illustrator, R
- TEXT FORMATTING: TEX, LATEX, MS Word
- WEB: html

CONSULTING EXPERIENCE

- Synthetic Landform Creation for the U.S. Army and Naval Research Laboratory
- Demonstration Devices and Text Development for The American Museum of Natural History
- Fluid Sculpture Creation
- Educational Video Creation
- Technical Advisor for Tidal Electric, Inc.

- Thermobaric effects on salt fingering for the U.S. Navy