ROSEMARY C. CAPO

Department of Geology and Environmental Science
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EDUCATION

University of California, Los Angeles, Ph.D., 1990, Geochemistry
Dissertation: *Application of strontium isotopes to late Cenozoic paleoceanography and stratigraphy*
Advisors: D.J. DePaolo, R.V. Ingersoll

University of Texas at Austin, B.S., M.A., 1984, Geology
Masters thesis: *Petrology and geochemistry of a Cambrian paleosol developed on Precambrian granite, Llano Uplift, Texas.* Committee: L.E. Long, D.S. Barker, R.L. Folk

PROFESSIONAL APPOINTMENTS

2020-2023	*Assistant Dean for Graduate Studies* and *Academic Integrity Officer*, Dietrich School of Arts and Sciences, University of Pittsburgh
Fall 2021	*Acting Associate Dean for Graduate Programs,* Dietrich School of Arts and Sciences, University of Pittsburgh
2000-present	*Associate Professor*, Department of Geology & Environmental Science, University of Pittsburgh
1994 – 2000	*Assistant Professor*, Department of Geology & Planetary Science, University of Pittsburgh
2010 – 2011	*Faculty Researcher*, US-DOE-NETL Oak Ridge Institute for Science and Education
2002 – 2003	*Visiting Scientist***,** Dept. of Earth and Atmospheric Sciences, Cornell University
1994	*Associate Scientist*, Geological & Planetary Sciences, California Institute of Technology
1992 – 1994	*Postdoctoral Associate*, Jet Propulsion Laboratory (advisor: O.A. Chadwick)
1990 – 1992	*Research Fellow in Geochemistry*, Charles Arms Laboratory, California Institute of Technology, (advisor: G.J. Wasserburg)
1989 – 1990	*Research Associate*, Dept. of Earth and Planetary Science, University of California, Berkeley
1984 – 1989	*Research and Teaching Assistant/Associate*, Dept. of Earth and Space Science, University of California, Los Angeles
1981 – 1982	*Research Assistant,* Texas Bureau of Economic Geology
1982 – 1984	*Teaching Assistant*, University of Texas at Austin

RESEARCH EXPERTISE

Geochemical and isotopic studies of low-temperature processes, including atmosphere-water-soil nutrient cycling, weathering, carbonate diagenesis and pedogenesis. The application of geochemical tools to stratigraphic correlation, paleoceanography, paleoclimate and geoarchaeology. Environmental geochemistry including ground and surface water-rock interaction related to unconventional natural gas extraction, geologic carbon sequestration, coal combustion byproducts, and acid mine drainage.

PROFESSIONAL AFFILIATIONS

American Chemical Society, AAPIiG, American Geophysical Union, Geochemical Society, GeoLatinas,

Geological Society of America (Fellow)

PUBLICATIONS

(Supervised or co-supervised by Capo: §post-doc, *graduate student, or †undergraduate student):

Peer-reviewed publications

Stewart, B.W. and Capo, R.C. (2022) Chapter 10: Metal isotope signatures as tracers for unconventional oil and gas fluids. In *Environmental Impacts from the Development of Unconventional Oil and Gas Reserves* (eds. J. Stolz, D. Bain, M. Griffin), Cambridge University Press, pp. 246-271; doi:10.1017/9781108774178.013.

Matecha, R.M.*, Xiong, W., Heck, W.F. †, Stewart, B.W., Capo, R.C., Hakala, J.A. (2022) Experimental investigation of barium sources and fluid-rock interaction in unconventional Marcellus Shale wells using Ba isotopes. *Energy & Fuels 36*, 4470-4478.

Gardiner*, J.B., Stewart, B.W., Capo, R. C., Phan, § T.T., Hakala, J.A. and Keating E.H. (2021) Tracking natural CO_2 migration through a sandstone aquifer using Sr, U and C isotopes: Chimayó, New Mexico. J. *of Greenhouse Gas Control* 104: https://doi.org/*10.1016/j.ijggc.2020.103209*

Hedin, B.C.*, Capo, R.C., Stewart, B.W., Hedin, R.S. (2020) Critical metal recovery potential of Appalachian acid mine drainage treatment solids. *International Journal of Coal Geology* *10.1016/j.coal.2020.103610*

Tieman, Z.G., Stewart, B.W., Capo, R.C., Phan, T.T. §, Lopano, C.L., Hakala, J.A. (2020) Barium isotopes track the source of dissolved solids in produced water from the unconventional Marcellus Shale gas play. *Environmental Science and Technology* 54: 4275-4285.

Wallrich, I.L.R.*, Capo, R.C., Stewart, B.W., Hedin, B.C.*, Phan, T.T. § (2020) Neodymium isotopes track rare earth element sources in coal mine drainage. *Geochimica et Cosmochim. Acta* 269: 465-483.

Hedin, B.C.*, Capo, R.C., Stewart, B.W., Hedin, R.S., Lopano, C.L., Stuckman, M.Y. (2019) The evaluation of critical rare earth element (REE) enriched treatment solids from coal mine drainage passive treatment systems. *International Journal of Coal Geology* 208: 54-64.

Matecha, R.M.*, Capo, R.C., Stewart, B.W., Thompson, R.L., Hakala, J.A. (2021) A single column separation method for barium isotope analysis of geologic and hydrologic materials with complex matrices. *Geochemical Transactions 22:4,* https://doi.org/10.1186/s12932-021-00077-z.

Phan§, T.T., Gardiner, J.B.*, Capo, R.C., Stewart, B.W., 2018, Geochemical and multi-isotopic (Li, Sr, Nd, U) perspectives of sediment sources, depositional conditions, and diagenesis of the Marcellus Shale, Appalachian Basin, USA. *Geochimica et Cosmochimica Acta*, 222: 187-211.

Pfister*, S., Capo, R.C., Stewart, B.W., Macpherson, G.L., Phan, T.T§., Gardiner*, J.B., Diehl, J.R., Lopano, C.L., Hakala, J.A., 2017, Geochemical and lithium isotope tracking of dissolved solid sources in Permian Basin carbonate reservoir and overlying aquifer waters at an enhanced oil recovery site, northwest Texas, USA. *Applied Geochemistry* 87: 122-135.

Stewart, B.W., Capo, R.C., Hedin, B.C.*, Hedin, R.S., 2017, Rare earth element resources in coal mine drainage and treatment precipitates in the Appalachian Basin, USA. *Int. J. Coal Geology* 169: 28-39.

Phan§, T.T., Capo, R.C., Stewart, B.W., Macpherson, G.L., Rowan, E.L., Hammack R.W., 2016, Factors controlling Li content and isotope composition in formation waters and host rocks of Marcellus Shale, Appalachian Basin. *Chemical Geology* 420, 162-179.

Wolfe, A.L.*, Stewart, B.W., Capo, R.C., Dzombak, D.A., Liu, R., Gordon, G., Anbar, A.D., 2016, Iron isotope investigation of hydrothermal and sedimentary pyrite and their aqueous dissolution products. *Chemical Geology 427*, 73-82.

Johnson, J., Graney, J., Capo, R.C., Stewart, B.W., 2015, Identification and quantification of basin brine and road salt sources in watersheds along the New York / Pennsylvania border, U.S.A., *Applied Geochemistry*, 60: 37-50.

Phan§, T.T., Capo, R.C., Stewart, B.W., Graney, J.R., Johnson, J.D., Sharma, S., Toro, J., 2015, Trace metal distribution and mobility in drill cuttings and produced waters from Marcellus shale gas extraction: uranium, arsenic, barium. *Applied Geochemistry* 60: 89-103.

Stewart, B.W., Capo, R.C., Kirby, C.S., 2015, Geochemistry of unconventional shale gas from formation to extraction: Petrogenesis, hydraulic fracturing, and environmental impacts (Preface). *Applied Geochemistry* 60, 1-2.

Stewart, B.W., Chapman*, E., Capo, R.C., Johnson, J.D., Graney, J.R., Kirby, C.R., Schroeder, K.T., 2015, Origin of brines, salts and carbonate from shales of the Marcellus Formation: Evidence from geochemical and Sr isotope study of sequentially extracted fluids, *Applied Geochemistry*, 60: 78-88.

Capo, R.C., Stewart, B.W., Rowan, E.L., Kolesar Kohl*, C.A., Wall§, A., Chapman*, E.C., Hammack R.W., Schroeder, K.T., 2014, The strontium isotopic evolution of Marcellus Formation produced waters, southwestern Pennsylvania, *Inter. Journal of Coal Geology,* v. 126, 57-63.

Kolesar Kohl* C.A., Capo, R.C., Stewart, B.W., Wall§, A.J., Hammack, R.W. and Guthrie, G.G., 2014, Strontium isotopes test long-term zonal isolation of injected and Marcellus Formation water after hydraulic fracturing. *Environmental Science and Technology* v. 48, 9867—9873.

Macpherson G.L., Capo R.C., Stewart B.W., Phan§ T.T., Schroeder K.T., Hammack R.W., 2014, Temperature-dependent Li isotope ratios in Appalachian Plateau and Gulf Coast Sedimentary Basin saline water, *Geofluids*: v. 14: 419-429.

Newell, D.L., Perkins, G., Larson, T., Pugh, J.D., Stewart, B.W., Capo, R.C., and Trautz, R., 2014, Tracing CO2 leakage into groundwater using carbon and strontium isotopes during a controlled CO2 release field test. *Int. Journal of Greenhouse Gas Control* v. 29, 200-208.

Soeder, D., Sharma, S., Pekney, N., Hopkinson, L., Dilmore, R., Kutchko, B., Stewart, B.W., Hakala, J.A., Carter, K., Capo, R.C., 2014, U.S. DOE methods for assessing the environmental risks of shale gas development, *Int. J. Coal. Geol.,* v. 126, 4-19.

Brubaker*, T.M., Stewart, B. W., Capo, R.C., Schroeder, K. T., Chapman*, E. C., Spivak-Birndorf, L. J., Vesper, D.J., Cardone, C.R., Rohar, P.C., 2013, Coal fly ash interaction with environmental fluids: Geochemical and strontium isotope results from combined column and batch leaching experiments. *Applied Geochemistry*, v. 32, 184-194.

Chapman*, E.C., Capo, R.C., Stewart, B.W., Hedin, R.S., Weaver* T.J., and Edenborn, H.M., 2013, Strontium isotope quantification of siderite, brine and acid mine drainage contributions to high-TDS abandoned gas well discharges in the Appalachian Plateau. *Applied Geochemistry*, v. 31, 109-118.

Wall§A.J., Capo R.C., Stewart B.W., Phan§, T.T., Hakala J.A., Jain J., Guthrie G., 2013, High throughput method for Sr extraction from variable matrix waters and 87Sr/86Sr isotope analysis by MC-ICP-MS, *J. Anal. Atom. Spect.* v. 28, 1338-1344; DOI: 10.1039/c3ja30350k.

Chapman*, E.C., Capo, R.C., Stewart, B.W., Hammack, R., Schroeder, K., and Edenborn, H.M., 2012, Geochemical and strontium isotope characterization of produced waters from Marcellus Shale natural gas extraction, *Environmental Science and Technology* v.46: 3545-3553.

Sharma, S., Sack, A., Adams, J., Vesper, D., Capo, R.C., Edenborn, H., 2012, Using stable isotopes to understand carbon cycling in a coal mine drainage site in Allegheny County, Pennsylvania USA, *Applied Geochemistry*, v. 29: 32-42.

Spivak-Birndorf, L. J., Stewart, B. W., Capo, R.C., Chapman*, E. C., Schroeder, K. T., and T.M. Brubaker*, 2012, strontium isotope study of coal utilization byproducts interacting with environmental waters. *J. Environmental Quality* v. 41: 144-154.

Liu, R., Wolfe*, A.L., Dzombak, D.A., Horwitz, C.P., Stewart, B.W., and Capo, R.C., 2009, Controlled electrochemical dissolution of hydrothermal and sedimentary pyrite. *Applied Geochem.* v. 24: 836-842.

Liu, R., Wolfe*, A.L., Dzombak, D.A., Stewart, B.W., and Capo, R.C., 2008, Comparison of dissolution under oxic acid drainage conditions for eight sedimentary and hydrothermal pyrite samples. *Environmental Geology,* v. 56 (1): 171-182.

Liu, R., Wolfe*, A.L., Dzombak, D.A., Horwitz, C.P., Stewart, B.W., and Capo, R.C., 2008. Electrochemical study of hydrothermal and sedimentary pyrite dissolution. *Applied Geochemistry* v. 23: 2724-2734.

Wolfe*, A. L., Liu, R., Stewart, B. W., Capo, R.C. and Dzombak, D. A., 2007, A Method for Generating uniform size-segregated pyrite particle fractions, *Geochemical Transactions*, 8:9 DOI:10.1186/1467-4866-8-9; 8p.

Homsey*, L. K., and Capo, R.C., 2006, Integrating geochemistry and micromorphology to identify feature function at Dust Cave, a Paleoindian through Middle Archaic site in Northwest Alabama, *Geoarchaeology,* v. 21, 261-293.

Kairies*, C.L., Capo, R.C., Watzlaf, G. R., 2005, Chemical and physical properties of iron hydroxide precipitates associated with passively treated coal mine drainage in the bituminous region of Pennsylvania and Maryland, *Applied Geochemistry*, v. 20, 1445-1460.

Winters*, W.R. and Capo, R.C., 2004, Groundwater flow parameterization of an Appalachian coal mine complex, *Ground Water,* v. 42, 700-710.

Whipkey*, C. E., Capo, R.C., Hsieh, J.C.C., and Chadwick. O.A., 2002, Development of magnesian calcite and dolomite in Quaternary soils on the island of Hawaii, J. *Sedimentary Res.*, v. 72, 158-165.

Capo, R.C., Whipkey*, C.E., Chadwick, O.A., and Blachère, J., 2001, Reply: Pedogenic origin of dolomite in a basaltic weathering profile, Kohala Peninsula, Hawaii, *Geology*, 29, 563-565.

Stewart, B.W., Capo, R.C., and Chadwick, O.A., 2001, Effects of rainfall on weathering rate and base cation provenance in volcanic soils, Kohala Peninsula, Hawaii, *Geochimica et Cosmochimica Act*a, v. 65, 1087-1099.

Capo, R.C., Whipkey*, C.E., Chadwick, O.A., and Blachère, J., 2000, Pedogenic origin of dolomite in a basaltic weathering profile, Kohala Peninsula, Hawaii, *Geology*, 28, 271-274.

Whipkey*, C. E., Capo, R.C., Chadwick. O.A., and Stewart, B.W., 2000, The importance of sea spray to the cation budget of a coastal Hawaiian soil: a strontium isotope approach, *Chemical Geology*, v. 168, p. 37-48.

Capo, R.C. and Chadwick, O.A., 1999, Sources of calcium and strontium in desert soil and calcrete, *Earth and Planetary Science Letters*, v. 170, 61-72.

Capo, R.C., Stewart, B.W., and Chadwick, O.A., 1998, Strontium isotopes as tracers of earth surface processes: theory and methods, *Geoderma,* v. 82, 197-225.

Stewart, B.W., Capo, R.C., and Chadwick, O.A., 1998, Quantitative strontium isotope models for weathering, pedogenesis, and biogeochemical cycling, *Geoderma,* v. 82, 173-195.

Montanari, A., Bice, D.M., Capo, R., Deino, A., DePaolo, D.J., Emmanuel L., Monechi, S., Renard, M., Zevenboom, D., 1997, Integrated stratigraphy of the Chattian to mid-Burdigalian pelagic sequence of the Contessa Valley (Gubbio, Italy), in Montanari, A., Odin, G.S., and Coccioni, R., *Miocene Stratigraphy, An Integrated Approach, Developments in Paleontology and Stratigraphy*, vol. 15, Elsevier, Amsterdam, 249-277.

Banner, J. L., Musgrove, M., and Capo, R. C., 1994, Tracing ground-water evolution in a limestone aquifer using Sr isotopes: Effects of multiple sources of dissolved ions and mineral-solution reactions, *Geology,* v. 22, 687-690.

Capo, R. C., 1994, Micromorphology and geochemistry of a Cambrian paleosol developed on granite, Llano Uplift region, central Texas, USA, in Ringrose-Voase, A. and Humphreys, G., eds., *Soil Micromorphology: Studies in Management and Genesis. Developments in Soil Science Series*, v. 22, Elsevier, Amsterdam, 257-264.

Montanari, A., Deino, A., Coccioni, R., Langenheim, V.E., Capo, R., Monechi, S., 1991, Geochronology, Sr isotope analysis, magnetostratigraphy, and plankton stratigraphy across the Oligocene-Miocene boundary in the Contessa section (Gubbio, Italy). *Newsletters in Stratigraphy* v. 23, 151-180.

Capo, R. C. and DePaolo, D. J., 1990, Seawater strontium isotope variations from 2.5 million years ago to the present, *Science*, v. 249, 51-55.

Patterson, R. T., Brunner, C. A., Capo, R. C. and Dahl, J., 1990, A paleoenvironmental study of Early to Middle Pleistocene foraminifera of the Santa Barbara Formation, Santa Barbara, California, USA, *Jour. Paleontology*, v. 64, 1-25.

Barton, M.D., Battles, D.A, Bebout, G.E., Capo, R.C., Christensen, J.N., Davis, S.R., Hanson, R.B., Michelsen, C.J., Trim, H.E., 1988, Mesozoic contact metamorphism in the United States, in W.G. Ernst , ed., *Metamorphism and Crustal Evolution of the Western United States, Rubey Vol 7:* Englewood Cliffs, New Jersey, Prentice-Hall, p. 110-178.

Capo, R.C. and DePaolo, D.J., 1988, Sr isotopic analysis of marine carbonates from the Massignano section across the Eocene/Oligocene Boundary, in *The Eocene/Oligocene Boundary in the Marche-Umbria Basin (Italy):* International Subcommission on Paleogene Stratigraphy Special Publication: Ancona, Industrie Grafiche Fratelli Aniballi, p. 189-192.

Other Reports or Proceedings

Wall, A.J. [§], Capo, R.C., Stewart, B.W., Phan, T.T. [§], Jain, J.C., Hakala, J.A., Guthrie, G.D. (2016) High throughput method for strontium isotope analysis by multi-collector-inductively coupled plasma-mass spectrometer. NETL-TRS-12-2016; *NETL Technical Report Series*, U.S. Department of Energy, National Energy Technology Laboratory: Pittsburgh, PA, 69 p.

Hammack, R.W., Harbert, W., Sharma, S., Stewart, B.W., Capo, R.C., Wall[§], A.J., Wells, A., Diehl, R., Blauschild, D., Sams, J., Veloski, G. (2014) An Evaluation of Fracture Growth and Gas/Fluid Migration as Horizontal Marcellus Shale Gas Wells are Hydraulically Fractured in Greene County, Pennsylvania. NETL-TRS-3-2014; *EPAct Technical Report Series*; U.S. Department of Energy, National Energy Technology Laboratory: Pittsburgh, PA, 76 p.

Keating, E.H., Newell, D.L., Stewart, B.W., Capo, R.C., Pawar, R. (2014) Further insights into interconnections between the shallow and deep systems from a natural CO2 reservoir near Springerville, Arizona, U.S.A. *Energy Procedia* 63, 3195-3201.

Hammack, R., Zorn, E., Harbert, W., Capo, R.C., Sharma, S., Siriwardame, S., 2013, An Evaluation of zonal isolation after hydraulic fracturing; results from horizontal marcellus shale gas wells at NETL's Greene County Test Site in southwestern Pennsylvania, Soc. Petrol. Eng. SPE 16-5720, 8 p.

Keating, E., Viswanathan, H., Fessenden, J., Carey, J., Guthrie, G., Hakala, J., Capo, R., Stewart, B., and Gardiner, J.* (2011) The challenge of predicting groundwater quality impacts in CO2 leakage scenarios: Results from field, laboratory, and modeling studies at a natural analog site in New Mexico, USA. *Energy Procedia* 4, 3239-3245.

Stiles, J.M., Donovan, J.J., Dzombak, D.A., Capo, R.C., and Cook, L., 2004, Geochemical cluster analysis of mine water quality within the Monongahela basin, *Proc. 25th W. Virginia Surface Mine Drainage Task Force Symposium*, 1819-1830.

Capo, R.C., Winters*, W. R., Weaver*, T. J., Stafford*, S. L., Hedin, R. S., Stewart, B.W., 2001, Hydrogeologic and geochemical evolution of deep mine discharges, Irwin syncline, Pennsylvania, *Proc. 22nd W. Virginia Surface Mine Drainage Task Force Symposium*, 144-153.

Published abstracts of presentations at national and [£]international conference proceedings ([§]post-doc, *graduate or †undergraduate student supervised or co-supervised by Capo):

2022 Schaffer CR*, Capo RC, Stewart BW, Hedin BC, Vesper DJ, Cravotta III CA (2022) Multidecadal geochemical evolution of acid mine drainage in an Appalachian coal basin. *Geological Society of America Annual Meeting Abstracts with Programs 54(5),* Denver, CO; doi: 10.1130/abs/2022AM-381086

Dobra KS*, Stewart BW, Capo RC (2022) Leveraging barium isotopes to evaluate utility of freshwater bivalve shells as paleoenvironmental monitors of river geochemistry in the lower Allegheny River watershed, Pennsylvania. *Geological Society of America Annual Meeting Abstracts with Programs 54(5),* Denver, CO; doi: 10.1130/abs/2022AM-380352

Gardiner JB, Xiong W, Wang J, Small M, Stewart BW, Capo RC, McAdams B, Hakala JA, Thomas RB (2022) Ensuring CO_2 storage and groundwater protection through water monitoring: applying geochemical and statistical tools. Battelle Conference on Innovations in Climate Resilience, Columbus, OH.

2021 Matecha RM*, Xiong W, Capo RC, Stewart BW, Heck WF*, Lopano CL, Hakala JA (2021) Experimental investigation of Marcellus Shale interaction with fluids at downhole conditions

using Ba isotopes. *Geological Society of America Annual Meeting Abstracts* 58-4, Portland, https://doi.org/10.1130/abs/2021AM-367084.

2020 Matecha RM*, Heck, W†, Capo, RC, Stewart BW, Xiong, W., Lopano CL, Hakala JA, (2020) Experimental investigation of barium sources and fluid-rock interaction in unconventional Marcellus Shale wells using Ba isotopes, *Geological Society of America Annual Meeting (online meeting).*

Stewart BW, Capo RC, Phan TP, Matecha RM*, Hakala JA, Lopano CL (2020, invited) Origin of conventional and unconventional produced water brines in the Appalachian Basin, USA, using radiogenic and stable metal isotopes. *American Chemical Society Annual Meeting, Philadelphia,* Pennsylvania, Abstract accepted, meeting cancelled due to COVID-19.

Phan TT, Sharma S, Gardiner JB, Thomas RB, Stuckman M, Stewart BW, Capo RC, Lopano CL, Hakala JA (2020) Applying geochemical and isotopic signals for monitoring CO2 and brine leakage at a CO_2 flooding oil field in Texas, USA. *American Chemical Society Annual Meeting, Philadelphia, Pennsylvania*, accepted, meeting cancelled due to COVID-19.

2019 Stewart BW, Tieman ZG*, Capo RC, Matecha RM*, Phan TP, Lopano CL, Hakala JA (2019) Determining sources of barium and other dissolved solids in oil and gas produced water using stable barium isotopes. *Geological Society of America Annual Meeting, Phoenix, AZ: Geol. Soc. Am. Abstr. Prog. 51(5), 92-12.*

Hedin, B., Lopano CL, Stuckman, M, Capo RC (2019) Characterization of Rare Earth Elements in Coal Mine Drainage Treatment Solids. *Pittsburgh International Coal Conference*

Phan TT, Sharma S, Gardiner JB, Thomas RB, Stuckman M, Stewart BW, Capo RC, Lopano CL, Hakala JA (2019) Assessing the usefulness of multiple isotope systems (C, O, Li, B, Sr) for CO_2 and brine leakage monitoring at a CO_2 flooding oil field in Texas, USA. *Geological Association of Canada/Mineralogical Association of Canada Annual Meeting, Quebec, Canada.*

2017 Phan TT†, Capo RC, Gardiner JB*, Stewart BW (2017) Sediment Sources, Depositional Environment, and Diagenetic Alteration of the Marcellus Shale, Appalachian Basin, USA: Nd, Sr, Li and U Isotopic Constraints. *American Geophysical Union Fall Meeting, San Francisco, California*, Abstract PP14A-05.

Hedin BC*, Capo RC, Stewart BW, Cravotta CA III, Hawkins JW, Hedin RS (2017) Cation exchange as a control on coal mine drainage geochemistry in the Appalachian region, eastern USA. International Goldschmidt Geochemistry Conference, Paris, France. Abstract #1582.

*Tieman ZG, Stewart BW, †Phan TT, Capo RC, Hakala JA, Lopano CL (March 2017) Sources of Ba in the Marcellus Shale and associated produced waters. *Geological Society of America Northeast-North Central Joint Meeting*, Pittsburgh, PA.

*Wallrich, I.L.W., Stewart BW, Capo RC, †Phan TT, Hedin, BC, 2017, Nd isotopes track rare earth element sources in acid mine drainage, *International Goldschmidt Geochemistry Conference,Paris, France Abstract #4124.*

2016 Capo RC (invited) Fluid-rock interactions related to unconventional shale gas produced water and drilling waste. IUPAC: *ISSP-17, Geneva Switzerland.*

Stewart BW, Capo RC, Hedin, BC*, Wallrich, ILR*, Hedin, RS (2016) Production and precipitation of rare earth elements in acidic to alkaline coal mine discharges, Appalachian Basin, USA. *American Geophysical Union Fall Meeting, San Francisco, California*, Abstract B53K-03.

Stewart BW, Capo RC, Phan, TT, Hakala, JA (invited) Deposition, hydrocarbon formation, and water-rock interaction in the Appalachian Basin, USA: Geochemical and multi-isotope tools. *American Chemical Society Annual Meeting, Philadelphia, PA*.

Stewart BW, Capo RC, Hedin, B, Hedin, RS (2016) Controls on rare earth elements in abandoned coal mine drainage in the Appalachian Basin, eastern USA. *International Goldschmidt Geochemistry Conference, Yokohama, Japan.*

Stewart BW, Capo RC (2016, invited) An overview of inorganic geochemical tools for identifying and quantifying the interaction of produced water from Marcellus, conventional, and legacy oil

and gas wells with streams and groundwater in the *Appalachian Basin. Shale Network Workshop 2016, State College, PA.*

2015 Phan T.T.†, Capo R.C., Stewart B.W., Macpherson G.L., Rowan E.L., Hammack R.W. (2015) Elevated Li and behavior of its isotopes in formation brines and host rocks of Marcellus Shale, Appalachian Basin. *American Association of Petroleum Geologists (AAPG) Annual Meeting, Denver, CO.*

Stewart BW, Capo RC (2015) The origin and mobilization of late-stage produced waters from unconventional shale reservoirs. *Geological Society of America Annual Meeting, Baltimore, MD: Geol. Soc. Am. Abstr. Prog.* 47.

2014 Capo R.C., Kolesar Kohl CA*, Stewart, BW, Wall, AJ†, Schroeder, KT, Hammack, RW, Guthrie, GD (2014) Strontium isotopes test long-term zonal isolation of injected and Marcellus Formation water after hydraulic fracturing. *International Goldschmidt Geochemistry Conference*, Sacramento, California.

Pfister, S.A., Gardiner, J.B., T.T. Phan, G.L. Macpherson, J.R. Diehl[3] C.L. Lopano, B.W. Stewart, Capo, R.C. (2014) Geochemical effects of CO2 injection on produced water chemistry at an enhanced oil recovery site in the Permian Basin of east Texas, USA: Preliminary geochemical and Li isotope results. 2014 AGU meeting, San Francisco.

Capo, R.C., Stewart, B.W. (2014) Geochemistry of geologic carbon storage from enhanced oil recovery and high-CO_2 natural analogue sites. *DOE/NETL Carbon Storage R&D Project Review Meeting: Developing the Technologies and Infrastructure for CCS*. Pittsburgh, Pennsylvania.

Stewart, B.W., Capo, R.C. (2014) Dissecting black shales and associated fluids from the Middle Devonian Marcellus Formation, Appalachian basin, USA. *Geological Society of America Annual Meeting*, Vancouver, Canada: Geol. Soc. Am. Abstr. Prog.

2013 Capo R.C., Stewart B.W., Kolesar*, C., Rowan E., Wall§, A.J., Chapman* E., Schroeder, K, Hammack, R.W., 2013, invited, Application of the Sr isotopic composition of produced waters from Devonian gas wells in the Appalachian basin, USA, as a tracer of subsurface reactions. *10th International Symposium on Applied Isotope Geochemistry, Budapest, Hungary*. INVITED

Capo R.C.. Stewart B.W., Rowan E., Wall§, A.J., Chapman* E., Schroeder, K,. Hammack, R.W., 2013, The strontium isotopic and geochemical evolution of produced waters from the Marcellus Formation. 2013 AAPG Annual Meeting, Pittsburgh.

Kolesar*, C.A., Capo R.C., Wall§, A.J., 2013, B.W. Stewart, Schroeder, K.T., Hammack, R.W. Using strontium isotopes to test stratigraphic isolation of injected and formation waters during hydraulic fracturing, 2013 AAPG Annual Convention, Pittsburgh. AAPG Search and Discovery Article #90163. (*AAPG Best Student Oral Presentation, 3rd place Award*)

Macpherson G.L., Capo R.C., Stewart B.W., Phan§ T.T., Schroeder K.T., Hammack R.W., 2013, δ7Li of Saline Water: Northern Appalachian Basin and Gulf Coast Sedimentary Basin, USA. 2013 *AAPG Annual Meeting*, Pittsburgh

Stewart, B.W., Chapman*, E.C., Capo, R.C., Graney, J.R., Johnson, J.D., Origin of dissolved solids in the Marcellus Shale produced water, *Internat. Goldschmidt. Conf.*, Florence, Italy, August, 2013.

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Stewart BW, Capo RC, Chapman EC*, Phan TT†, Gardiner JB*, Johnson JD, Graney JR, Sharma S, Toro J (2013) Experimental fluid-rock studies of natural gas-bearing black shales and application to paleoenvironment, formation fluids, and environmental impacts of hydraulic fracturing *10th International Symposium on Applied Isotope Geochemistry (AIG-10),* Budapest, Hungary.

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INVITED SEMINAR, WORKSHOP AND COLLOQUIA TALKS

Jul 2016 *International Union of Pure and Applied Chemistry- International Society of Sustainability Professionals* Joint Workshop-Solubility in energy and waste issues of environmental concern, Geneva, Switzerland.

Aug 2014 "*Geochemical and Isotopic Tools for Geologic Carbon Storage*"; CCS monitoring tutorial at CMU for senior researchers from the Industrial Technology Research Institute in Taiwan.

Nov 2013 Facing the Challenges: Symposium on Shale Gas Extraction, Duquesne University, "Isotopic signatures as tracers of shale gas fluids"

Sep 2013 Plenary speaker, National Research Council Workshop on the Development of Unconventional Hydrocarbon Resources in the Appalachian Basin, Morgantown, WV, "Identifying and assessing potential impacts of unconventional hydrocarbon production on surface and groundwater quality"

Aug 2013 Applied Isotope Geochemistry Workshop, Budapest, Hungary, "Application of the Sr isotopic composition of produced waters from Devonian gas wells in the Appalachian basin, USA, as a tracer of subsurface reactions"

Nov 2012 West Virginia University, Dept. of Geology and Geography, "Isotope Studies of the Origin and Evolution of Devonian Formation Waters from the Appalachian Basin"

Mar 2010 University of Pittsburgh, Civil and Environmental Engineering, "Identification of fossil fuel related groundwater interactions with Sr isotopes"

Oct 2005 University of Pittsburgh, Freshman Studies Colloquium, "Adventures of a field-based geochemist"

Mar 2005 University of Pittsburgh, Civil and Environmental Engineering, "Application of chemical and isotopic methods to studies of water-rock interaction: AMD and biogeochemical cycling in soils"

Nov 2001 Cornell University, Dept. of Earth and Atmospheric Sciences, "Hydrogeologic and Geochemical Evolution of Deep Mine Discharges, Irwin Syncline, Pennsylvania"

Apr 2001 Surface Mine Drainage Task Force Symposium, Morgantown, West Virginia, "Hydrogeologic and Geochemical Evolution of Deep Mine Discharges, Irwin Syncline, Pennsylvania"

Apr 2001 Carnegie Mellon University, Environmental Engineering seminar

Feb 2000 Consol Energy, Pittsburgh, "Hydrogeologic and geochemical evolution of a bituminous coal basin"

Jul 1999 Spectroscopy Society of Pittsburgh/Society of Analytical Chemists of Pittsburgh Forum on Inorganic Mass Spectrometry Invited Speaker, July 1999

Nov 1998 The Pennsylvania State University, Department of Geosciences

Apr 1998 AWG Phillips Petroleum Distinguished Lecturer: University of California, Davis, Department of Geology,

May 1998 University of California, Irvine, Department of Earth Systems Science

Nov 1998 6th Annual Monastery Run Project symposium, St. Vincent's College

Nov 1997 Brown University, Department of Geological Sciences

Nov 1997 University of Rochester, Department of Earth & Environmental Sciences University of Pittsburgh School of Engineering Environment and Energy Colloquium 1997, 1998

May 1997 Geological Society of America Cordilleran Meeting Symposium: Hawaiian Islands as a Natural Laboratory for Weathering and Ecosystem Studies, Kona, Hawaii

Aug 1996 Jet Propulsion Laboratory,"Radiometric dating of terrestrial and extraterrestrial materials"

Oct 1994 Soil Science Society of America Annual Meeting Symposium, Seattle: "Stable isotopes in soil environments: theory and applications"

Feb 1994 Indiana University/Purdue University at Indianapolis, Department of Geology

Mar 1994 State University of New York, Albany, Department of Geological Sciences; University of Pittsburgh, Department of Geology & Planetary Science; University of Miami, Rosensteil School of Marine Science, Florida

Apr 1993 Univ. of California, Riverside, Department of Soil and Environmental Sciences

Oct 1992 University of Kansas, Lawrence, Department of Geology

Sep 1992 Scripps Institute of Oceanography, University of California

FIELD WORK

1997 – present *Allegheny and Monongahela River Basins, Pennsylvania***.** Human impacts on stream chemistry, including AMD and affected streams (with R. S. Hedin, T. Weaver, W. Winters, C. Kairies, A. Wall, S. States)

2010 – present *Appalachian natural springs.* Natural hot and warm springs and spas (led by D. Vesper, WVU)

Jul 2009 *Morrison Formation, Spring Creek, WY.* Measure section and sample sediments and carbonate (with Tim Gallagher)

2009 – 2011. *Española Basin, Chimayó, NM*. Water well, brine and aquifer sampling (led by A. Hakala, NETL and E. Keating, Los Alamos NL)

1993 – 2011. *Owens River system and Death Valley, California***.** Sierra Nevada stream sampling and field parameters. Plio-Pleistocene lacustrine sediments and core

1997 – 1998. *French Creek/Pymatuning watershed, New York and Pennsylvania***.** Stream water and fresh water mussel shell sampling

1993 – 2000. *Desert Project Research Site, Las Cruces, New Mexico.* Quaternary pedogenic carbonate and petrocalcic soils (led by O. Chadwick, L. Gile, R. Grossman, C. Monger)

1994 – 2002. *Kohala Peninsula and South Point, Hawaii.* Sampling of soil, rain, and vegetation; examination of soil profiles, pedogenic carbonate, and fresh and weathered basalt (led by O. A. Chadwick and R. Gavenda)

June 2000. *Superior Province, Ontario, Canada.* Precambrian paleosols, marine carbonate, fluvial clastic sediments, and banded iron formation (led by H. Ohmoto)

May 1984. *Squaw Creek, Llano Uplift, Central Texas.* Mapping and sampling Cambrian paleosol for geochemical, isotopic and micromorphological analysis

EXTERNAL RESEARCH FUNDING (Funding amount refers to University of Pittsburgh except where noted)

Dept. of Interior-Office of Surface Mine Reclamation and Enforcement: *Applied Science program.* Optimizing rare earth element capture during treatment of acid mine drainage: Validation of geochemical modeling through bench-scale experiments and proof-of-concept field studies. $200,000 (01/2023-12/2024). PI B. Stewart; co-Is R.C. Capo (University of Pittsburgh); C.A. Cravotta III (USGS); BC Hedin (Hedin Environmental)

Dept. of Interior-Office of Surface Mine Reclamation and Enforcement: *Mine Drainage Technology Initiative*. Quantifying the geochemical evolution of water discharged from a flooded mine pool to optimize mine drainage treatment strategies. $200,000 (07/2020-12/2022) PI: R.C. Capo. Co-Is: B.W. Stewart (University of Pittsburgh), C.A. Cravotta III (USGS)

DOE-NETL/Leidos Geologic Carbon Storage: Novel geochemical signal methodologies-T08. $200,000 (08/2019 to 03/2023) PI: R.C. Capo. Co-I: B.W. Stewart

DOE-NETL/Leidos: Geochemical Testing & Analysis of Reactive Flow Tests and Modeling of Established Isotope Tracers in Unconventional Oil and Gas (UOG) Basins T010. $164,000 (2019-2022)

PI: B.W. Stewart. Co-I: R.C. Capo

DOE-NETL/AECOM: Geologic Carbon Storage: Novel geochemical signal methodologies (T220). $37,131 (2017-2018) PI: B.W. Stewart. Co-I: R.C. Capo

DOE-NETL-AECOM: Chemical analysis of reactive flow tests/ Comprehensive groundwater field testing $30,020 T209 (2017-2018) PI: B.W. Stewart. Co-I: R.C. Capo

DOE-NETL-AECOM/URS: Natural geochemical tracers in groundwater. $54,640 (2016-2018) PI: R. Capo. Co-I: B. Stewart

DOE-NETL-AECOM/URS: Natural isotope tracers in groundwater. $35,000 (2016-2017) PI: B.Stewart. Co-I: R. Capo

DOE–NETL–URS; Fluid and solid isotope characterization at the MSEEL Site WV. $10,500 (2016) PI: B. Stewart; Co-I: R. C. Capo

DOE–Energy Efficiency and Renewable Energy: Optimizing parameters for predicting geochemical behavior and performance of discrete fracture networks in geothermal systems. Total Award:~$1M; Univ. of Pittsburgh: $215,661 (2011–2014) PI: J. A. Hakala (NETL) Co-Is: R. C. Capo, B. Stewart (Pitt). G. Bromhal, D. Crandall, B. Kutchko, C. Lopano, K. Rose, E. Rosenbaum, Y. Seol (NETL); S. Sharma (WVU), L. Li (PSU)

DOE–NETL-Regional University Alliance. Physical-chemical effects of fluid-shale interactions. $95,000 (2013–2014). PI: R. C. Capo

DOE – NETL-Regional University Alliance CO_2 Storage: Natural isotope tracers $175,000 (2013–2014) PI: R. C. Capo; Co-I: B. Stewart

DOE – NETL-Regional University Alliance Unconventional energy: Natural tracers – produced waters. $39,000 (2013–2014) PI: R.C. Capo

DOE–NETL-Regional University Alliance Natural isotope tracers for quantitative monitoring, verification and accounting of injected CO_2. PI: R.C. Capo $202, 261 (2011-2013 Task 136)

DOE–NETL-Regional University Alliance Evaluation of isotopic composition of geologic end-members and produced water. $242,440 (2012 – 2013) PI: R.C. Capo; Co-I: B. Stewart

DOE –National Energy Technology Laboratory Biogeochemical indicators and processes for development of monitoring verification and accounting tools. $66,405 (2010–2011) PI: R.C. Capo

Colcom Foundation Marcellus Environmental Fund, Impacts of hydraulic fracturing operations on stream water quality: Geochemical and isotopic baseline assessment of watersheds potentially impacted by Marcellus Shale gas development. $169,042; Univ. of Pittsburgh: $66,622 (2011 – 2013) PI: C. Kirby (Bucknell) Co-Is: R.C. Capo, B. Stewart, J. Graney (SUNY Binghamton)

DOE –National Energy Technology Laboratory Novel geochemical tools to predict and monitor the fate and impact of subsurface CO2. $135,000 (2010-2011) PI: R.C. Capo Co-I: B. Stewart (Pitt), D. Vesper (WVU)

DOE –National Energy Technology Laboratory Natural isotope tools for NRAP strategic monitoring. $60,501 (2010–2011) PI: R.C. Capo; Co-I: B. Stewart

NASA Origins Program-Astrobiology Institute Evolution of a habitable planet. $~5.7 M; Univ. Pittsburgh: $230,972 (2003–2009) PI: H. Ohmoto (Penn State) Co-Is: R. Capo, B. Stewart, M. Schoonen (SUNY Stony Brook) and 14 other co-Is from Penn State

DOE–National Energy Technology Laboratory Regional collaboratory for the study of trace elements associated with fossil fuels and coal utilization byproducts $621,970; Univ. Pittsburgh: $327,970 (2006–2009) PI: B. Stewart, Co-I: R.C. Capo, D. Vesper, F. King (WVU)

The Heinz Endowments. Education Initiative: One Step at a Time – Campus Sustainability. $100,000; Univ. Pittsburgh: $30,000 (2008–2009) PI: I. Nair (CMU)Subcontract PI: R. Capo

NSF–EAR-Instrumentation and Facilities Program. Technician Support: Geochemistry laboratories at the University of Pittsburgh, Phase II. **$**83,079 (2005–2008) PI: R.C. Capo; Co-I: B. Stewart

Green Building Alliance Improved production of pigment as a byproduct of the treatment of coal mine drainage in Western Pennsylvania**.** $81,564; Univ. Pittsburgh: $48,864 (2007-2008)PI: R.C. Capo (University Partner) PI: R. Hedin (Iron Oxide Recovery, Business Partner)

NSF-EAR-Instrumentation and Facilities Supplementary: Repair of thermal ionization mass spectrometer for iron isotopes. $25,234 (2004) PI: B. Stewart; Co-PI: R. Capo

NSF–Hydrology Collaborative Research: Field and experimental iron isotope investigation of sedimentary pyrite dissolution in Appalachian coal mine drainage. $159,979; Univ. Pittsburgh: $75,979 (2003-2005) PI: B. Stewart; Co-I: R.C. Capo; PI (CMU): D.A. Dzombak

DOE-NETL/EPA WV173 Phase III: EPA Region III Mine Pool Project**.** ~$700,000; Univ. Pittsburgh: $94,628 (2001–2002) PI: P. Ziemkiewicz (Natl. Mine Reclamation Center) Subcontract PI: R.C. Capo (with 5 subcontracts to WVU and CMU)

NSF–EAR-Instrumentation and Facilities Program Technician Support: Geochemistry laboratories at the University of Pittsburgh, Phase I**.** $118,347 (2002-2005) PI: R.C. Capo; Co-I: B. Stewart

DOE-NETL/EPA Abandoned mine pool flooding of the Pittsburgh, Ohio and Irwin Basins**.**~$700,000; Univ. Pittsburgh $76,340 (2000-2001). PI: P. Ziemkiewicz (Natl. Mine Reclamation Center) Subcontract PI: R.C. Capo With five co-Is from WVU and CMU

DOE-NETL/EPA WV173: Monongahela Basin EPA Region III Mine Pool Project ~$700,000; Univ. Pittsburgh $52,597 (1999 -2000) PI: P. Ziemkiewicz (Natl. Mine Reclamation Center) Subcontract PI: R.C. Capo with five co-Is from WVU and CMU

NASA Planetary Instrument Development and Definition Program Miniature In situ geochronology instrument for planetary surface deployment: breadboard development **.** $396,622; Univ. Pittsburgh: $121,622 **(**1999–2001) JPL PIs G. Cardell; M. Sinha (JPL).Pitt PI: B. Stewart; Co-Is: R. Capo, D. Crown

NASA Origins Program–Astrobiology Institute Establishment of the Penn State Astrobiology Center**.** ~$5.0 M; Univ. Pittsburgh $345,000 **(**1998 -2003) PI: H. Ohmoto Co-Is: R.C. Capo, B. Stewart, Pitt; M. Schoonen (SUNY Stony Brook) and 14 other co-Is from Penn State

NASA-JPL Center for Space Microelectronics Development of variable environment laser ablation system for Mars in situ geochronology instrument. $56,736 (1997-1999)**.** PI: B. Stewart: Co-I: R.C. Capo

JPL Mini-Directors Research Development Fund In-situ miniature age dating laboratory development. $21,931(1997-1998) PI: B. Stewart; Co-I: R.C. Capo

NSF Education and Human Resources Enhancing geoscience education and public outreach: Partnership between the University of Pittsburgh and the Carnegie Museum of Natural History**.** $65,492 (1998– 2000) PI: R.C. Capo Co-Is: D. Crown, H. Rollins, J. Donohue

NSF-EAR-Geology and Paleontology Program The effect of Quaternary climate change on the balance of silicate mineral weathering and eolian input in desert soils. $126,139 (1997–2000) PI: R.C. Capo

NSF-EAR-Instrumentation and Facilities Program Acquisition of a thermal ionization mass spectrometer $275,000 (1998) PI: R.C. Capo, Co-I: B. Stewart

RESEARCH FUNDING – UNIVERSITY OF PITTSBURGH

Social Science Research Initiative Development of Interdisciplinary Geophysical and Geochemical Methods for the Analysis and Spatial Modeling of Prehistoric Landscapes in the Frank Church Wilderness, Idaho, and Southeastern Slovenia. $49,981 **(**2017-2020) PI: B. Hanks, Co-I:R.C. Capo

Central Research and Development Fund Critical materials for clean energy: Rare earth element and neodymium isotopic analysis of Appalachian Basin abandoned coal mine drainage and related minerals and precipitates $15,596 (2016-2018) PI: R.C. Capo

Central Research and Development Fund The effect of climate on weathering and soil formation: Kohala Peninsula . $13,269 **(**1995-1997) PI: R.C. Capo

Curriculum Development Grant Environmental Studies Curriculum**.** $5,000 (1996**)** PI: R.Capo

University Center for Social and Urban Research An integrated environmental assessment model for indoor air quality $4,000 (1997–1998) PI: R.C. Capo; Co-I: D. Crown

Univ. of Pittsburgh Provost's Fund: Research Instrumentation Acquisition of variable environment laser ablation system for Mars geochronology instrument. $22,328 (1997) PI: B. Stewart; Co-I: R. Capo

OTHER GRANTS, CONTRACTS AND FELLOWSHIPS

USDOE-Oak Ridge National Laboratory Faculty Research Participation Program (2011) Sabbatical support, $32,080

NSF-Archeology (PI S. Olsen Carnegie Museum of Natural History) $9,800 (2013–2014)

Dept. of Agriculture SBIR/PA-DEP *Growing Greener Program*. PI R.S. Hedin*,* Hedin Environmental*, s*ubcontract, $19,500 (2004, 2007)

NASA Astrobiology Institute Director's Research Scholar Program *(*for Ph.D. student Sherry Stafford*)*, $6,800 (2001-2002)

National Energy Technology Laboratory Student Partnership Program (PI G. Holder, School of Engineering. DOE-NETL Mentor: G. Watzlaf, Advisor: R. Capo, for Ph.D. student Candace Kairies, $95,000 (1999-2002)

1999– 2002	Postdoctoral Research Fellowship, California Institute of Technology
1984- 1985	University Fellow, University of California, Los Angeles
1982	Summer University Fellow, University of Texas at Austin
1981	Geological Society of America Grant-in-Aid-of-Research

TEACHING

Teaching accomplishments:

- *Development of the University of Pittsburgh Environmental Studies Bachelor of Arts Program.* As part of creation of the Environmental Studies B.A., developed team-taught interdisciplinary science/policy courses (*Topics in Environmental Studies: Air Quality in Southwestern Pennsylvania*; GEOL 3963*: Water Quality in Southwestern Pennsylvania*) involving field trips and guest speakers from industry, environmental groups, health professions, regulatory and state and federal government agencies, now taught every year. Developed new geology courses in *Geologic Hazards* (team taught); *Environmental Geochemistry*
- Awarded *University Curriculum Development Grant*s to (1) update *Groundwater Geology*, adding a laboratory section that includes fieldwork and computer assignments. (2) develop recitation sections for lecture-only *Environmental Geology* (150-250 student introductory course) to allow hands-on exercises.
- University of Pittsburgh PI on grant from Heinz Endowments (*Creating Sustainability: One Step at A Time Program*), a cooperative project of Carnegie Mellon University, the University of Pittsburgh, and Duquesne University, that resulted in creation of an undergraduate course in *Sustainability (GEOL 3962),* together with a multi-university *Student Sustainability Symposium* hosted by Sustainable Pittsburgh (2008, 2009)
- Supervised or co-supervised over 20 undergraduate research projects, resulting in published abstracts and student presentations at national and regional research conferences (see below)
- Co-led field trips to survey Western U.S. geology for undergraduate and graduate students
- Member, Graduate Faculty (1996 – present)
- Participated in *Speaking in the Disciplines* course; integrated student presentations into Mineralogy

and Geology of the National Parks courses.

Courses Taught

Undergraduate teaching

Geology (GEOL 0800) 3 cr. General introduction to geology for non-majors and majors with no previous geology course (typical enrollment 150-250); covers all fields of geology, emphasizing the major geodynamic processes that shape the Earth's surface and interior, and the coevolution of life and the Earth's surface/ocean/atmosphere. One hour of recitation each week designed to give students hands-on activities in small groups with teaching assistants. Class size: 160-250 students. Fall, 2016-2019.

Mineralogy (GEOL 1001) 4 cr. Introduction to mineral structures, chemistry, petrogenesis, and analytical techniques (including optical microscopy); includes material formerly taught in GEOL 1002 (below) after the courses were merged in 1999. Intensive laboratory section (with teaching assistant) introduces students to identification of minerals and interpretation of micro- and macroscopic structures using the petrographic microscope. Class size: 25-35 students. Taught every spring since 2016

Geology of the National Parks (GEOL 0802) 3 cr. Introductory-level course that related features of US national parks with the rocks, fossils and tectonic and climatic events that shaped them. Class size: 20-30. Taught summer 2018-2020.

Environmental Geology (GEOL 0860) 3 cr. Introductory-level course for the B.S. in Geology or Environmental Science and the Environmental Studies B.A. Topics include: Rocks and minerals, oceans, atmosphere, soil. Earthquakes, volcanoes, landslides, subsidence, weather hazards. Climate change. Water resources and pollution. Fossil fuels and renewable energy. Class size: 160-250 students. Taught every fall 1994 - 2016

Environmental Geochemistry (GEOL 1515) 3 cr. Upper division course required for Environmental Studies B.A. majors; elective for the B.S. Topics include chemistry of the atmosphere, ozone depletion, air pollution, eutrophication, ground and surface water chemistry and pollution, organic contaminants, toxicology, drinking water treatment. Student presentations involve related topics with a focus on current regional issues. Class project involved inorganic analysis of student drinking water/well water samples. Class size: 25-70 students. Every fall from 2001 to 2012; Spring and Fall 2014.

Groundwater Geology (GEOL 1051) 4 cr. Upper division course, required for the B.S. in Environmental Geology. Covered chemical and physical hydrology, including groundwater contamination, fate and transport. I received a *Curriculum Development Grant* to add and develop a laboratory section. Involved student presentations and team projects. Class size: 20-30 students. Taught every spring from 1994-2000

Geologic and Environmental Hazards (GEOL 1640) 3 cr. Upper division elective course co-developed with D. Crown. Covered mass wasting and subsidence, volcanic eruptions, earthquakes, tornadoes, hurricanes, flooding, wildfires and related topics. Project based; involved student presentations. Class size: 20-25 students. Alternate years 1995-2001.

Graduate teaching

Mineralogy and Petrology (GEOL2002) Fundamentals of rock and soil-forming minerals, with emphasis on integrating rocks and minerals from field scale to microscopic scale through examination of hand samples and use of the petrographic microscope. Offered 2020; in development.

Topics in Geochemistry (GEOL 3953) Variable topic-based course; lectures and guest lectures, student presentations and research papers; Trace elements and isotope systems; Evolution of the atmosphere; Astrobiology; Appalachian Shale Gas Resources; Alternate years, 2003 – present

Advanced Analytical Geochemistry (GEOL 2502) The first half focused on theory and applications of XRD, XRF, SEM, mass spectrometry, and other methods. The second half was project based. Taught alternate years, 1994 – 2002

Isotope Geochemistry (GEOL 2520). Fundamentals including the use of isotopes for radiometric dating and isotopic composition as petrogenetic and environmental tracers. Taught alternate years, 1994 – 2002

Advanced Environmental Geochemistry (GEOL 2515) Cross-listed with GEOL 1515, with longer presentation and additional research paper required. Taught 2002 – 2016.

Topics in Economic and Environmental Geology (GEOL 3962): Sustainability *Topics in Environmental Studies (GEOL 3963):* Air Quality. Water Quality

Teaching Associate, University of California, Los Angeles *1984 – 1989*
Taught laboratory sections in Fundamentals of Earth Science, Earth History, Introduction to Oceanography, Principles of Paleontology, Mineralogy-Petrology

Teaching Assistant, University of Texas at Austin *1981– 1983*
Taught laboratory sections in Optical Mineralogy and Crystallography, Sedimentary and Metamorphic Petrology, Field Geology (summer camp), Analytical Techniques

GRADUATE STUDENT AND POST OCTORAL ADVISING:
(co-advised with [a]B. Stewart, and [o]A. Hakala)

Postdoctoral researchers

[ao]Thai Phan (2012 – 2018)
[o a]Andrew Wall (2011 – 2014)

Graduate Students (4 current Ph.D. and 6 Ph.D. and 11 M.S. alumni)**:**

Current advisees:

Rebecca Matecha[a] **(**5th yr Ph.D. student) Ba sources and water-rock interaction in Appalachian shales

Tashane Boothe[a] (2nd yr Ph.D. student). Role of biotic interaction in critical metal recovery from AMD

Camille Schaeffer[a] (3rd yr Ph.D.) Multidecadal geochemical evolution of coal mine discharges

Kristi Dobra[a] (3rd yr Ph.D.) Freshwater mussels as records of paleoenvironmental change

Former graduate student advisees:

Benjamin Hedin (Ph.D. 2021) Coal pollution to critical metals: Recycling rare earth elements from acid mine drainage. *Currently*: Environmental Scientist, Hedin Environmental

Irene Wallrich (M.S. 2017) Nd isotopes track rare earth element sources in acid mine drainage, Appalachian Basin, USA. *Currently*: Program coordinator, Graduate School, Vanderbilt University, TN

Matthew Dieterich (M.S., 2015) Physicochemical effects of synthetic hydraulic fracturing fluid on core samples of the Middle Devonian Marcellus Shale and underlying Huntersville Chert, Greene County, Pennsylvania, USA. *Currently*: Geoscience Laboratory Manager, Hydrus Technology, Houston TX

Samantha Pfister (M.S., 2015) Geochemical and lithium isotope characterization of Ogallala aquifer and Permian Basin carbonate reservoir waters at an enhanced oil recovery site, northwest Texas, USA. *Currently*: Assistant Scientist, HydroGeoLogic, Inc., Philadelphia PA

Courtney Kolesar Kohl (M.S., 2014): Geochemistry and isotopic composition of Appalachian Basin produced waters. *Currently*: Operations Geologist, Chevron Corp.

James Gardiner (Ph.D., 2013) Isotopic investigation of subsurface rock and fluid interactions: Case studies of CO_2 sequestration and gas-bearing shale formations. *Currently*: Research Scientist, Leidos/ National Energy Technology Laboratory

Elizabeth C. Chapman (Ph.D., 2011). Fossil fuel related water-rock interaction in the Appalachian Basin, Pennsylvania and New York: A geochemical and strontium isotope investigation. *Currently*: Geologist, Echelon Applied Geochemistry Consulting, Murrysville, PA

Sherry L. Stafford (Ph.D., 2007) Precambrian paleosols as indicators of paleoenvironments on the early Earth (M.S., 1999) Strontium isotopic ratios trace natural alkaline additions to coal mine drainage. *Currently:* Analyst, Global Portfolio and Prioritization, ExxonMobil, Houston, TX

Lara Homsey (M.S., 2003; Ph.D. Anthropology, 2004) M.S. Archeological feature identification using geochemistry: Dust Cave, AL. *Currently*: Associate Professor of Anthropology, Indiana University of Pennsylvania

Candace L. Kairies (Ph.D., 2003). Characterization of iron rich precipitates associated with untreated and passively treated coal mine discharges in the Bituminous region of Pennsylvania and Maryland.

Currently: Professor of Geoscience/Department Chair, Winona State Univ., MN

Elizabeth Bryant (M.S., 2002) Geochemical modeling of a bituminous coal basin, southwestern Pennsylvania. *Currently*: Hydrologist and Project Manager, CH2MHill, San Diego, CA

Amanda C. Reynolds (M.S., 2001) Paleoenvironmental reconstruction of the Pennsylvanian-Permian Dunkard Basin: Geochemical evidence from lacustrine core and associated paleosols. *Currently*: Petrophysicist and Reservoir Quality Specialist, ExxonMobil, Houston, TX

William Winters (M.S., 2000). Hydrogeologic and geochemical evolution of a bituminous coal basin, Westmoreland County, Pennsylvania. *Currently*: Hydrologist & Manager, US Department of Interior, Office of Surface Mining, Knoxville, TN

Charles E. Whipkey (Ph.D., 1999). Effect of Quaternary climate change on the development of desert soils: mineralogical and isotopic analysis. *Currently*: Emeritus Professor of Environmental Science & Geology Mary Washington College, VA

Craig Rowland (M.S., 1998; co-advised with D. Crown). Thesis: An integrated environmental assessment model for indoor air quality. ERP Manager, Pittsburgh

Theodore J. Weaver (M.S., 1998) Occurrence and significance of alkaline mine drainage in northern Appalachia. *Currently*: Consulting Geologist, Hedin Environmental, Inc., Pittsburgh, PA

Gregory Ayres (M.S., 1997) Influence of pedogenesis on the weathering and mobility of rare earth elements along the Kohala climate transect, Hawaii. *Currently:* Senior Hydrogeologist; Manager, Pittsburgh office Leggett, Brashears &Graham Groundwater & Environmental Engineering Services

Graduate Committee Member

University of Pittsburgh Geology: Nicholas DeLillo (Ph.D., 1998); MaryLynn Yurko (M.S., 1999); Victoria A. Pretti (M.S., 2000); Garrett E. Sleeman (M.S., 2000); Steven J. Schatzel (Ph.D., 2001); Joseph Minervini (M.S., 2001); Ann Kim (Ph.D., 2002); William Beatty (Ph.D., 2003); Gina Hobbs (M.S. 2003); Katie Walden (M.S. 2004); Barbara Hamel (M.S. 2005); Brian Lipinski (Ph.D., 2007); Stephen Scheidt (Ph.D. 2010); Tonya Brubaker (M.S. 2010); Amy Wolfe (Ph.D. 2010); Marion Sikora (Ph.D. 2013); Zachary Tieman (M.S. 2017); Justin Mackey (M.S.2017); Monica McGrath (M.S. 2018); Melissa Griffore (M.S.2018)

University of Pittsburgh Anthropology: Lara Homsey (Ph.D., 2004) *School of Engineering/Department of Chemical Engineering:* Celeste J. Powell (Ph.D., 2000)

Dartmouth: Danielle Niu (Ph.D., 2021)

UNDERGRADUATE RESEARCH ADVISEES:

Will Heck (B.S. Geology, 2020) Tracking barium release in Marcellus Shale produced waters using Ba isotopes. Currently: grad student, Tulane. *Corinne Hite* (B.S. Geology, 2018) Strontium isotope signatures of sources to Searles Lake, CA. Currently: Res. Asst. Univ. Hawaii. *Anna Thornton* (B.S. Geology, 2017) Appalachian Valley and Ridge spring provenance determination using Sr isotopes. Currently: Associate Geologist, Pennoni Assoc. Inc. *Emily Burt* (B.S. Environmental Geology, 2015) Sr isotopes and geochemistry of mussel shells as environmental indicators, Allegheny River. Currently: Ph.D. student, University of Southern California. *Megan Achille* (B.A. Environmental Studies 2013) Effects of sequential chemical extraction of common aquifer minerals. Currently: lawyer with specialty in environmental law, Alaska. *Anna Statkiewicz* (B.S. Geology 2012) Geochemical investigation of tufa deposition, western Pennsylvania. Currently: Senior Staff Scientist, Langan International LLC. *Kelly Flannery*[2, 5] (B.S., Geology 2013) Oxidative leaching of arsenic and iron from arsenopyrite (FeAsS) in acidic solutions Currently: Science Teacher, Pinellas Cty, FL. *Timothy Gallagher*[5] (B.Phil, 2010) Carbonate mineralization in the Morrison Formation, Spring Creek, Wyoming. Currently: Postdoctoral Fellow, Jackson School, Univ. Texas. *James Gardiner*[2] (B.S., Geology, 2008) Soil Trace Element Evidence for Horse Corralling During the Copper Age in Northern Kazakhstan. Currently: Research Scientist, NETL/Leidos. *Justin Hynicka*[2,5] (B.A. Environmental Studies/B.S. Chemistry 2008), Sr isotope tracking

of cation sources in arid soils from the Atacama Desert, Chile. Currently: Sr. Scientist & Forester, Green Infrastructure Center. *Patrick Milham*[4] (B.S., Political Science, 2005) Geochemical analysis of AMD impacted blue lakes, PA*;* Currently: Director of advocacy, NextGen America. *Aaron Fellows* (B.S., Physics, 2006) SEM analysis of sedimentary pyrite. Currently: USDA Agricultural Research Service. *Erin Minster* (B.S., Environ. Geol., 2002) Sr isotopic composition of calcite, Desert Project Area, NM. Currently: Curry County, OR SWCD GIS & Data Management. *John Boulanger*[2,] (B.S., Geology, 2000) Effect of Pleistocene climate change: Las Cruces Trench, NM (New Mexico Tech); Currently: Assoc. VP, Oil & Gas Services Arcadis. *M. Jenny Lee*[2,4] (B.S., Environmental Geology, 2000) Assessment of acidic drainage remediation efforts on Cowanshannock Creek, Armstrong County, Pennsylvania. Erica Love (B.S., Geology, 1999) Internship: Pennsylvania Dept. of Environmental Protection Currently: TetraTech NUS. Jeffrey D. Patterson[2,4] (major: Chemistry) Relationship between iron and aluminum loading and fish diversity: Little Deer Creek, Allegheny County. Jeanne Thompson (B.S., Biology, 2000) *Comparison of trace metal content of commercial iron oxides and iron precipitates from coal mine drainage in southwestern Pennsylvania.* Currently Occupational Safety Officer, SEPTA, Philadelphia. *Matthew Wolinsky*[3,4] (B.S. Applied Mathematics/B.A. Environmental Studies, 1999) Relationship of hydrology and geochemistry of mine discharges: Irwin basin. Currently: Shell Oil. Erik Hoffmann[4] (major: Geology) XRD of clay associated with the Pittsburgh Coal. Currently: Petroleum Systems Analyst, BP, Houston. Tara Laishley (B.S., Geology, 1998*)* Ground Water Remediation Techn. Center. Currently: Principal Scientist, AGES, Inc., Clinton, PA. *Chad R. Lupp*[1,4] (B.A., Environmental Studies, 1998) Faunal diversity and water quality in an AMD affected stream: Little Deer Creek. Currently: GIS analyst, Lafayette, CO. *Elizabeth Breitenbach* (B.S., Geology, 1996) Subsurface geology, University of Pittsburgh

[1]Presented at Geological Society of America Annual Meeting. [2] Presented at International Goldschmidt Meeting, [3]Co-author of paper presented at 16th International Pittsburgh Coal Conf. [4]Partial funding through University Honors College/Chancellor's Undergraduate Research [5]Co-advisee with B. Stewart

Additional Lab and Field Assistants supported with external funds:
Current: Grace Bair, Nate Schoellert, Jack McGuane.
Former: Allie Ackerman, William Burger, Jason Cocklin, Valerie Costigan, Miranda DiFasio, Corinne Hite, Damara Kautz, Corinne Keubler, Amanda Illar, Richard Kilpatrick, Leah Thomas, Elizabeth Mahoney, Matthew McCullough, Katherine Roll, Janelle Shelatz, Andrew Stiff, Victoria Walker, Mary Lynn H. Yurko, Sarah Zimmerman

PROFESSIONAL DEVELOPMENT AND WORKSHOPS

Cutting Edge Leadership Leadereship Development, University of Pittsburgh (Sep 2022-April 2023)

Chapman Conference: Second Conference on Justice in Geoscience, Washington DC (Jun-Aug 2022)

*Diversity, Equity and Inclusion Training Workshop, Univ. Pittsburgh (*Oct 2020)

*Alan Alda Center for Communicating Science Workshop, Univ. Pittsburgh (*May 2019)

MSA Geochemistry of Geological Carbon Sequestration Short Course, Lawrence Berkeley National Laboratory (Dec. 2013)

Geochemical Modeling with Geochemist's Workbench workshop, Denver (Oct. 2013)

Geothermal Resources Council Recent Advances in Geothermal Geochemistry Workshop, Univ. of California, Davis (July 2012)

NSF-sponsored Environmental and Social Implications of Hydraulic Fracturing and Gas Drilling in the United States, Nicholas School of the Environment, Duke University (Jan. 2012)

Desert Project Tour, Las Cruces, New Mexico, sponsored by New Mexico State University and New Mexico Bureau of Mines and Mineral Resources (2000)

NASA – Jet Propulsion Laboratory PIDDP Planetary Instrument Development Workshop (1997)

University of Pittsburgh Institute of Politics/Environmental City Network, Pittsburgh Technology Council Workshops: Combined Sewer Overflow/Storm Sewer Infrastructure (1998). Land-Use Management

Issues in Southwest Pennsylvania (1999). Land Use Management Techniques: Benefits and Costs (1999)

University of Pittsburgh Survival Skills and Ethics Workshops Lab Management (1995);Teaching (1994)

Spectroscopy Society of Pittsburgh Short Course: Elemental and isotopic analysis of elemental speciation by ICP-MS (1995)

Geological Society of America Continuing Education courses: Contaminant Organic Geochemistry (1995). Hydrology and Geo chemistry of Wetlands (1995) Contaminant Hydrogeology: Monitoring, Protection, and Cleanup (1991)

SERVICE

National/International

Past Chair/Chair/Vice Chair, Mineralogy, Petrology, Geochemistry & Volcanology Div., Geol. Soc. America (2019-2022)

Chair, Early Career Award, Mineralogy, Petrology, Geochemistry & Volcanology Div., Geol. Soc. America (2020)

Nominations Committee, Mineralogy, Geochemistry, Petrology & Volcanology Division, Geol. Soc. America (2016)

Guest Editor: Special Issue *Applied Geochemistry*: "Geochemistry of Unconventional Shale Gas: Petrogenesis, Hydraulic Fracturing, Environmental Impacts" (2015)

External Program Reviewer, Duquesne University Center for Environmental Research and Education (2014)

Invited Panelist, NSF-funded workshop "Environmental and Social Implications of Hydraulic Fracturing and Gas Drilling in the United States", Duke University (2012).

Workshop Leader, "Preparing for a Career in the Geosciences", offered through the "On the Cutting Edge" program supported by NSF and NAGT. Session leader for "Strategies to broaden participation", co-leader for sessions "Engaging students in the classroom"; "Teaching an introductory course"; Preparing for academic interviews"; "Setting up your research lab" (2014)

Panel Reviewer, NSF-EAR Instrumentation and Facilities Laboratory Technician Support (2017). NSF-Water Sustainability and Climate (2012). NASA-Mars Science Laboratory Participating Scientist Program (2011). Proposal reviewer, NSF.

Session/Symposium co-convener co-chair, International Goldschmidt Conf., "Indicators of Carbon Capture, Storage and Migration in Natural and Engineered Systems" (2010) AAPG Ann. Mtg "Geochemical Assessment of Petroleum Resources" (2013). "Geochemistry of Flowback and Produced Waters from Hydraulically Fractured Black Shale" Geolog. Soc. of America Annual Meeting (2013). Geological Society of America Symposium "Indicators of Atmospheric Inputs into Terrestrial and Marine Environments" (1998) *Co-organizer*, Rachel Carson Centennial Symposium (2006)

Planning Committee member, Rachel Carson Legacy Conferences: Sustaining the Web of Life in Modern Society (2007); Green Chemistry: Solutions for a Healthy Environment (2008). *Program Committee member*, Geochemical Society (1996–1999)

Manuscript Reviewer: Nature-Sustainability, Environmental Science and Technology, Geochim. Cosmochim. Acta, Science, Nature, Earth & Planetary Science Letters, Geological Society of America, Geology, Geophysical Research Letters, Paleoceanography, Water Resources Research

University Service

Development of the University of Pittsburgh Environmental Studies Bachelor of Arts Program.

Assisted in initiation of program and development of program structure, curriculum, interdisciplinary offerings, Advisory Board recruitment and formation, student recruitment efforts, creation of Environmental Studies Coordinator position. Participated in fundraising efforts with the Office of Institutional Development, including successful $2 million Heinz Endowments gift. The program has over 100 majors and 500 graduates

Co-organizer of multi-university Student Sustainability Symposia

Co-PI on Heinz Endowments grant to develop the "One Step at a Time" campus sustainability program, undergraduate course and undergraduate student symposium involving the University of Pittsburgh, Duquesne University and Carnegie Mellon University (2008, 2009)

University of Pittsburgh Committee Service:

Mentoring for Diversity Subcommittee (2022); Hispanic Languages & Literature Diversity Committee (2021-2022); University Council for Graduate Studies (2020-); Dietrich School Graduate Student Organization Advisor (2020-); Dietrich School of Arts and Sciences Faculty Grants Committee (2019-2022); Dietrich School of Arts and Sciences Faculty Diversity Committee (2017-); Dietrich School Diversity Task Force (2018-); Dietrich School of Arts and Sciences Undergraduate Curriculum Committee (2012-2015); Faculty of Arts and Sciences Tenure Council representative (2005-2008; 2018); College of Arts and Sciences Academic Integrity Committee (2005-2007); College of Arts and Sciences Nominating Committee (2005-2007); College of Arts and Sciences Science Committee (1997 – 2000); Arts and Sciences Grants Committee (2001 – 2003) Advisory Committee on Environment, Institute of Politics, (1998 – 2000); Environmental Steering Committee, Center for Social and Urban Research (1995–1998)

Other: Mentoring first generation graduate and professional students, Provost Mentoring & Advising Summit (2022); Judge, Dietrich School Grad Expo (2022); Advisor, Dietrich School Graduate Student Organization (2020-2023); TA/TF Mentoring workshops (2021-2022); Symposium co-organizer, A.J. Sharkey Symposium "Mass Spectrometry of the Earth and Environment" sponsored by the American Chemical Society and Spectroscopy Society of Pittsburgh (1997); University Honors College Undergraduate Research Fair student advisor 1998, 2005, 2007. FAS Minority Graduate Student Workshop speaker (1997); INVEST NOW minority high school student lab tour (1997); supervision of student intern (1999). Honorable mention, 32nd Annual Exhibition of Western Pennsylvania Printing: capabilities brochure: "Environmental Studies" (1997). Featured in articles in the Pittsburgh Business Times (1996), Pittsburgh Post-Gazette (1997), Pittsburgh TEQ magazine (1997), University Research Review (1997, 1998, 1999), Pitt Magazine (1998, 2000); Radio interview with KQV: Environmental Studies Program (1996); Science Daily "New Evidence of Horse Domestication (2006), NSF Discovery "Finding the first horse whisperers" (2010)

Department of Geology & Environmental Science Service

Chair, GES Diversity Committee (2019-2020); Director of Graduate Studies (2012-2013); Undergraduate Curriculum Committee; Environmental Studies Executive Committee; G&PS Space Committee Faculty Search Committees. Assisted in development of 5-year facilities plan. Renovation of five laboratories. Curriculum Review Committee (1995– 1999). Curriculum revision for Bachelor of Science in Geology and Environmental Geology

Community Service

STEM Career Day representative, Woodland Hills Academy (2015). *Judge*, Region 4 Finals, Siemens Competition in Math, Science & Technology (2013). *American Geological Inst. Special Award Judge*, Intel International Science and Engineering Fair, (2012). *Girl Scouts*: Led field trip to AMD treatment facility for *EPA Water Drop* badge (2002). *Panelist and workshop participant: Expanding Your Horizons, Carnegie Mellon University* for girls in grades 6-10 to increase interest in math and science related careers (2000). Latin American Cultural Union presentation for children (1999).

Pittsburgh Public Schools K-12 Outreach: Pittsburgh Public Schools Gifted Center Science Fair Judge (2013); CAPA High School guest lecture, AP Chemistry (2010); Liberty K-5 Elementary School presentations: "Field adventures of two geologists, their daughter and her dragon" (2002); "Calcium carbonate: caves, coral, caliche and clams"(2001); "Desert Geology" (2000); "Geology of the Western U.S."(1999); "Geology of Eastern Canada" (1999)