

CURRICULUM VITAE

David A. Butterfield

Contact Data

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Education

B.A., with honors, Chemistry and German, Portland State University, 1980
Ph.D., Oceanography, University of Washington, 1990

Professional Experience

Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle, Washington
Senior Research Scientist (2003-present)
Oceanographer (1993-2003)
School of Oceanography, University of Washington, Seattle, Washington
Affiliate Assistant Professor (1997-2003)
Affiliate Associate Professor (2003-present)
NOAA, Pacific Marine Environmental Laboratory, Seattle, Washington
National Research Council Postdoctoral Associate (1991-1992)
Peace Corps, Togo, West Africa
Secondary school (lycée) physics and chemistry teacher (1981-1983)

Professional Memberships

American Geophysical Union, Geochemical Society, American Chemical Society

Research Experience

Interdisciplinary studies of submarine volcanoes and hydrothermal systems. Participation in 36 submersible expeditions to hydrothermal sites on the Juan de Fuca Ridge, Explorer Ridge, Southern East Pacific Rise, Mid-Atlantic Ridge, Kermadec and Mariana volcanic arcs, 1984-2006. Chief scientist on two expeditions. Development and application of sampling instrumentation, analytical chemistry techniques and computer applications. Design and operation (2001 to 2006) of a sampling and monitoring node of the NeMO-Net real-time acoustic-satellite observatory at an active hydrothermal vent.

Publications (as of January 2007)

In-progress:

D.A. Kadko, K. Gronvold, and D.A. Butterfield (submitted 2007): Application of Radium Isotopes to Determine Crustal Residence Times of Hydrothermal Fluids from two Sites on the Reykjanes Peninsula, Iceland. *Geochimica Cosmochimica Acta*.

Kelly, N., A. Metaxas, and D.A. Butterfield (submitted 2007): Spatial and temporal patterns in colonization of deep-sea hydrothermal vent invertebrates on the Juan de Fuca Ridge, NE

Pacific. *Mar. Ecol. Prog. Ser.*

Sharma, M., E. Rosenberg, and D. Butterfield (submitted 2006): Search for the proverbial mantle osmium sources to the oceans: Hydrothermal alteration of mid-ocean ridge basalt. *Geochim. Cosmochim. Acta*.

Fontaine, F., W.S.D. Wilcock, and D. A. Butterfield (accepted 2007): Physical controls on the salinity of hydrothermal vent fluids. *Earth Planet. Sci. Lett.*

Published:

Carney, S.L., J.F. Flores, K.M. Orobona, D.A. Butterfield, C.R. Fisher, and S.W. Schaeffer (2007): Environmental differences in hemoglobin gene expression in the hydrothermal vent tubeworm, *Ridgeia piscesae*. *Comparative Biochemistry and Physiology, Part B*. **146(2)**, 326-337.

Huber, J.A., D.A. Butterfield, and J.A. Baross (2006): Diversity and distribution of subseafloor Thermococcales populations in diffuse hydrothermal vents at an active deep-sea volcano in the northeast Pacific ocean. *J. Geophys. Res.*, **111**, G04016, doi:10.1029/2005JG000097.

Nielsen, S.G., Rehkamper, M., Teagle, D.A.H., Butterfield, D.A., Alt, J.C., Halliday, A.N. (2006): Hydrothermal fluid fluxes calculated from the isotopic mass balance of thallium in the ocean crust. *Earth Planet. Sci. Lett.*, **251**, 120-133.

Lang, S.Q., D.A. Butterfield, M.D. Lilley, H.P. Johnson, and J.I. Hedges (2006): Dissolved organic carbon in ridge-axis and ridge-flank hydrothermal systems. *Geochim. Cosmochim. Acta*, 70(15), 3830-3842.

Hey, R.N., G.J. Massoth, R.C. Vrijenhoek, P.A. Rona, J. Lupton, and D.A. Butterfield (2006): Hydrothermal vent geology and biology at Earth's fastest spreading rates. *Mar. Geophys. Res.* 27 (2): 137-153 JUN 2006.

Lupton, J., D. Butterfield, M. Lilley, L. Evans, J. Resing, R. Embley, E. Olson, G. Proskurowski, W. Chadwick, Jr., E. Baker, C. de Ronde, K.-I. Nakamura, K. Roe, R. Greene, and G. Lebon (2006): Submarine venting of liquid carbon dioxide on a Mariana Arc volcano. *Geochem. Geophys. Geosyst.* **7**, Q08007, doi:10.1029/2005GC001152.

Embley, R.W., W.W. Chadwick, Jr., E.T. Baker, D.A. Butterfield, J.A. Resing, C.E.J. de Ronde, V. Tunnicliffe, J.E. Lupton, S.K. Juniper, K.H. Rubin, R.J. Stern, G.T. Lebon, K.-I. Nakamura, S.G. Merle, J.R. Hein, D.A. Wiens, and Y. Tamura (2006): [Long-term eruptive activity at a submarine arc volcano](#). *Nature*, 441(7092), 494–497.

Ludwig, K.A., Kelley, D.S., Butterfield, D.A., Nelson, B.K., and Fruh-Green, G (2006) Formation and evolution of carbonate chimneys at the Lost City hydrothermal field. *Geochim. Cosmochim. Acta*, **70**, 3625-3645.

- Huber, J.A., H.P. Johnson, D.A. Butterfield, and J.A. Baross (2006): Microbial life in ridge flank crustal fluids. *Environ. Microbiol.* 8 (1): 88-99 JAN 2006.
- Kelley, D.S., J.A. Karson, G.L. Früh-Green, D. Yoerger, T.M. Shank, D.A. Butterfield, J.M. Hayes, M.O. Schrenk, E. Olson, G. Proskurowski, M. Jakuba, A. Bradley, B. Larson, K. Ludwig, D. Glickson, K. Buckman, A.S. Bradley, B. Brazelton, K. Roe, M.J. Elend, A. Delacour, S.M. Bernasconi, M.D. Lilley, J.A. Baross, R.E. Summons, and S.P. Sylva (2005): [A serpentinite-hosted ecosystem: The Lost City hydrothermal field](#). *Science*, 307(5714), 1434–1440.
- Butterfield, D.A., Lilley, M.D., Huber, J.A., Roe, K.K., Embley, R.E., Baross, J.A. and Massoth, G.J., (2004) Mixing, Reaction and Microbial Activity in the Sub-seafloor Revealed by Temporal and Spatial Variation in Diffuse Flow Vents at Axial Volcano. In *The Sub-seafloor Biosphere at Mid-ocean Ridges*, (eds. W.S.D. Wilcock, D.S. Kelley, J.A. Baross, E. DeLong, and C. Cary) Geophysical Monograph, American Geophysical Union.
- Früh-Green, G.L., D.S. Kelley, S.M. Bernasconi, J.A. Karson, K.A. Ludwig, D.A. Butterfield, and C. Boschi (2003): 30,000 years of hydrothermal activity at Lost City. *Science*, **301**, 495-498.
- Lilley, M.D., Butterfield, D.A., Lupton, J.E., and Olson, E.J. (2003) Magmatic events can produce rapid changes in hydrothermal vent chemistry. *Nature*, **422**(6934), 878–881.
- Huber, J., Butterfield, D.A., and Baross, J.A. (2003) Bacterial diversity in a subseafloor habitat following a deep-sea volcanic eruption. *FEMS-Microbiology Ecology*, **43**(3), 393-409.
- Butterfield, D.A., Fouquet, F., Halbach, M., Halbach, P.E., Humphris, S.E., Lilley, M.D., Lüders, V., Petersen, S., Scott, S., Seyfried, W.E. Jr., Shimizu, M., and Tivey, M.K. (2003) How can we describe fluid-mineral processes and the related energy and material fluxes? In *Mass and Energy Flux in Marine Hydrothermal Systems Dahlem Workshop Report Volume 89*. P.E. Halbach, V. Tunncliffe, and J. Hein (eds.) Berlin: Dahlem University Press, 183-209.
- Butterfield, D.A., Seyfried, W.E. Jr., and Lilley, M.D. (2003) Composition and evolution of hydrothermal fluid chemistry. *Mass and Energy Flux in Marine Hydrothermal Systems Dahlem Workshop Report Volume 89*. P.E. Halbach, V. Tunncliffe, and J. Hein (eds.) Berlin: Dahlem University Press, 123-161.
- Mehta, M.P., Butterfield, D.A., and Baross, J.A. (2003) Phylogenetic diversity of nitrogenase (nifH) genes in deep sea and hydrothermal vent environments of the Juan de Fuca ridge. *Applied and Environmental Microbiology*. **69**:960-970.
- Huber, J., Butterfield, D.A., and Baross, J. (2002) Temporal changes in archaeal diversity and chemistry in a mid-ocean ridge subseafloor habitat. *Applied and Environmental Microbiology* **68**: 1585-1594.

- Cowen, J.P., Giovanonnoni, S.J., Kenig, F., Johnson, H.P., Butterfield, D.A., Rappe, M.S., Hutnak, M., and Lam, P. (2003) Fluids from aging ocean crust that support microbial life. *Science*, **299**, 120-123.
- Kelley, D.S., J.A. Karson, D.K. Blackman, G. Fruh-Green, J.Gee, D.A. Butterfield, M.D. Lilley, E.J. Olson, M.O. Schrenk, K.K. Roe, G. Lebon, P. Rizzigno, J. Cann, B. John, D.K. Ross, S. Hurst, and G. Sasagawa (2001) An off-axis hydrothermal vent field near the Mid-Atlantic Ridge at 30°N. *Nature*, **412**, 145-149.
- Butterfield, D.A., Nelson, B.K., Wheat, C.G., Mottl, M.J., and Roe, K.K. (2001) Evidence for basaltic Sr in mid-ocean ridge flank hydrothermal systems and implications for the global oceanic Sr isotope balance. *Geochim. Cosmochim. Acta.*, **65**, 4141-4153.
- Sharma, M., G.J. Wasserburg, A.W. Hofmann, and D.A. Butterfield (2000): Osmium isotopes in hydrothermal fluids from the Juan de Fuca Ridge. *Earth Planet. Sci. Lett.*, **179**, 139-152.
- Butterfield, D.A. (1999) Deep Ocean Hydrothermal Vents, in "The Encyclopedia of Volcanoes", Academic Press, New York, 857-875.
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- Embley, R.W., J.E. Lupton, G. Massoth, T. Urabe, V. Tunnicliffe, D.A. Butterfield, T. Shibata, O. Okano, M. Kinoshita, and K. Fujioka (1998): Geologic, chemical, and biologic evidence for recent volcanism at 17.5°S: East Pacific Rise. *Earth Planet. Sci. Lett.*, **163**, 131-147.
- Kadko, D., and D.A. Butterfield (1998) The relationship of hydrothermal fluid composition and crustal residence time to maturity of vent fields on the Juan de Fuca Ridge. *Geochimica et Cosmochimica Acta*, **62**, 1521-1534.
- Butterfield, D.A., I.R. Jonasson, G.J. Massoth, R.A. Feely, K.K. Roe, R.E. Embley, J.F. Holden, R.E. McDuff, M.D. Lilley, and J.R. Delaney (1997) Seafloor eruptions and evolution of hydrothermal fluid chemistry. *Philosophical Transactions of the Royal Society of London A*, **355**, 369-386.
- Tunnicliffe, V., R.W. Embley, J.F. Holden, D.A. Butterfield, G.J. Massoth, and S.K. Juniper (1997): Biological colonization of new hydrothermal vents following an eruption on Juan de Fuca Ridge. *Deep-Sea Research I*, **44**(9-10), 1627-1644.
- Embley, R.W., W.W. Chadwick, Jr., I.R. Jonasson, D.A. Butterfield, and E.T. Baker (1995) Initial results of the rapid response to the 1993 CoAxial event: Relationships between hydrothermal and volcanic processes. *Geophysical Research Letters*, **22**(2), 143-146.
- Lupton, J.E., E.T. Baker, G.J. Massoth, R.E. Thomson, B.J. Burd, D.A. Butterfield, R.W.

- Embley, and G.A. Cannon (1995) Variations in water-column ^3He /heat ratios associated with the 1993 CoAxial event, Juan de Fuca Ridge. *Geophysical Research Letters*, **22**(2), 155-158.
- Massoth, G.J., E.T. Baker, R.A. Feely, D.A. Butterfield, R.E. Embley, J.E. Lupton, R.E. Thomson, and G.A. Cannon (1995) Observations of manganese and iron at the CoAxial seafloor eruption site, Juan de Fuca Ridge. *Geophysical Research Letters*, **22**(2), 151-154.
- Butterfield, D.A., and G.J. Massoth (1994): Geochemistry of north Cleft segment vent fluids Temporal changes in chlorinity and their possible relation to recent volcanism. *Journal of Geophysical Research*, **99**(B3), 4951-4968.
- Butterfield, D.A., R.E. McDuff, M.J. Mottl, M.D. Lilley, J.E. Lupton, and G.J. Massoth (1994) Gradients in the composition of hydrothermal fluids from the Endeavour segment vent field: Phase separation and brine loss. *Journal of Geophysical Research*, **99**(B5), 9561-9583.
- Butterfield, D.A., R.E. McDuff, J. Franklin, and C.G. Wheat (1994) Geochemistry of hydrothermal vent fluids from Middle Valley, Juan de Fuca Ridge. Chapter 20 in *Proceedings of the Ocean Drilling Program, Scientific Results, 139*, Mottl, M.J., E.E. Davis, A.T. Fisher, and J.F. Slack (eds.), College Station, TX, 395-410.
- Massoth, G.J., E.T. Baker, J.E. Lupton, R.A. Feely, D.A. Butterfield, K.L. Von Damm, K.K. Roe, and G.T. Lebon (1994): Temporal and spatial variability of hydrothermal manganese and iron at Cleft segment, Juan de Fuca Ridge. *Journal of Geophysical Research*, **99**(B3), 4905-4923.
- Trefry, J.H., D.A. Butterfield, S. Metz, G.J. Massoth, R.P. Trocine, and R.A. Feely (1994) Trace metals in hydrothermal solutions from Cleft segment on the southern Juan de Fuca Ridge. *Journal of Geophysical Research*, **99**(B3), 4925-4935.
- You, C.F., D.A. Butterfield, A.J. Spivack, J.M. Gieskes, T. Gamo, and A.J. Campbell (1994) Boron and halide systematics in submarine hydrothermal systems: Effects of phase separation and sedimentary contributions. *Earth and Planetary Science Letters* **123**, 227-238.
- Lilley, M.D., D.A. Butterfield, E.J. Olson, J.E. Lupton, S.A. Macko, and R.E. McDuff (1993) Anomalous CH_4 and NH_4^+ concentrations at an unsedimented mid-ocean-ridge hydrothermal system. *Nature*, **364**, 45-47.
- Mortlock, R.A., P.N. Froelich, R.A. Feely, G.J. Massoth, D.A. Butterfield, and J.E. Lupton (1993) Silica and germanium in Pacific Ocean hydrothermal vents and plumes. *Earth and Planetary Science Letters* **119**, 365-378.
- Butterfield, D.A., G.J. Massoth, R.E. McDuff, J.E. Lupton, and M.D. Lilley (1990)

Geochemistry of hydrothermal fluids from Axial Seamount Hydrothermal Emissions Study Vent Field, Juan de Fuca Ridge: Subseafloor boiling and subsequent fluid-rock interaction. *Journal of Geophysical Research*, **95**(B8), 12,895-12,921.

Massoth, G.J., D.A. Butterfield, J.E. Lupton, R.E. McDuff, M.D. Lilley, and I.R. Jonasson (1989) Submarine venting of phase-separated hydrothermal fluids at Axial Volcano, Juan de Fuca Ridge. *Nature*, **340**(6236), 702-705.

Massoth, G.J., H.B. Milburn, S.R. Hammond, D.A. Butterfield, R.E. McDuff, and J.E. Lupton (1989) The geochemistry of submarine venting fluids at Axial Volcano, Juan de Fuca Ridge: new sampling methods and a VENTS Program rationale. Global Venting, Midwater and Benthic Ecological Processes, M.P. De Luca and I. Babb (eds.), National Undersea Research Program Report 88-4, 29-59.

Synergistic Activities:

Service on RIDGE 2000 Steering Committee and Endeavour Integrated Studies Oversight committee, 2001-2006. 89th Dahlem Conference organizing committee. Development and use of innovative sampling technology for fluids and particles from hydrothermal environments to promote interdisciplinary research involving microbiology, fluid chemistry, and particle chemistry. Mentoring undergraduates through research projects.

Collaborators:

Graduate Advisor
Russell E. McDuff

Postdoctoral Advisor
Richard Feely

Other recent collaborators:

J. Baross, D. Kelley, H.P. Johnson, M.D. Lilley at University of Washington
M.K. Tivey at Woods Hole
J. Huber at Marine Biological Laboratory, Woods Hole
C. Moyer at Western Washington University
R. Lee at Washington State University
V. Tunnicliffe at University of Victoria
G. Massoth and C. de Ronde, GNS Science, New Zealand

Academic Committee Member for:

Julie Huber (M.S. 2002, Ph.D. 2004)
Jonathan Z. Kaye (Ph.D. 2003)
Susan Q. Lang (M.S. 2003; Ph.D. 2006)
Kristin Ludwig (M.S. 2004)
Mausmi Mehta (M.S. 2004; Ph.D. 2006)
Diane Nielsen (M.S. 2006)
Brian Kristall (M.S. 2004)
Andrew Opatkiewicz (M.S. 2007)
Billy Brazelton (M.S. 2006)

Undergraduate Research Advisor for:

Paige Randall (2002)
Jonathan Forester (2002)
Elena Wagner (2004)
Toby McLeod (2005)
Taylor Dixon (2006)

Presentations at National and International Meetings

(first-author only, chronological order)

- D.A. Butterfield, R.E. McDuff, M.D. Lilley, G.J. Massoth, and J.E. Lupton (1988) Evidence for phase separation of hydrothermal fluids from Axial Volcano, Juan de Fuca Ridge, 1988 Spring AGU meeting. EOS Trans. AGU, 69, 303.
- D.A. Butterfield, R.E. McDuff, M.D. Lilley, G.J. Massoth, and J.E. Lupton (1988) Chemistry of hydrothermal fluids from the ASHES vent field: evidence for phase separation, 1988 Fall AGU meeting. EOS Trans. AGU 69, 1468.
- D.A. Butterfield, R.E. McDuff, M.D. Lilley, and G.J. Massoth (1989) Chemical heterogeneity in vent fluids from the Endeavour Ridge, 1989 Fall AGU meeting, EOS Trans. AGU, 70, 1163.
- D.A. Butterfield, R.E. McDuff, M.D. Lilley, and G.J. Massoth (1990) Geochemistry of hydrothermal fluids from the Endeavour segment, Juan de Fuca Ridge, 1990 Fall AGU meeting. EOS Trans. AGU, 71, 1680.
- D. A. Butterfield and B. K. Nelson (1991) Strontium isotope systematics in hydrothermal fluids from Axial Seamount, 1991 Fall AGU meeting, EOS Trans. AGU, 72, 539.
- D. A. Butterfield, M.D. Lilley, and R.E. McDuff (1992) The Endeavour Main Vent Field revisited: Phase separation and unusual alkali and boron chemistry. 1992 Fall AGU meeting, EOS Trans. AGU, 73, 253.
- D. A. Butterfield and K. K. Roe (1994) Temporal variability in hydrothermal vent fluid composition from Cleft and Coaxial segments, Juan de Fuca Ridge. 1994 Fall AGU meeting, EOS Trans. AGU, 75, 618.
- D. A. Butterfield, K.K. Roe, G.J. Massoth, R.W. Embley, and R.E. McDuff (1995) Spatial and temporal variability in vent fluid composition along the Juan de Fuca Ridge. 1995 Fall AGU meeting. EOS Trans. AGU, 76, F420.
- D. A. Butterfield (1996) Chemistry of hydrothermal fluids from the Southern East Pacific Rise, 14-18°S. January, 1996, RIDGE Workshop on: Processes and Fluxes on a Superfast Spreading Ridge: The Southern East Pacific Rise. Summarized in RIDGE Workshop Report.

- D. A. Butterfield (1996) Seafloor volcanic eruptions and the evolution of hydrothermal fluid chemistry. March, 1996, Royal Society Discussion Meeting on Mid-Ocean Ridges.
- D. A. Butterfield (1997) Chemical evolution after seafloor volcanic events. March, 1997, RIDGE Workshop on Event Detection and Rapid Response to Volcanic Events on the Mid-ocean Ridge. Summarized in workshop final report.
- D. A. Butterfield, K.K. Roe, J. Ishibashi, and J.E. Lupton (1997) Time series chemistry of hydrothermal fluids from the Southern East Pacific Rise, 14-18°S. 1997 Fall AGU meeting. EOS Trans. AGU, 78, F706.
- D.A. Butterfield Hydrothermal response to diking/eruptive events. RIDGE Juan de Fuca Results Symposium, November 1999, Seattle.
- D. A. Butterfield, K K Roe, J. Huber, J. Baross, M. D. Lilley, E A McLaughlin-West, R E Embley, W. Chadwick Geochemical and microbiological studies at Axial Volcano, Juan de Fuca Ridge. AGU Fall Meeting, December 1999.
- D. A. Butterfield, K.K. Roe, J. Huber, J. Baross, R. Feely, J. Gendron, G. Lebon, M. Lilley, Geochemical-Microbial investigations in a submarine hydrothermal system. Ridge Theoretical Institute on the Subsurface Biosphere at Mid-Ocean Ridges, July 2000.
- D.A. Butterfield, Phase Separation and Element Fractionation in Hydrothermal Systems, Geology Colloquium, Free University of Berlin, Nov 2, 2000.
- D.A. Butterfield, K.K. Roe, D. Kadko and M.K. Tivey, Tidal Variability in Diffuse Flow Vents in the Main Endeavour Field, AGU Fall Meeting, December 2001.
- D. A. Butterfield, et al., Mixing, reaction, and microbial activity in sub-seafloor hydrothermal reservoirs: AGU/ASLO Winter Meeting, February 2002.
- D. A. Butterfield et al., Review of hydrothermal chemistry of the Endeavour segment. RIDGE 2000 Integrated Studies Community Education Workshop. Long Beach, February 2002.
- D.A. Butterfield, M.D. Lilley, J.A. Huber, and J.A. Baross, Sub-seafloor processes and the composition of diffuse hydrothermal fluids. EOS Trans. AGU, 83(47), Fall Meet. Suppl., Abstract V11C-01. December 2002.
- D.A. Butterfield, Scientific Use of ROVs, Presentation and panel discussion at Underwater Intervention meeting in New Orleans, February 2003.
- D.A. Butterfield and RIDGE community, Endeavour Segment, Juan de Fuca Ridge, Integrated Studies Site: Update and Opportunities. EOS Trans. AGU, 84(46), Fall Meet. Suppl., 2003.

D.A Butterfield et al., Fluid-Volatile Chemistry in Serpentine-Hosted Hydrothermal Systems, AAAS Annual Meeting, February 13, 2004.

D.A. Butterfield et al., Overview of Vent Fluid Chemistry from the Mariana Volcanic Arc. 2004 AGU Fall Meeting, talk V44A-01.

D.A. Butterfield, A. Opatkiewicz, and K. Roe Time Series Chemical and Microbiological Studies on the Endeavour Segment, Juan de Fuca Ridge. RIDGE 2000 Integrated Studies Site Progress and Planning Meeting, Vancouver, B.C., November 2005.

D.A. Butterfield et al., Up-Close Fluid Sampling at a Deep Submarine Lava Eruption. 2006 AGU Fall Meeting, talk V13C-07.

As of January, 2007.