

## Biographical Sketch

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NICHOLAS W. HAYMAN

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### Education

Doctorate in Philosophy, Geological Sciences, University of Washington, 2003  
Master of Science, Geological Sciences, SUNY Albany, 1997  
Bachelor of Science, Geological Sciences, SUNY Albany, 1995, *Magna Cum Laude*

### Positions Held

Lecturer, Department of Geological Sciences, University of Texas - Austin, 2009-*present*  
Research Associate, Institute for Geophysics, University of Texas - Austin, 2007-*present*  
Research Scientist, Duke University, 2006 - 2007  
Research Associate, Duke University, 2003 - 2006  
Graduate Research & Teaching Assistant, University of Washington, 1997 - 2003  
Graduate Research & Teaching Assistant, SUNY Albany, 1995 - 1997  
Chevron Production Technology Company Intern, 1998  
National Science Foundation Undergraduate Research Fellow, Lamont Doherty Earth Observatory, 1994

### Professional Activities

Ocean crustal faults & fault-rock samples, 2003-*present*: mid-ocean ridge spreading centers & ocean crustal materials including microstructural-mineralogical-geochemical analyses, rock-mechanics experiments, & field mapping of analog areas such as Iceland and the Troodos Ophiolite.

Marine geological & geophysical investigations, 2003-*present*: scientific drilling, human occupied, remotely operated, & autonomous underwater vehicles, & underway geophysical data acquisition:

- RRS James Cook expedition to the Cayman Trough, D. Connelly chief-scientist, March-April, 2010
- IODP Expedition 319, Riser Drilling of the Kumano Basin, Nankai Accretionary Margin, off-shore Japan, McNeil, Byrne, Eiichiro co-chiefs, June-July, 2009
- Shinkai 6500 Investigation of Tenryu Canyon, Nankai Accretionary Prism, off-shore Japan, Kawamura and Anma co-chiefs, April, 2008
- IODP Expedition 312, Superfast-spread East Pacific Rise crust, J. Alt co-chief, November-December, 2005
- NSF/NOAA/JASON Project: The Lost City, Shore-based participant, Ballard and Kelley PIs, August, 2005
- Alvin/Jason II submersible investigation of Pito Deep rift wall, NE-edge of Easter Microplate, Karson chief-scientist, February, 2005
- IODP Expedition 304, Atlantis Massif, Mid-Atlantic Ridge, Blackman co-chief, November-December, 2004

Structural studies of US fault systems, 1995-*present*: field mapping & meso-to-microstructural analyses of northeastern Paleozoic-age Taconic Range, Death Valley & western US basin & range, Washington State central Cascade Range.

Rift evolution studies, 2010-*present*, including structural studies of the Cordillera Darwin via the Sloop Pelagic, Lavier & Dalziel co-chiefs, February-March, 2010.

Studies of granular materials, 2002-*present*: Fundamental and applied studies of granular materials, including ongoing analog-materials experiments with Karen Daniels (NCSU Physics) & investigations of sedimentary mudrocks.

### Publications

**Hayman, N.W.**, Burmeister, K., Kawamura, K., Anma, A., and Yamada, Y., 2011, Oblique deformation in Tenryu Canyon of the Nankai accretionary prism, in *Springer volume Accretionary Prisms and Convergent Margin Tectonics in the Northwest Pacific Basin*, edited by Yujiro Ogawa.

### **Publications** (*continued*)

- Hayman, N. W.**, N. R. Grindlay, M. R. Perfit, P. Mann, S. Leroy, and B. M. de Lépinay (2011), Oceanic core complex development at the ultraslow spreading Mid-Cayman Spreading Center, *Geochem. Geophys. Geosyst.*, 12, Q0AG02, doi:10.1029/2010GC003240.
- Hayman, N.W.**, Ducloué, L., Foco, K.L., and Daniels, K.E.D., 2011, Granular controls on periodicity of stick-slip events: kinematics and force-chains in an experimental fault, *Pure and Applied Geophysics*, DOI 10.1007/s00024-011-0269-3
- Barker, A. K., Coogan, L.A., Gillis, K.M., **Hayman, N.W.**, Weis, D, 2010, Direct observation of a fossil high-temperature, fault-hosted, hydrothermal upflow zone in crust formed at the East Pacific Rise, *Geology*, 38, 379-382.
- Hayman, N. W.**, and J. A. Karson, 2009, Crustal faults exposed in the Pito Deep Rift: Conduits for hydrothermal fluids on the southeast Pacific Rise, *Geochem. Geophys. Geosyst.*, 10, Q02013.
- Cheney, E.S., and **Hayman, N.W.**, 2009, Cenozoic shortening of the central Cascade Range, Washington State, USA, *GSA Bulletin*, v.121, pp.1135-1153.
- Daniels, K.E., and **Hayman, N.W.**, 2008. Force Chains in seismogenic faults visualized with photoelastic granular shear experiments, *Journal of Geophysical Research*, v. 113, B11411.
- Hirose, T., **Hayman, N.W.**, 2008, Structure, permeability, and strength of a fault zone in the footwall of an oceanic core complex, the Central Dome of the Atlantis Massif, Mid-Atlantic Ridge, *Journal of Structural Geology*, 30, pp.1060-1071.
- Hayman, N.W.**, Karson, J.A., 2007, Faults and damage zones in fast-spread crust exposed on the north wall of the Hess Deep Rift: Conduits and seals in axial hydrothermal systems, *Geochem. Geophys. Geosyst.*, 8, Q10002.
- Hayman, N.W.**, 2006, Shallow-crustal fault rocks from the Black Mountains, CA. *Journal of Structural Geology*, 28, 1767-1784.
- Hayman, N.W.**, Housen, B.A., Cladouhos, T.T., Livi, K., 2004, Magnetic and clast fabrics as measurements of grain-scale processes within the Death Valley shallow crustal detachment faults: *Journal of Geophysical Research*, v. 109, B05409.
- Hayman, N.W.**, Knott, J., Cowan, D.S., Nemser, E., Sarna-Wojcicki, A.M., 2003, Quaternary low-angle slip on detachment faults in Death Valley, California: *Geology*, v.31, pp. 343-346.
- Hayman, N.W.**, and Kidd, W.S.F., 2002. Reactivation of prethrust, synconvergence normal faults within the Champlain-Taconic thrust system, west-central Vermont, U.S.A.: *Geological Society of America Bulletin*, v. 114, pp. 476-489.

### **Additional Publications**

- Hayman, N.W.**, et al., 2010, Future scientific drilling of oceanic crust (headline article), *EOS*, Transactions, American Geophysical Union, 91, pp. 133-134.
- Cheney, E.S. & **Hayman, N.W.**, 2010, The Chiwaukum Structural Low: Cenozoic shortening of the central Cascade range, Washington State: USA: Reply, *GSA Bulletin*, 122, 2103-2108.
- Hayman, N.W.**, Anma, R. and Veloso, E. 2009, Data Report: Microstructure of chilled margins in the sheeted dike complex of Integrated Ocean Drilling Program (IODP) Hole 1256D. In Teagle, D., Alt, J., Umino, S., Miyashita, S., Banerjee, N., Wilson, D. and the Expedition 309/312 Scientists, *Proceedings of the IODP, 309/312*: College Station, TX, USA.
- Daniels, K. E. and **Hayman, N. W.** 2009, Boundary conditions and event scaling of granular stick-slip events. Powders and Grains 2009: Proceedings of the 6th International Conference on Micromechanics of Granular Media, p. 567-570.
- Cheney, E.S. and **Hayman, N.W.** 2009, The Chiwaukum Structural Low, eastern Cascade Range, Washington, *GSA Field Guide* 15, pp.19-52.
- Cheney, E.S., and **Hayman, N.W.**, 2007, Regional Tertiary sequence stratigraphy and structure on the eastern flank of the Central Cascade Range, Washington, *GSA Field Guide* 9, pp. 179-208.
- Givens, S., Ludwig, K., **Hayman, N.**, 2005, Troodos ophiolite field program, Ridge 2000, p.27.

### **Additional Publications** (*continued*)

**Hayman, N.W.**, and Kidd, W.S.F., 2002. Champlain Thrust System in the Whitehall Shoreham area: *in* Karabinos, P., and McLelland, J. (eds.) Field guide for the 2002 NEIGC/NYGSA field conference, pp. A1-A27.

Cowan, D.S., Cladouhos, T.T., **Hayman, N.W.**, Morgan, J., Vrolijk, P., 1999, Field and Laboratory studies of fault rocks from detachment faults, western Black Mountains, Death Valley, *in* USGS Open-File Report 99-153.

### **Publications resulting from a Shipboard Party**

Connelley, D.P., and multiple authors, 2012, Hydrothermal vent fields and chemosynthetic biota on the world's deepest seafloor spreading center, *Nature Communications*, 3, doi:10.1038/ncomms1636.

Saffer, D., McNeill, L., Byrne, T., Araki, E., Toczko, S., Eguchi, N., Takahashi, K., and the Expedition 319 Scientists, 2010. *Proc. IODP*, 319: Tokyo (Integrated Ocean Drilling Program Management International, Inc.). doi:10.2204/iodp.proc.319.2010

Lin, W., and multiple authors, 2010, Present-day principal horizontal stress orientations in the Kumano forearc basin of the southwest Japan subduction zone determined from IODP NanTroSEIZE drilling Site C0009 *Geophysical Research Letters*, 37, L13303.

Ildefonse, and multiple authors, 2007, Oceanic core complexes and crustal accretion at slow-spreading ridges. *Geology*, 35, 623-626.

Wilson, D.S., and multiple authors, 2006. Drilling to gabbro in intact oceanic crust. *Science*, 312, 1016-1020.

Expedition 309 and 312 Scientists, 2006. Superfast spreading rate crust 3: a complete in situ section of upper oceanic crust formed at a superfast spreading rate. *IODP Prel. Rept.*, 312.

Karson, J.A., and multiple authors, 2005, Nested-scale Investigation of tectonic windows into super-fast spread crust exposed at the Pito Deep rift, Easter Microplate, SE Pacific, *InterRidge News*, v. 14, 5-8.

Blackman, D.K., Ildefonse, B., John, B.E., MacLeod, C.J., Ohara, Y., Miller, D.J., and the Expedition 304/305 Project Team, 2004. Oceanic core complex formation, Atlantis Massif—oceanic core complex formation, Atlantis Massif, Mid-Atlantic Ridge: drilling into the footwall and hanging wall of a tectonic exposure of deep, young oceanic lithosphere to study deformation, alteration, and melt generation. *IODP Sci. Prosp.*, 304/305.

### **Select Meeting Abstracts**

Browne, C.M., and **Hayman, N.W.**, 2011, Hydrothermal and tectonic processes recorded in fault rocks from the upper oceanic crust, Fall AGU.

**Hayman, N.W.**, Karson, J.A., 2010, Ocean crustal fault rocks and the chemo-mechanical record of hydrothermal fluid flow, Fall AGU.

Browne, C.M., **Hayman, N.W.**, Milliken, K., and Reed, R., 2010, Particle Size Distribution in micro-shear bands from NanTroSeize drilling of the Nankai accretionary prism, Japan, Fall AGU.

Daniels, K.E., **Hayman, N.W.**, Ducloué, L., and Foco, K.L., 2010 Granular controls on the periodicity of stick-slip events: kinematics and force-chains in an experimental fault, Fall AGU.

Substitute for Murton, B.J., 2010, Hydrothermal vents at 5000m on the Mid-Cayman Rise: The deepest and hottest hydrothermal systems yet discovered, Fall AGU.

**Hayman, N.W.**, et al., 2009, Structural geology of cuttings and cores recovered from below the Kumano forearc basin, Nankai accretionary margin of Japan: Expedition 319 of the IODP, AGU Fall Meeting, NH31A-1100

**Hayman, N.W.**, 2009, Flexing the margin: Alternative hypotheses for flank uplift along the Texas Gulf of Mexico margin, GSA South-Central Section, Paper No. 11-1

**Hayman, N.W.**, 2008, Oxide Gabbros from IODP Hole 1309D: Recorders of High-Temperature Strain and Alteration of the Atlantis Massif, An Oceanic Core Complex on the Mid-Atlantic Ridge, Annual meeting of the GSA, Paper no.130-5

**Select Meeting Abstracts** (*continued*)

- Tartarotti, P., **Hayman, N.W.**, and others, 2006, Structure of Hole 1256D, *Eos Trans. AGU* 87(52), Fall Meet. Suppl., Abstract B31B-1091.
- Pollock, MA, Klein, EM, Karson, JA, and **Hayman, N.W.**, 2006, Geochemistry of dikes and lavas in ocean crust, *Eos Trans. AGU* 87(52), Fall Meet. Suppl., Abstract T41B-1571.
- Morgan, L.A., and multiple authors, 2005. Internal structure of basaltic lavas and sheeted dikes in 3 Ma Super-fast EPR crust exposed at Pito Deep: *Eos Trans. AGU* 86(52), Fall Meet. Suppl., Abstract T33D-0588.
- Hirth, G., and multiple authors, 2005. Structural constraints on the evolution of the Atlantis Massif based on results from IODP Expedition 304/305: *Eos Trans. AGU* 86(52), Fall Meet. Suppl., Abstract T41D-1334.
- Bowles, M., Hayman, N.W., Karson, J.A., Kelley, D.S., 2004, Fault-hosted hydrothermal breccia at 22°40'N on the Mid-Atlantic Ridge, *Eos Trans. AGU* 85(47), B13A-0197.
- Hayman, N.W., 2001, Mineral growth associated with, but potentially post-dating a late crenulation cleavage in Taconic slates, Abstracts, Northeast GSA, Abstract 2848.

**Select Invited Lectures**

- Texas A&M, Center for Tectonophysics, February 25<sup>th</sup>, 2009, “Faults of subaxial origin exposed in the Hess and Pito Deep Rift walls: implications for hydrothermal systems and seismicity of axial regions.”
- European Geophysical Union, Hayman, N.W. and Karson, J.A., 2008, “The role of brittle deformation during fast-to-superfast seafloor spreading inferred from tectonic windows into East Pacific Rise-spread crust.”
- Chiba University, Japan, Kanto Asperity Project Workshop, February 16-17, 2008.
- Rice University, November 15, 2007, “Faults of subaxial origin exposed in the Hess and Pito Deep Rift walls: implications for hydrothermal systems and seismicity of axial regions.”
- East Carolina University, November 17, 2006, “Drilling and diving into fault zones in the ocean crust”.
- Iowa State University, November 3, 2006, “Faults and fault-rocks in the desert and the ocean: granular controls on Earth’s fundamental plate boundaries.”
- SUNY Albany/RPI, April 14, 2004, “A record of shallow crustal faulting preserved within rocks from the Death Valley low-angle normal (detachment) faults.”
- University of North Carolina, September 16, 2004, “A record of shallow crustal faulting preserved within rocks from the Death Valley low-angle normal (detachment) faults.”

**Thesis & Dissertation:**

- Hayman, N.W., 1997, Pre-thrust normal faults and post-tectonic micas in the tectonic range of west-central Vermont, M.Sc. thesis for SUNY Albany, Department of Earth and Atmospheric Sciences, 179 pp.
- Hayman, N.W., 2003, Structure and petrology of gouge and breccia bearing shallow crustal shear zones of detachment faults in Death Valley, California, Ph.D. dissertation for University of Washington, 167 pp.

**Professional Affiliations**

Geological Society of America; American Geophysical Union; Mineralogical Society of America

**Synergistic Activities**

- University of Texas, Austin committees: Jackson School of Geosciences Strategic Planning Council; UTIG Science Planning Council; UTIG APEC (Staff Review); UTIG Innovation & Opportunity fund; UTIG library committee
- Ad-Hoc Reviewer for: American Journal of Science, Geology, Geophysical Research Letters, G-Cubed, GSA Bulletin, Journal of Geophysical Research, Journal of Structural Geology, Proceedings of the IODP, Tectonophysics; National Science Foundation OCE, EAR, & Margins; Swiss National Science Foundation.
- Attended Ocean Exploration planning workshop, University of Rhode Island, May 9-10, 2011

### **Synergistic Activities** (*continued*)

Attended Polar Research Vessel planning workshop, National Science Foundation, Feb 28-March 1, 2011  
Attended GeoPRISMS Subduction cycles and deformation initiative meeting, Texas, Jan 5-7, 2011  
Co-chair of Fall AGU session: OS14A. Integrated Studies at Oceanic Spreading Centers: Linking Spreading Center Processes Across Disciplinary Boundaries II  
Attended GeoPRISMS Rift Initiation and Evolution workshop, Santa Fe, NM, November 4-5, 2010.  
Attended Gordon Conference on Rock Deformation, Tilden, New Hampshire, August 8-13, 2010.  
Attended Margins renewal workshop, San Antonio, TX, February 15-17, 2010.  
Attended INVEST, a planning workshop for IODP renewal, September 23-25, 2009, Bremen, Germany.  
Co-Convener of Ocean Leadership workshop: Scientific Drilling of Mid-Ocean Ridge and Ridge Flank settings, August 27-28, 2009, UTIG.  
ICDP workshop for “Testing the Extensional Detachment Paradigm: A borehole observatory in the Sevier Desert basin, western United States”, Solitude, Utah, July, 2008  
Proponent and attendee for the Kanto Asperity Project, Chiba City, Japan, February 2008  
Special Session on Faulting in the Oceanic Crust at the 2007 Fall meeting of the AGU, with Delwayne Bonenstiehl.  
Ridge 2000 Field Program as summarized in Givens et al. (2005).  
IODP “Mission Moho” Planning committee, Portland, OR, September, 2006.  
East-coast Earthscope NSF Planning committee, Arlington, VA, March, 2004.  
Unaffiliated field conference in Death Valley, CA, with rock mechanics groups from Rice and Penn State Universities.  
Special session on Transpression and Transtension, 2002 annual meeting of the Geological Society of America, co-sponsored by Mike Edwards and John Dewey.

### **Teaching**

Marine Tectonics (co-lecturer), Spring, 2011-present.  
Topics in Marine Geology and Geophysics (readings, co-convener), 2009-present.  
EOS 11: The Dynamic Earth (Survey class), Duke University, Summer 1, 2006.  
Teaching assistant from 1995-2003 including course development, lecture, & laboratory: Structural Geology, Mineralogy, Geodynamics, Field Mapping, Geobiology.  
*Supervised students:* Lucie Ducloué (visiting ENS student, 2010); Cassandra Browne (expected Ph.D. 2015); Sebastian Ramirez (w/ Sean Gulick, expected Ph.D. 2016); Anna Eliza Svartmann Dias (w/ Luc Lavier, expected Ph.D. 2016).  
*M.Sc. committee member:* Lindsay Morgan (Duke University)  
*Informal co-advising:* Eliza Nemser (M.Sc.), Eric Rheinert (M.Sc.), Gabriel Cisneros (M.Sc.), Jennifer Locke (B.Sc.), Marshall Bowles (M.E.M.), Meagen Pollock (Ph.D.).

### **Grants and Awards**

#### *Current Grants and Awards:*

Petrobras, Geological and Geophysical Investigations of Rift Processes, September 1, 2011-August 31, 2015 (Luc Lavier lead PI)  
National Science Foundation, Ocean Sciences Division, OCE-1130078, Expedition Oriented Research: Sedimentation and Tectonics in Kumano forearc basin evolution, NantroSEIZE study area, September 1, 2011-August 31, 2013, Hayman lead-PI, Sean Gulick & Kitty Milliken co-PIs.  
National Science Foundation, Ocean Sciences Division, OCE-0961775, Constraints on the Mechanics of Ocean Crustal Faults, September 1, 2010-August 31, 2013, Hayman single PI  
Ocean Leadership-IODP, Hayman, P.I., participation in Expedition 319, including post-cruise award.  
Non-PI level collaboration with Bureau of Economic Geology: Shell-UT Unconventional Research (SUTUR) support (Milliken lead PI); Mudrock Systems Research Laboratory (Ruppel lead PI).

*Pending (in review) Grants & Awards:*

NSF-OPP, Collaborative Research: A high-res study of volcanic, tectonic, and hydrothermal processes in the Bransfield Rift, Antarctica, a world-class example of a young, propagating rift, Hayman lead-PI, w/ Lavier, Dalziel, German, Harris, & Ellins co-PIs.

*Past support, grants, and awards:*

Support from the Caribbean Basins, Tectonics, and Hydrocarbons (CBTH) Project (2010)

Support from UTIG, Innovation & Opportunity Awards (2010, 2011)

Ocean Leadership-IODP, Hayman, co-P.I., support for Workshop on Mid-Ocean Ridge drilling.

USSSP-IODP, Hayman P.I., Post-expedition support for IODP Exp.312.

USSSP-IODP (authored by Hayman via Karson), Salary Support for Expeditions 304 & 312.

USSSP-IODP (authored by Hayman via Karson, PI), Post-expedition support for IODP Expedition 304.

NSF-OCE 0222154: Nested-Scale Investigation of Pito Deep (multi-institution; to Karson & Klein, Duke University): 2/14/04-1/31/08 (extended).

Petroleum Research Fund: Outcrop Analogue for fault seal, (authored by Hayman to Darrel S. Cowan, University of Washington), 2000-2003.

NSF-EAR 94177590: Fault rock research (to Darrel Cowan, University of Washington).

Mineralogical Society of America, Kraus Crystallography Award: Mesophases and minerals: A comparison of electron, X-Ray, and modeled diffraction patterns from low crystallinity clay minerals, 2003.

University of Washington: Chevron Research Fellowship, 1998; Peter Misch Award, 2000; Joe Vance Award 2002 (each with graduate student support).

Geological Society of America graduate student research grant, 1998.

**Advisors:**

Postdoctoral Advisor (Duke University): Jeffrey Karson

Ph.D. Committee (University of Washington): Darrel Cowan (advisor), Mark Ghiorso, Sean Willett, Trenton Cladouhos.

M.Sc. Committee (SUNY Albany): Win Means (advisor), W.S.F. (Bill) Kidd, Win Means, Greg Harper.

Chevron Supervisor: Doug Goff

Lamont-Doherty advisor: Jeff Gee

**Professional Affiliations** (last 48 months, not including UTIG): Ryo Anma (Tsukuba, JP), Abigail Barker (Uppsala, Swe), Kurtis Burmeister (College of the Pacific), Eric Cheney (University of Washington), Laurence Coogan (University of Victoria, CA), Karen Daniels (North Carolina State University), Kathy Gillis (University of Victoria, CA), Nancy Grindlay (University of North Carolina, Wilmington), Takehiro Hirose (Kyoto, JP), Kiichiro Kawamura (JP), Sylvie Leroy (Fr), Paul Mann (University of Houston), Bernard Mercier de Lepinay (Fr), Bramley Murton (Southampton, UK), Mike Perfit (UFla), Andres Veloso (Chile).