Curriculum Vitae of Steve Pride

ADDRESS:
Energy Geosciences Division, Lawrence Berkeley National Lab, 1 Cyclotron Road, MS74R316C, Berkeley, CA 94720. Tel: (510) 495-2823, Fax: (510) 486-5686, Email: srpride@lbl.gov

ACADEMIC/PROFESSIONAL PREPARATION:
- *University of California at Berkeley*, Geophysics, B.A. 1985.
- *Texas A&M University*, Geophysics, Ph.D. 1991.
- *Massachussetts Institute of Technology*, Geophysics, post-doc 1991-1993.

ACADEMIC/PROFESSIONAL APPOINTMENTS:
- 2004 – Present: Adjunct professor of Geophysics, Department of Earth and Planetary Sciences, *University of California at Berkeley*, Berkeley, CA.
- 2003 – Present: Staff scientist, *Lawrence Berkeley National Laboratory*, Berkeley, CA.
- 2003 – 2005: Research professor of Geophysics, *Stanford University*, Stanford, CA.
- 2000 – 2001: Visiting professor of Geophysics, *Stanford University*, Stanford, CA.
- 1997 – 2003: Full professor of Geophysics, *University of Rennes*, Rennes, France.
- 1993 – 1997: Associate professor of Geophysics (Maitre de Conference), *Institut de Physique du Globe de Paris*, Paris, France.

OTHER POSITIONS :
- 2004 – Present: Owner and CEO of *Pride Mountain Vineyards*, a 48-employee winery in St. Helena, CA that I actively run and manage. I work 60% time at LBNL due to this.

DISTINCTIONS:
- 2006: U.S. Patent 7150188, "Non-invasive measurement of fluid-pressure diffusivity using electro-osmosis."
- 2003 – 2005: Associate Editor of *Geophysics*.
- 1997 – 2005: Advisory Editor of *Physics of the Earth and Planetary Interiors*.
- 2001, 2006: Consultant for *Exxon Mobil*.
- 1996: "Editors Citation for Excellence in Refereeing," *American Geophysical Union*.

TEACHING:
I teach the UC Berkeley class EPS 104 entitled "Mathematical Methods of Geophysics" every other year. The last time I taught it was Spring 2015 (19 students) and I will teach it again in the Spring 2017.

CURRENT RESEARCH ACTIVITY:
I am the lead PI of a 9-scientist-team research effort entitled "Geophysical Monitoring of Subsurface Fluid-Injection" funded at $1.7 million/year from DOE Basic Energy Sciences. Topics include forward modeling of all changes to the Earth caused by fluid injection and, in particular, how physical properties of the Earth change due to fluid injection (via fluid substitution, stress-induced changes and new fracturing) as well as the inverse problem of obtaining hydrogeological fields from time-lapse geophysical surveys collected during fluid injection. I am also directing the research of a UC Berkeley (EPS) graduate student, Stephen Breen, working on the fundamental laws that control two-phase immiscible-fluid flow in porous media and have leading an effort into understanding the laws of hydrodynamic dispersion in porous materials.

PUBLICATIONS:

[52] S. R. Pride, D. W. Vasco, E.G. Flekkoy and R. Holtzman (2016) Dispersive transport and symmetry of the dispersion tensor in porous media. *Phys. Rev. E* (submitted)

[51] E. G. Flekkoy, S. R. Pride and R. Toussaint (2016). Onsager symmetry from mesoscopic time-reversibility and the hydrodynamic dispersion tensor for coarse-grained systems. *Phys. Rev. E* (submitted).

[50] D.W.Vasco, P. Harness, S. R. Pride and M. Hoversten (2016) Estimating fluid-induced stress change from observed deformation. *Geophys. J. Int.* (accepted)

[49] S.R. Pride, J.G. Berryman, M. Commer, S. Nakagawa, G.A. Newman and D.W. Vasco (2016) Changes in geophysical properties caused by fluid injection into porous rocks: Analytical models. *Geophys. Prosp.*, doi:10.1111/1365-2478.12435 (1-25).

[48] D.W. Vasco, S.R. Pride and M. Commer (2016) Trajectory-based modeling of fluid transport in a medium with smoothly-varying heterogeneity. *Water Resources Research*, accepted.

[47] Y.J. Masson and S.R. Pride (2015) Mapping the mechanical properties of rocks using automated indentation tests. *J. Geophys. Res. Solid Earth*, **120**, doi:10.1002/2015JB012248.

[46] O. Aursjo and S.R. Pride (2015) Lattice-Boltzmann method for diffusion-limited partial dissolution of fluids. *Phys. Rev. E*, **92**, 013306.

[45] Y.J. Masson and S.R. Pride (2014) On the correlation between material structure and seismic attenuation anisotropy in porous media. *J. Geophys. Res.,* **119,** 2848-2870.

[44] Y.J. Masson and S.R. Pride (2014) A fast algorithm for invasion percolation. *Transport in Porous Media*, **102**, 301-312.

[43] Y. J. Masson and S.R. Pride (2011) Seismic attenuation due to patchy saturation. *J. Geophys. Res.,* **116,** B03206.

[42] Y. J. Masson and S.R. Pride (2010) Finite-difference modeling of Biot's poroelastic equations across all frequencies. *Geophysics*, **75**, N33-N41.

[41] Chen, J., Hubbard, S.S., Williams, K.H., Pride, S.R., Li, L. Steefel, C. and L. Slater (2009) A state-space Baysian framework for estimating biogeochemical transformations using time-lapse geophysical data. *Water Resources Research*, **45**, W08420.

[40] Pride, S.R. and J.G. Berryman (2009) Goddard rattler-jamming mechanism for quantifying pressure dependence of elastic moduli of grain packs. *Acta Mechanica*, **205**, 185-196.

[39] Pride, S.R., Flekkoy, E.G. and O. Aursjo (2009) Mechanisms of seismic EOR. *World Oil*, **230**, 49-52.

[38] Pride, S.R., Flekkoy, E.G. and O. Aursjo (2008) Seismic stimulation for enhanced oil recovery. *Geophysic,* **73,** P8-P21.

[37] Masson, Y.J. and S.R. Pride (2007) Poroelastic finite-difference modeling of seismic attenuation and dispersion due to mesoscopic-scale heterogeneity. *J. Geophys. Res.*, **112,** B03204.

[36] Haines, S.S., Pride, S.R., and S.L. Klemperer (2007) Seismoelectric imaging of shallow targets. *Geophysics,* **72**, G9 – G20.

[35] Haines, S.S. and S.R. Pride (2006) Seismoelectric numerical modeling on a grid. *Geophysics,* **71**, N57 – N65.

[34] Pride, S.R. and Y.J. Masson (2006) Acoustic attenuation in self-affine porous structures. *Physical Review Letters*, 97, 184301.

[33] Masson, Y.J., Pride, S.R., and K.T. Nihei (2006) Finite difference modeling of Biot's poroelastic equations at seismic frequencies. *Journal of Geophysical Research*, **111**, B10305.

[32] Pride, S.R. and S. Garambois (2005) The seismoelectric wave theory of Frenkel. *Journal of Engineering Mechanics*, **131**, 898-907.

[31] Berryman, J.G. and S.R. Pride (2005) Dispersion of waves in porous cylinders with patchy saturation. Part I. Formulation and torsional waves. *Journal of the Acoustical Society of America*, **117**, 1785 – 1795.

[30] Toussaint, R. and S.R. Pride (2005) Interacting damage models mapped onto Ising and percolation models. *Physical Review E*, **71**, 046127.

[29] Pride, S.R. (2005) Relationships between seismic and hydrological properties. Chapter 9 of *Hydrogeophysics*, edited by Y. Rubin and S. Hubbard, Kluwer Academic Publishers.

[28] Pride, S.R., Moreau, F. and P. Gavrilenko (2004) Mechanical and electrical response due to fluid-pressure equilibration following an earthquake. *Journal of Geophysical Research*, **109**, B03302.

[27] Pride, S.R., Berryman, J.G. and J.M. Harris (2004) Seismic attenuation due to wave-induced flow. *Journal of Geophysical Research*, **109**, B01201.

[26] Pride, S,R. and J.G. Berryman (2003) Linear dynamics of double-porosity dual-permeability materials I. Governing equations and acoustic attenuation. *Physical Review E*, **68**, 036603.

[25] Pride, S,R. and J.G. Berryman (2003) Linear dynamics of double-porosity dual-permeability materials II. Fluid transport equations. *Physical Review E*, **68**, 036604.

[24] Pride, S.R. et al. (2003) Permeability dependence of seismic amplitudes, *The Leading Edge*, **22**, 518-525.

[23] Toussaint, R. and S.R. Pride (2002) Fracture of disordered solids in compression as critical phenomenon: I. Statistical mechanics formalism. *Physical Review E*, **66**, 036136.

[22] Toussaint, R. and S.R. Pride (2002) Fracture of disordered solids in compression as a critical phenomenon: II. Model Hamiltonian for a population of interacting cracks. *Physical Review E*, **66**, 036137.

[21] Toussaint, R. and S.R. Pride (2002) Fracture of disordered solids in compression as a critical phenomenon: III. Analysis of the localization transition. *Physical Review E*, **66**, 036138.

[20] Berryman, J.G., Pride, S.R. and H. F. Wang (2002) A differential scheme for elastic properties of rocks with dry or saturated cracks. Geophysical Journal International, **150**, 1-15.

[19] Pride, S.R. and R. Toussaint (2002) Thermodynamics of fiber bundles. *Physica A*, **312**, 159-171.

[18] Pride, S.R. and S. Garambois (2002) The role of Biot slow waves in electroseismic wave phenomena. *Journal of the Acoustical Society of America*, **111**, 697-706.

[17] Berryman, J.G. and S.R. Pride (2002) Models for computing geomechanical constants of double-porosity materials from the constituent's properties. *Journal of Geophysical Research*, **107**, 10.1029/2000JB000108.

[16] Pride, S.R. and J.G. Berryman (2002) Attenuation of P waves by wave-induced flow, In *Poromechanics II*, Jean-Louis Auriault (ed.), 775-782, Balkema, Rotterdam.

[15] Berryman, J.G. and S.R. Pride (2002) Dispersion of extensional and torsional waves in porous cylinders with patchy saturation, In *Poromechanics II*, Jean-Louis Auriault (ed.), 613-618, Balkema, Rotterdam.

[14] Pride, S.R., Tromeur, E. and J.G. Berryman (2001) Biot slow-wave effects in stratified rock. *Geophysics*, **67**, 271-281.

[13] Pride, S.R. and E.G. Flekkoy (1999) Two-phase flow through porous media in the fixed-contact-line regime. *Physical Review E*, **60**, 4285-4299.

[12] Flekkoy, E.G. and S.R. Pride (1999) Reciprocity and cross-coupling of two-phase flow in porous media from Onsager theory. *Physical Review E*, **60**, 4130-4137.

[11] Pride, S.R. and J.G. Berryman (1998) Connecting theory to experiment in poroelasticity. Journal of the Mechanics and Physics of Solids, 46, 719-747.

[10] Berryman, J.G. and S.R. Pride (1998) Volume-averaging, effective stress rules and inversion for microstructural response of multicomponent porous media. *International Journal of Solids and Structures*, **35**, 4811-4843.

[9] Pride, S.R. (1998) The theory of electroseismic wave phenomena. In *Poromechanics*, Thimus et al. (eds.) 295-300, Balkema, Rotterdam.

[8] Haartsen, M.W. and S.R. Pride (1997) Electroseismic waves from point sources in layered media. *Journal of Geophysical Research*, **102,** 24745-24769.

[7] Pride, S.R. and M.W. Haartsen (1996) Electroseismic wave properties. *Journal of the Acoustical Society of America*, **100**, 1301-1315.

[6] Elieutin, A., P. Morat, S.R. Pride, and J. LeMouel (1996) Processing spatially distributed electrical signals on stressed and deteriorating rock samples. *Cahiers du Centre Europeen de Geodynamique et de Sismologie*, **12,** 131-140.

[5] Morat, P., J. LeMouel, S.R. Pride and C. Jaupart (1995) Remarkable oscillations of temperature, humidity, and electric potential observed in an underground quarry. *Comptes Rendus de l' Academie des Sciences, Paris*, **320,**173-180.

 [4] Pride, S.R. (1994) Governing equations for the coupled electromagnetics and acoustics of porous media. *Physical Review B*, **50**, 15678-15696 [**636 citations as of November 2016**].

[3] Pride, S.R., F.D. Morgan and A.F. Gangi (1993) Modeling the drag forces of porous media acoustics. *Physical Review B*, **47**, 4964-4978.

[2] Pride, S.R., A.F. Gangi, and F.D. Morgan (1992) Deriving the equations of motion for porous isotropic media. *Journal of the Acoustical Society of America*, **92**, 3278-3290.

[1] Pride, S.R. and F.D. Morgan (1991) Electrokinetic dissipation induced by seismic waves. *Geophysics,* **56**, 914-925.

FIVE MOST CITED PUBLICATIONS (as of November 2016):

636 citations: Pride, S.R. (1994) Governing equations for the coupled electromagnetics and acoustics of porous media. *Physical Review B*, **50**, 15678-15696

491 citations: Pride, S.R., Berryman, J.G. and J.M. Harris (2004) Seismic attenuation due to wave-induced flow. *Journal of Geophysical Research*, **109**, B01201

274 citations: Pride, S.R. and M.W. Haartsen (1996) Electroseismic wave properties. *Journal of the Acoustical Society of America*, **100**, 1301-1315

241 citations: Haartsen, M.W. and S.R. Pride (1997) Electroseismic waves from point sources in layered media. *Journal of Geophysical Research*, **102,** 24745-24769

217 citations: Pride, S,R. and J.G. Berryman (2003) Linear dynamics of double-porosity dual-permeability materials I. Governing equations and acoustic attenuation. *Physical Review E*, **68**, 036603

INVITED PRESENTATIONS:

2015: *Flowtrans International Conference.* Lecture title: "Geophysical monitoring of fluid injection," November 16-18. Strasbourg, France.

2014: *SAPEM 2014 Royal Institute of Technology KTH*. Lecture title: "Acoustic properties of heterogeneous porous materials," December 16-19, Stockholm, Sweden.

2010: *UC Santa Cruz, Department of Earth and Marine Sciences, weekly seminar.* Lecture title: "Seismically-induced flow in porous media." May 28, Santa Cruz, CA.

2010: IV *European Conference on Computational Mechanics (ECCM)*. Lecture title: "Seismic dispersion and attenuation in porous media." May 16-21, Paris, France.

2007: *AGU Fall Meeting*. Lecture title: "Electrokinetic coupling between seismic and electric fields in applied geophysics." December 10, San Francisco, CA.

2007: *DOE BES Computational Geosciences Symposium*. Lecture title: "Modeling seismic properties of rocks and sediments." May 2-4, Washington DC.

2006: *ExxonMobil Rock-Physics Workshop*. Lecture title: "Seismic attenuation and its relation to heterogeneity." March 23-24, Houston, TX.

2006: *Schlumberger-MIT Rock-Physics Workshop*. Lecture title: "Seismic attenuation and its relation to heterogeneity." January 29-30, Cambridge, MA.

2005: *Rainbow in the Earth Workshop*. Lecture title: "The intimate relation between seismic attenuation and heterogeneity." August 17-18, Berkeley, CA.

2005: *Society of Exploration Geophysics, Development & Production Forum*. Lecture title: "Understanding and interpreting seismic attenuation." May 12-17, Austin, Texas.

2004: *Society of Exploration Geophysics, Convention Workshop*. Lecture title: "Electrokinetic coupling in exploration geophysics." October 14, Denver, Colorado.

2003: *International Union of Theoretical and Applied Mechanics (IUTAM): Symposium on porous media.* Lecture title: "Electroseismic exploration." May 18-23, Kerkrade, The Netherlands.

2003: *Shell International Exploration & Production: Geophysical colloquium.* Lecture title: "Can permeability be determined from seismic data?" May 2, Rijswijk, The Netherlands.

2002: AGU *Fall Meeting: special session on damage rheology and earthquakes*. Lecture title: "Statistical theory of shear localization in brittle rocks." December 6, San Francisco.

2002: *Universite Joseph Fourier, Laboratoire de Geophysique Interne et Tectonophysique: Weekly Seminar Series.* Lecture title (translated from the french): "The thermodynamics of brittle fracture." June 6, Grenoble, France.

2001: *Department of Energy: Workshop on Determining Permeability from Seismic Attenuation.* Lecture title: "Attenuation by wave-induced flow." December 7, Claremont Hotel, Berkeley, California.

2001: *Harvard University: Solid Earth Physics Seminar Series*. Lecture title: "Brittle fracture of rocks in compression: treating fracture localization as a critical-point phenomena." May 15, Cambridge, Massachusetts.

2001: *ExxonMobil Research and Engineering Company: Engineering Physics CTC Colloquium.* Lecture title: "Electrokinetic transport laws." May 11, Clinton, New Jersey.

2001: *Stanford University, Geophysics Department: weekly seminar series*. Lecture title: "Brittle fracture of rocks in compression: treating fracture localization as a critical-point phenomena." March 8, Stanford, California.

2001: *Texas A&M University, Geology and Geophysics Department: weekly seminar series*. Lecture title: "The universality of brittle fracture." February 9, College Station, Texas.

2001: *University of Southern California, Department of Geophysics: weekly seminar series*. Lecture title: "The universality of brittle fracture." January 15, Los Angeles, California.

2001: *Colorado School of Mines, Department of Geophysics: Heiland Lecture Series.* Lecture title: "Electroseismic wave phenomena." January 5, Golden, Colorado.

2000: *Istituto Nazionale di Oceanografica e di Geofisica Sperimentale (OGS): weekly seminar series.* Lecture title: "Electroseismic wave phenomena." June 22, Trieste, Italy.

2000: *Seismic Signatures of Fluid Transport*, a workshop sponsored by the SEG (Society of Exploration Geophysics), EAEG (European Association for Exploration Geophysics), and WIT (the German Wave Inversion Technology Consortium). Lecture title: "Is the Biot slow wave ever important in exploration seismology?" February 27-29, Berlin, Germany.

1999: *Massachusetts Institute of Technology, Department of Earth and Planetary Sciences: weekly seminar series.* Lecture title: "Crustal transport laws." November 23, Cambridge, Massachusetts.

1999: *Gordon Research Conference on Rock Deformation: Grain Boundaries, Interphase Boundaries and Surfaces.* Lecture title: "The structure of the water/silicate interface and its effect on rock transport properties." August 8-13, New London, New Hampshire.

1999: *Transport Through Fractures and Fracture Networks*, a workshop sponsored by the French CNRS. Lecture title: "Electromagnetic effects around large fault systems." June 16-18, Carry-le-Rouet, France.

1999: The *Role of Fluids and Fluid Pressure During Tectonic Deformation*, a workshop sponsored by Geosciences Rennes, France. Lecture title: "Deformation of the crust over geologic time scales: poroelasticity vs. poroplasticity." May 6, Rennes, France.

1998: *The Annual Meeting on Petroleum Physics*, sponsored by the Norwegian Physical Society. Lecture title: "The electrokinetics of porous media." August 20-24, Fevik, Norway.

1998: *Institut de Physique du Globe de Paris: Main Seminar Series.* Lecture title (translated from the french): "Elasticity theory in a crust with heterogeneity at all scales." January 19, Paris, France.

1996: *University of Oslo, Department of Physics: Weekly Seminar Series.* Lecture title: "Surface conductivity in rocks." May 28, Oslo, Norway.

1996: *Universite Louis Pasteur, Ecole et Observatoire de Physique du Globe (IPG Strasbourg): Weekly Seminar Series.* Lecture title (translated from the french): "The electroseismic effect." February 8, Strasbourg, France.

1996: *Institut de Physique du Globe de Paris: Main Seminar Series*. Lecture title (translated from the french): "The theory of surface conduction in rocks." April 14, Paris, France.

1995: *Materials Research Society (MRS) 1995 Fall Meeting*. Lecture title: "Influence of the grain/liquid interface on porous-continuum physics." November 27--December 1, Boston, Massachusetts.

1995: *Fall Meeting of SAID* (Societe d'Analyse et Interpretation Diagraphie). Lecture title: "Electroseismic wave phenomena." October 4, La Defense, France.

1994: *Universite Joseph Fourier, Laboratoire de Geophysique Interne et Tectonophysique: Weekly Seminar Series*. Lecture title (translated from the french):   "Electroseismic wave phenomena." January 12, Grenoble, France.

1993: *Institut de Physique du Globe de Paris: Main Seminar Series*. Lecture title : "Coupling between seismic waves and electromagnetic fields." November 25, Paris, France.

1991: *Invited Seminar at Schlumberger-Doll Research.* Lecture title: "Acoustics of porous media." October 18, Ridgefield, Connecticut.

1989: *Invited Seminar at ARCO Research*. Lecture title: "Seismic inversion in porous media." January 11, Plano, Texas.

TEACHING AT UC BERKELEY:

Earth & Planetary Sciences 104: "Mathematical Methods of Geophysics," Spring, 2007 and 2009.

1. The Laws of Geophysics (12 lectures)
   vectors and tensors; the notion of a continuum; the three conservation laws in a continuum; thermodynamics (and statistical mechanics) as the source of constitutive laws; heterogeneity and anisotropy; intuitive understanding of vector differential operators; some vector differential identities; Maxwell's equations; the book of nature written on one page; dimensional analsysis; reduction to waves, diffusions, and potentials.

2. Homogeneous Partial Differential Equations (6 lectures)
   separation of variables in cartesion coordinates (trigonometric functions), cylindrical coordinates (Bessel functions), and spherical coordinates (spherical harmonics); Fourier analysis; plane-wave response.

3. Inhomogeneous Partial Differential Equations} (7 lectures)
   the Dirac delta function and its properties (1D to 3D); the point-source response (Green's function) for waves, diffusions, and potentials (1D to 3D); Cauchy's theorem applied to integral transforms.

SUPERVISED RESEARCH:
(D.E.A. is a one year french master's degree involving a 5 month research project)

Breen, Steve, Doctoral candidate in Geophysics at the University of California, Berkeley, diploma to be obtained Spring 2018: "Experiments and modeling of immiscible invasion." Research advisor.

Yder Masson, PhD in Geophysics obtained Fall 2010 at *University of California, Berkeley*: "Computing the seismic attenuation in complex porous materials." Research advisor.

Olav Aursjo, Doctoral diploma in Physics obtained Fall 2008 at *University of Oslo*: "Seismic stimulation to mobilize trapped non-aqueous-phase liquids." Partial research advisor.

Seth Haines, PhD diploma obtained December, 2004 at *Stanford University*: "Electroseismic data collection and processing techniques." Partial research advisor.

Yder Masson, D.E.A. diploma obtained June 2003 at *University of Rennes*: "Scattering from heterogeneous oil-water fluid distributions in porous media."

Thomas Bardaine, D.E.A. diploma obtained June 2002 at *University of Rennes*: "Earthquake periodicity and the possible correlation with magnetic storms."

Renaud Toussaint, Doctoral diploma in Geophysics obtained March 2001 at *University of Rennes*: "Brittle failure of rocks in compression treated as a critical-point phenomena."

Erwan Thibault, D.E.A. diploma obtained June 2000 at *Institut de Physique du Globe de Paris*: "The possible correlation between magnetic storms and seismicity."

Lawrence Armstrong, D.E.A. diploma obtained June 1996 at *Institut de Physique du Globe de Paris*: "2D finite-difference modeling of coupled two-phase flow and electric potentials."

Renaud Toussaint, D.E.A. diploma obtained June 1995 at *Institut de Physique du Globe de Paris*: "Numerical modeling of the zeta potential and surface electrical conduction in porous rocks."