

David Bercovici — *Curriculum Vitae*

Contact information

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Education

1989 Ph.D. Geophysics and Space Physics, University of California, Los Angeles
1987 M.S. in Geophysics and Space Physics University of California, Los Angeles
1982 B.S. in Physics (Minor in History), Harvey Mudd College Claremont, California

Professional Appointments:

2011-present Frederick William Beinecke Professor of Geophysics
2006-2012 Chair, Dept. Geology and Geophysics, Yale University
2009-present Deputy Director, Yale Climate and Energy Institute, Yale University
2004-present Professor of Mechanical Engineering, Yale University
2002-2006 Director of Graduate Studies, Dept. Geology & Geophysics, Yale University
2001-present Professor, Yale University
1998-2001 Professor, University of Hawaii
1999-2000 Chair, Department of Geology and Geophysics, University of Hawaii
1998 Visiting Researcher (Directeur de Recherche Associé), Centre National de la Recherche Scientifique (CNRS), Ecole Normal Supérieure de Lyon, France
1995-1998 Associate Professor, University of Hawaii
1997-1998 Associate Chair and Graduate Chair, Department of Geology and Geophysics, University of Hawaii
1994-1997 Head, Division of Marine Geology and Geophysics, Department of Geology and Geophysics, University of Hawaii Honolulu,
1990-1995 Assistant Professor, University of Hawaii
1989-1990 Postdoctoral Fellow, Woods Hole Oceanographic Institution, Woods Hole, MA.
1985-1989 Research Assistant, University of California, Los Angeles

Fellowships, Awards & Honors

1996 James B. Macelwane Medal, American Geophysical Union
1996 Fellow, American Geophysical Union
1994-1999 NSF (Presidential) Young Investigator, National Science Foundation
1996 Board of Regents Medal for Excellence in Research, University of Hawaii
1999 ARCS (Achievement Rewards for College Scientists, Honolulu Chapter), Scientist of the Year Award
April 2008 Zatman Memorial Lecturer, Washington University in St. Louis

April 2004 Caswell-Silver Distinguished Lecturer, University of New Mexico
1989-1990 W. M. Keck Marine Geodynamics Postdoctoral Fellow, Woods Hole Oceanographic Institution

Professional Activities

Fellow, American Geophysical Union
2005-2006 NSF EarthScope Science and Education Committee
2004-present Senior Editor, *Treatise on Geophysics*, Elsevier
1998-2000 Associate Editor, *Journal of Geophysical Research*
1999-2001 NSF EAR Geophysics Program Panel Member
1992-1993 NASA Venus Data Analysis Program (VDAP) Panel Member
1993 NSF Grand Challenge Applications Group and High Performance Computing and Communications Program (GCAG/HPCC) Panel Member

Yale Activities

2011-present Co-Deputy Director Executive Committee Chair, Yale Climate & Energy Institute
2010-present Yale West Campus Science, Medicine, and Engineering Advisory Council
2010 Chair, Steering Committee, Yale Climate & Energy Institute
2009 Deputy Director and Executive Committee Chair, Yale Climate & Energy Institute
2008-2009 Chair, Science Chairs Council
2007,2008 Seminar Coordinator, Yale New Haven Teachers Institute
2002 Chair subcommittee on Energy and Water Management for the Yale Advisory Committee on Environmental Management

Advisors

Graduate advisor: Professor Gerald Schubert, University of California, Los Angeles.
Postdoctoral sponsors: Drs. John A. Whitehead & Henry J. B. Dick, Woods Hole Oceanographic Institution.

Postdoctoral Scholars Supervised

1994-1997 Stuart Weinstein, University of Hawaii (now Senior Geophysicist and Assistant Director at Pacific Tsunami Warning Center)
1998-2000 Garrett Ito, University of Hawaii (presently Professor at University of Hawaii)
2004-2006 Henri Samuel, Yale University (now Assistant Professor at Bayerisches Geoinstitut, Universität Bayreuth)
2004-2006 Saswata Hier-Majumder, Yale University (now Assistant Professor at University of Maryland)
2004-2006 Guillaume Richard, Yale University (now Researcher at ENS-Lyon)
2007-2008 Bryony Youngs, Yale University (now Geophysicist at Schlumberger)
2006-2008 Chloé Michaut, Yale University (now Assistant Professor at Institut du Physique de Globe, Paris)
2008 John Rudge, Yale University (now Lecturer, Cambridge University)
2010-2012 Peter Driscoll, Yale University

Graduate Students Advised

1991-1994	William Bruce Paulk, University of Hawaii, MSc
1993-1999	Christoph Heironymus, University of Hawaii and Danish Lithosphere Center, PhD; presently faculty member at Uppsala University, Sweden
1997-1999	Susannah Mistr, University of Hawaii, MSc; presently a medical doctor (in ophthalmology)
1999-2000	Christian Auth, University of Goettingen, PhD.
2002-2007	Garrett Leahy, Yale University, PhD; presently a Postdoctoral Fellow at WHOI
2002-2008	William Landuyt, Yale University, PhD; soon to be Green Scholar at Scripps Inst. Oceanography.
2004-2008	Ondrej Sramek, Yale University, PhD; presently Postdoctoral Researcher at Univ. Colorado, Boulder.
2007	Marine Denolle, Intern from ENS-Paris; presently Graduate Student at Stanford Univ.
2008-	Karen Paczkowski, Yale University PhD
2008-	Brad Foley, Yale University PhD
2008-	Zhengyu Cai, Yale University PhD

Grants and Awards

• National Science Foundation (NSF)

- Two-Phase Damage and the Interactions between Earth's Mantle and Climate: From Plate Tectonic Feedbacks to Carbon Capture, (PI) 2010-2013
- Two-phase damage theory and the generation of plate tectonics, (PI) 2006-2009
- Whole-mantle convection and the transition-zone water filter, (lead PI) 2003-2008
- PLUME: Imaging the Hawaiian Hotspot and Swell (co-PI), 2003-2007
- Two-phase model of damage, shear-localization and plate boundary formation, (PI) 2001-2004
- NSF (Presidential) Young Investigator Award, 1994-1999
- The Dynamics of Basalt Eruptions in the Deep Sea: Detailed Study of Eruptive Hyaloclastite Deposits with Alvin (co-PI), 1994-1995
- Mantle Plume-Lithosphere Interaction: An Interdisciplinary Study of the Dynamics of the Hawaiian Hotspot (lead PI), 1994 - 1996
- Distribution and geodynamic implications of intermediate wavelength geoid undulations (Co-PI), 1992 – 1994

• Department of Energy (NETL)

- Integrated experimental and modeling studies of mineral carbonation as a mechanism for permanent carbon sequestration in mafic/ultramafic rocks, (co-PI), 2010-2013

• National Aeronautics and Space Administration (NASA)

- Grand Challenge Applications: Three-dimensional spherical simulations of Earth's core and mantle dynamics (co-PI) 1996–1999
- Plastic Deformation of Venus' Lithosphere Over a Dynamic Mantle: Synthesis of Satellite Data Analysis with Laboratory and Theoretical Modelling, (PI) 1993–1995
- Present Day Plate Motions and the Rheology of the Plate Mantle System (PI) 1992–1994

Publications

1. Bercovici, D. and Y. Ricard, Generation of plate tectonics by two-phase grain-damage and pinning, submitted to *Phys. Earth Planet. Int.*, 2011.
2. Michaut, C., D. Bercovici, Y. Ricard and R.S.J. Sparks, Cyclic activity and magma gas waves during volcanic eruptions, in prep for submission to *Nature* (or *Nature Geosciences*), 2011.
3. Paczkowski, K., D. Bercovici, W. Landuyt, M. Brandon, Drip instabilities of continental lithosphere: acceleration and entrainment by damage, submitted *Geophys. J. Int.*. 2011.
4. Cai, Z., and D. Bercovici, Two-phase damage models of magma- and hydro-fracturing, submitted *Earth Planet. Sci. Lett.* 2011.
5. Foley, B.J., D. Bercovici and W. Landuyt, The conditions for plate tectonics on super-Earths: Inferences from convection models with damage, in review., *Earth Planet. Sci. Lett.*, 2011.
6. Laske, G., A. Markee, J.A. Orcutt, C.J. Wolfe, J.A. Collins, S.C. Solomon, R.S. Detrick, D. Bercovici, E.H. Hauri Images of Shallow Mantle Structure beneath the Hawaiian Swell Using PLUME Rayleigh Wave Phase Velocities, submitted to *Geophys. J. Int.*, 2011.
7. Bercovici, D., Mantle Convection, in *Encyclopedia of Solid Earth Geophysics*, H.K. Gupta, ed., Springer, pp.832-851, 2011.
8. Jellinek, A.M. and D. Bercovici, Seismic tremors and magma wagging during explosive volcanism, *Nature* **470**, 522–525, 2011.
9. Rozel, A., Y. Ricard, and D. Bercovici, A thermodynamically self-consistent damage equation for grain size evolution during dynamic recrystallization, *Geophys. J. Int.* **184**, 719–728, 2011.
10. C.J. Wolfe, S.C. Solomon, G. Laske, J.A. Collins, R.S. Detrick, J.A. Orcutt, D. Bercovici, E.H. Hauri Mantle P-wave Velocity Structure beneath the Hawaiian Hotspot, *Earth Planet. Sci. Lett.*, **303**, 267-280, 2011.
11. Rudge, J., D. Bercovici and M. Spiegelman, Disequilibrium melting of a two phase multicomponent mantle, *Geophys. J. Int.*, **184**, 699–718, 2011.
12. Bercovici, D. and C. Michaut, Two-phase dynamics of volcanic eruptions: Compaction, compression, and the conditions for choking, *Geophys. J. Int.*, **182**, 843–864, 2010.
13. Leahy, G. M., and D. Bercovici, Reactive infiltration of hydrous melt above the mantle transition zone, *J. Geophys. Res.*, **115**, B08406, doi:10.1029/2009JB006757, 2010.
14. Pagani, M., D. Bercovici, J.S. Wettlaufer, and J.J. Park, Perspectives on Climate Change, *Yale Daily News*, December 10, 2009.
15. Laske, G., J.A. Collins, C.J. Wolfe, S.C. Solomon, R.S. Detrick, J.A. Orcutt, D. Bercovici, and E.H. Hauri, Probing the Hawaiian Hotspot with New Broadband Ocean Bottom Instruments, *Eos* **90**(41), pp362-363, Oct 13, 2009.
16. C.J. Wolfe, S.C. Solomon, G. Laske, J.A. Collins, R.S. Detrick, J.A. Orcutt, D. Bercovici, E.H. Hauri Mantle Shear-wave Velocity Structure Beneath the Hawaiian Hotspot, *Science*, **326**, 1388–1390, 2009.
17. Landuyt, W., D. Bercovici, Formation and structure of lithospheric shear zones with damage. *Phys. Earth Planet. Int.*, **175**, 115-126, 2009.
18. Michaut, C. and D. Bercovici, A model for the spreading and compaction of two-phase viscous gravity currents, *J. Fluid Mech.*, **630** 299-329, 2009.
19. Michaut, C., D. Bercovici and R.S.J. Sparks, Ascent and compaction of gas-rich magma and the effects of hysteretic permeability, *Earth Planet. Sci. Lett.* **282**, 258-267, 2009.

20. Youngs, B.A.R. and D. Bercovici, Stability of a compressible hydrous melt layer above the transition zone, *Earth Planet. Sci. Lett.*, **278**, 7886 doi:10.1016/j.epsl.2008.11.024, 2009.
21. Richard, G. and D. Bercovici, Water induced convection in the Earth's mantle transition zone, *J. Geophys. Res.* **114**, B01205, doi:10.1029/2008JB005734, 2009
22. Landuyt, W. and D. Bercovici, Variations in planetary convective via the effect of climate on damage, *Earth Planet. Sci. Lett.* **277**, 29-37, 2009.
23. Ricard, Y. and D. Bercovici, A continuum theory of grain size evolution and damage, *J. Geophys. Res.*, **114**, B01204, doi:10.1029/2007JB005491, 2009.
24. Landuyt, W., D. Bercovici and Y. Ricard, Plate generation and two-phase damage theory in a model of mantle convection, *Geophys. J. Int.* **174**, Number 3, September 2008 , pp. 1065-1080, 2008.
25. Bercovici, D., editor, *Treatise on Geophysics, vol 7, Mantle Dynamics*; G. Schubert, editor in chief, Elsevier, New York, 2007.
26. Bercovici, D. Mantle dynamics, Past, Present and Future: An Overview, in *Treatise on Geophysics, vol. 7, Mantle Dynamics*, D. Bercovici editor; G. Schubert, editor in chief, Elsevier, New York; Ch. 1 pp. 1-30, 2007.
27. Leahy, G.M., and D. Bercovici, On the dynamics of a hydrous melt layer above the transition zone, *J. Geophys. Res.*, **112**, B07401, doi:10.1029/2006JB004631, 2007
28. Sramek, O., Y. Ricard and D. Bercovici, Simultaneous melting and compaction in deformable two-phase media, *Geophys. J. Int.*, **168**(3), 964–982, doi:10.1111/j.1365-246X.2006.03269.x, 2007.
29. S. Karato, D. Bercovici, G. Leahy, G. Richard, Z. Jing, The transition zone water filter model for global material circulation: where do we stand? *Earth's Deep Water Cycle, AGU Monograph Series*, **168**, pp289-313, edited by S.D. Jacobsen and S. van der Lee, 2006.
30. Richard, G., D. Bercovici and S.-i. Karato, Hydration of the mantle transition zone by subducting slabs, *Earth Planet Sci. Lett.* **251**, 156167, 2006.
31. Hier-Majumder, S., Y. Ricard and D. Bercovici, Role of grain boundaries in magma migration and storage, *Earth Planet Sci. Lett.* **248**, 735-749, 2006.
32. Samuel, H. and D. Bercovici, Oscillating and stagnating plumes in the Earth's lower mantle *Earth Planet Sci. Lett.* **248**, 90-105, 2006.
33. Bercovici, D. and S.-i. Karato, Mantle transition zone water filter, in *McGraw-Hill Yearbook of Science and Technology*, pp193-196, McGraw-Hill, New York, 2005.
34. Bercovici, D. and Y. Ricard, Tectonic plate generation and two-phase damage: void growth versus grainsize reduction, *J. Geophys. Res.*, **110**, B03401, doi:10.1029/2004JB003181, 2005.
35. Leahy, G.M. and D. Bercovici, The influence of the transition-zone water filter on convective circulation in the mantle, *Geophys. Res. Lett.* **31**, L23605, doi:10.1029/2004GL021206, 2004
36. Bercovici, D. and S.-i. Karato, Whole mantle convection and the transition-zone water filter, *Nature* **425**, 39-44, 2003a. , ,
37. Ricard, Y. and D. Bercovici, Two-phase damage theory and crustal rock failure: the theoretical 'void' limit, and the prediction of experimental data, *Geophysical J. Int.* **155**(3), 1057-1064, 2003. [doi: 10.1111/j.1365-246X.2003.02112.x]
38. Auth, C., D. Bercovici and U. Christensen, Two-dimensional convection with self-lubricating, simple damage rheology, *Geophys. J. Int.* **154** 783-800, 2003.

39. Bercovici, D. and S.-i. Karato, Theoretical Analysis of Shear Localization in the Lithosphere, in *Reviews in Mineralogy and Geochemistry: Plastic Deformation of Minerals and Rocks*, S.-i. Karato and H.-R. Wenk, eds, vol.51, ch.13, pp.387-420, Mineralogical Society of America, Washington DC, 2003b.
40. Bercovici, D., The generation of plate tectonics from mantle convection, *Earth Planet. Sci. Lett.*, (*Frontiers*) **205**, 107-121, 2003.
41. Bercovici, D. and Y. Ricard, Energetics of a two-phase model of lithospheric damage, shear localization and plate boundary formation, *Geophys. J. Int.*, **152**, 581-596, 2003.
42. Mistr, S.K. and D. Bercovici, A theoretical model of pattern formation in coral reefs, *Ecosystems*, **6**, 61–74, 2003.
43. D. Bercovici and G. Schubert, Schubert Receives the 2002 Harry H. Hess Medal, *EOS, Trans. AGU*, **84**, no.9, p.80, 2003
44. Bercovici, D., Y. Ricard and G. Schubert, A two-phase model for compaction and damage, 1. General theory, *J. Geophys. Res.*, **106**, 8887–8906, 2001.
45. Ricard, Y. Bercovici, D., and G. Schubert, A two-phase model for compaction and damage, 2. Applications to compaction, deformation and the role of interfacial surface tension, *J. Geophys. Res.*, **106**, 8907–8924, 2001.
46. Bercovici, D., Y. Ricard and G. Schubert, A two-phase model for compaction and damage, 3. Applications to shear localization and plate boundary formation, *J. Geophys. Res.*, **106**, 8925–8940, 2001.
47. Becker, J.M. and D. Bercovici, Pattern formation on the interface of a two-layer fluid: bi-viscous lower layer, *Wave Motion*, **34**, 431-452, 2001.
48. Hieronymus, C.F., and D. Bercovici, Focussing of eruptions by fracture wall erosion, *Geophys. Res. Lett.*, **28**, 1823–1826, 2001a.
49. Becker, J.M. and D. Bercovici, Long waves over a bi-viscous sea-bed: Transverse patterns, *Nonlinear Processes in Geophysics*, **9**, 1-8, 2001.
50. Hieronymus, C.F., and D. Bercovici, A theoretical model of hotspot volcanism: Control on volcanic spacing and patterns via magma dynamics and lithospheric stresses, *J. Geophys. Res.*, **106**, 683–702, 2001b.
51. Bercovici, D., Stopping the tectonic conveyor belt: Review of “Dynamic Earth: Plates, Plumes and Mantle Convection” by G.F. Davies, *Nature*, **405**, 396, 2000.
52. Becker, J.M. and D. Bercovici, Permanent bedforms in a theoretical model of wave-sea-bed interactions, *Non-linear Processes in Geophysics*, **7**, 31–35, 2000.
53. Hieronymus, C.F., and D. Bercovici, Non-hotspot formation of volcanic chains: control of tectonic and flexural stresses on magma transport, *Earth Planet. Sci. Lett.*, **181**, 539–554, 2000.
54. Bercovici, D., Y. Ricard, and M.A. Richards, The relation between mantle dynamics and plate tectonics: A primer, *The History and Dynamics of Global Plate Motions*, M.A. Richards, R. Gordon and R. Van der Hilst, editors, AGU Geophysical Monograph 21, pp 5-46, 2000.
55. Hieronymus, C.F., and D. Bercovici, Discrete, alternating hotspot islands formed by the interaction of magma transport and lithospheric flexure, *Nature* **397**, 604–607, 1999.
56. Bercovici, D., Generation of plate tectonics from lithosphere-mantle flow and void-volatile self-lubrication, *Earth Planet. Sci. Lett.* **154**, 139–151, 1998.
57. Ratcliff, J.T., D. Bercovici, G. Schubert, and L. Kroenke Mantle plume heads and the initiation of plate-tectonic reorganizations, *Earth Planet. Sci. Lett.* **156**, 195-207, 1998.

58. Dumoulin, C., D. Bercovici, and P. Wessel, A continuous plate-tectonic model using geophysical data to estimate plate margin widths, with a seismicity based example, *Geophys. J. Int.* **133**, 379–389, 1998.
59. Wessel, P., and D. Bercovici, Interpolation with splines in tension: A Green's function approach, *Math. Geol.* **30**, 77–93, 1998.
60. Bercovici, D. and A. Kelly, Nonlinear initiation of diapirs and plume heads, *Phys. Earth Planet. Int.* **101**, 119-130, 1997.
61. Bercovici, D., Review of *Fluid Physics in Geology* by D.J. Furbish, *GSA Today*, **7**, no.11, p.24, November 1997.
62. Kelly, A. and D. Bercovici, The clustering of rising diapirs and plume heads, *Geophys. Res. Lett.* **24**, 201-204, 1997.
63. Bercovici, D., "Macelwane Medal: Response", *Eos, Trans. AGU*, **78** no. 10, pages 108 & 113, March 11, 1997.
64. Bercovici, D., Plate generation in a simple model of lithosphere-mantle flow with dynamic self-lubrication, *Earth Planet. Sci. Lett.* **144**, 41–51, 1996.
65. Wessel, P., L. Kroenke, and D. Bercovici Pacific plate motions and undulations in geoid and bathymetry, *Earth Planet. Sci. Lett.* **140**, 53–66, 1996.
66. Bercovici, D. and J. Lin, A gravity-current model of cooling mantle plume-heads with temperature-dependent buoyancy and viscosity, *J. Geophys. Res.*, **101**, 3291–3309, 1996.
67. Bercovici, D., The unpredictable Earth, *Nature*, **377**, 272, (New Journal Review) 1995c.
68. Bercovici, D., On the purpose of toroidal flow in a convecting mantle, *Geophys. Res. Lett.* **22**, 3107–3110, 1995b.
69. Bercovici, D., A source-sink model of the generation of plate tectonics from non-Newtonian mantle flow, *J. Geophys. Res.* **100**, 2013–2030, 1995a.
70. Bercovici, D. and J. Mahoney, Double flood basalts and plume head separation at the 660 kilometer discontinuity, *Science* **266**, 1367–1369, 1994.
71. Bercovici, D. and P. Wessel, A continuous kinematic model of plate tectonic motions, *Geophys. J. Int.* **119**, 595–610, 1994.
72. Wessel, P., D. Bercovici and L. Kroenke, The possible reflection of mantle discontinuities in Pacific geoid and bathymetry, *Geophys. Res. Lett.* **21**, 1943–1946, 1994.
73. Bercovici, D., A theoretical model of cooling viscous gravity currents with temperature-dependent viscosity, *Geophys. Res. Lett.* **21**, 1177–1180, 1994.
74. Bercovici, D., G. Schubert, and P.J. Tackley, On the penetration of the 660 km phase change by mantle down-flows, *Geophys. Res. Lett.* **20**, 2599-2602, 1993.
75. Bercovici, D., A simple model of plate generation from mantle flow, *Geophys. J. Int.* **114**, 635–650, 1993.
76. Lozier, M.S. and D. Bercovici, Particle exchange in an unstable jet, *J. Phys. Oceanography*, **22**, 1506–1516, 1992.
77. Bercovici, D., H.J.B. Dick and T.P. Wagner, Nonlinear viscoelasticity and the formation of transverse ridges, *J. Geophys. Res.*, **97**, 14195-14206, 1992.
78. Bercovici, D., Wave dynamics in mantle plume heads and hotspot swells, *Geophys. Res. Lett.*, **19**, 1791–1794, 1992.
79. Bercovici, D., G. Schubert and G. A. Glatzmaier, Three-dimensional, infinite Prandtl number, compressible convection in a basally heated spherical shell, *J. Fluid Mech.* **239**, 683–719, 1992.

80. Bercovici, D., G. Schubert and G.A. Glatzmaier, Modal growth and coupling in three-dimensional spherical convection, *Geophys. Astrophys. Fluid Dyn.* **61**, 149-159, 1991.
81. Olson, P. and D. Bercovici, On the equipartitioning of kinetic energy in plate tectonics, *Geophys. Res. Lett.* **18**, 1751-1754, 1991.
82. Glatzmaier, G.A., G. Schubert and D. Bercovici, Chaotic subduction-like downflows in a spherical model of convection in the Earth's mantle, *Nature*, **347**, 274-277, 1990.
83. Schubert, G., D. Bercovici and G. A. Glatzmaier, Mantle dynamics in Mars and Venus: Influence of an immobile lithosphere on three-dimensional mantle convection, *J. Geophys. Res.* **95**, 14105-14129, 1990.
84. Bercovici, D., *A Numerical Investigation of Thermal Convection in Highly Viscous Spherical Shells with Applications to Mantle Dynamics in the Earth and Other Terrestrial Planets*, Ph.D. Dissertation, University of California, Los Angeles, 1989.
85. Bercovici, D., G. Schubert and G. A. Glatzmaier, Influence of heating mode on three-dimensional mantle convection, *Geophys. Res. Lett.* **16**, 617-620, 1989.
86. Bercovici, D., G. Schubert and G. A. Glatzmaier, Three-dimensional, spherical models of convection in the Earth's mantle, *Science* **244**, 950-955, 1989.
87. Bercovici, D., G. Schubert, G. A. Glatzmaier, and A. Zebib, Three-dimensional thermal convection in a spherical shell, *J. Fluid Mech.* **206**, 75-104, 1989.
88. Bercovici, D., G. Schubert, and A. Zebib, Geoid and topography for infinite Prandtl number convection in a spherical shell, *J. Geophys. Res.* **93**, 6430-6436, 1988.
89. Bercovici, D., and G. Schubert, Jovian seismology, *Icarus* **69**, 557-565, 1987.
90. Bercovici, D., G. Schubert and R. T. Reynolds, Phase transitions and convection in icy satellites, *Geophys. Res. Lett.* **13**, 448-451, 1986.

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