Application for Consent to Conduct Marine Scientific Research in Areas Under National Jurisdiction of

New Zealand

Date: 7/29/2010
Updated

1. General Information

1.1 Cruise name and/or #:	

1.2 Sponsoring institution:	
Name:	National Science Foundation
Address:	4201 Wilson Boulevard, Arlington, Virginia 22230 Division of Ocean Sciences (GEO/OCE)
Name of Director:	Julie D Morris, Division Director

1.3 Scientist in charge of the project (include CV and passport photo):	
Name:	Prof. Bradford H. Hager
Address:	Room 54-622, Dept. of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139-4307, USA
Telephone:	617 – 253-0126
Fax:	617-253-1699
Email:	brad@chandler.mit.edu

1.4 Scientist(s) from coastal state involved in the planning of the project:	
Name(s):	Prof. Timothy Stern, Prof. Martha Savage
Address:	School of Geography, Environment and Earth Sciences, Victoria University of Wellington, PO Box 600, Wellington, New Zealand Tel. (Stern) +64-4-463-5112 E-mail (Stern): Tim.Stern@vuw.ac.nz Tel. (Savage): +64-4-463-5961 E-mail (Savage): Martha.Savage@vuw.ac.nz

1.5 Submitting officer:	
Name and address:	Elizabeth Brenner /Rose M. Dufour Scripps Institution of Oceanography

	University of California, San Diego La Jolla, California 92093-0210
Nationality:	USA
Telephone:	(858)534-2841
Fax:	(858) 822-5811
Email:	Shipsked@ucsd.edu

2. Description of Project (Attach additional pages as necessary)

2.1 Nature and objectives of the project:
See project description below.

2.2 Relevant previous or future research cruises:
Cruise (TN-229) deployed about 30 Ocean Bottom Seismographs (OBS) in January-February of 2009. The cruise received New Zealand diplomatic clearance, reference no. US/NZ/1/15/2. The OBS's will be recovered during this cruise.

2.3 Previously published research data relating to the project:
Molnar, P., H. J. Anderson, E. Audoine, D. Eberhart-Phillips, K. R. Gledhill, E. R. Klosko, T. V. McEvilly, D. Okaya, M. K. Savage, T. Stern, and F. T. Wu, Continuous Deformation Versus Faulting through the Continental Lithosphere of New Zealand, *Science, 286*, 516-519, 1999.

3. Methods and Means to be Used

3.1 Particulars of vessel:	
Name:	*R/V Roger Revelle*
Nationality (Flag state):	USA Flag
Owner:	U.S. Navy
Operator:	University of California, San Diego, Scripps Oceanography
Overall length (meters):	84 m. [275']
Maximum draught (meters):	17'
Displacement/Gross tonnage:	3,180 long tons
Propulsion:	Tow 3000 hp Propulsion General Electric Bow Thruster: 1180 hp Azimuthing jet Tyupe Elliot Gill Model 50T 35 Propulsors: Two 3000 hp Z-Drives Lips Type FS 2500-450/1510BO
Cruising & Maximum speed:	12 knots
Call sign:	KAOU
Method and capability of communication (including emergency frequencies):	Email, master@rv-revelle.ucsd.edu Inmarsat-B, Telephone, Indian, 011-873-336780030

	Alternate, 011-873-336780020 Fax, Primary, 011-873-336780031 Alternate, 011-873-336780021 Telex, Primary, 336780033 (AnsBk=KAOU) Alternate, 336780022 (AnsBk=KAOU) Inmarsat-C, 436780010 Radio, Vessels guard standard GMDSS frequencies for calling, distress and dissemination of marine safety information. MMSI #, 367800100 SELCAL #, 71410 Telex, Primary, 336780033 (AnsBk=KAOU) Alternate, 336780022 (AnsBk=KAOU) Inmarsat-C, 436780010 Radio, Vessels guard standard GMDSS frequencies for calling, distress and dissemination of marine safety information. MMSI #, 367800100 SELCAL #, 71410
Name of master:	Tom Desjardins
Number of crew:	22
Number of scientists on board:	No more than 37

3.2 Aircraft or other craft to be used in the project:
none

3.3 Particulars of methods and scientific instruments		
Types of samples and data	Methods to be used	Instruments to be used
Recordings of seismic ground motion induced by regional and teleseismic earthquakes will be analyzed for shear-wave splitting, surface-wave anisotropy, and converted phases (receiver functions).	Passive listening to regional and global earthquakes.	30 Ocean Bottom Seismographs (OBS)
Temperature, salinity, Oxygen, currents, meteorological measurements.	Underway measurements from continuously pumped surface seawater and on-board sensors	Thermosalinograph, acoustic doppler sonars ADCP RDI Narrowband and RDI Broadband 150 kHz
Magnetometer if available	Towed Magnetometer.	Marine Magnetics SeaSpy

		Gradiometer
Bathymetry and sidescan	Swath mapping with multibeam system.	EM120 12 kHz 150 deg swath
Gravity if available	Gravimeter	Gravimeter-Bell BGM-3

3.4 Indicate whether harmful substances will be used:
The Ocean Bottom Seismographs that were be deployed on the seafloor contain lithium batteries (UN Committee of Experts on the Transportation of Dangerous Goods Number 3091) inside sealed pressure housings. The Ocean Bottom Seismographs with all of their lithium batteries will be recovered during this cruise.

3.5 Indicate whether drilling will be carried out:
None

3.6 Indicate whether explosives will be used:
None

4. Installations and Equipment

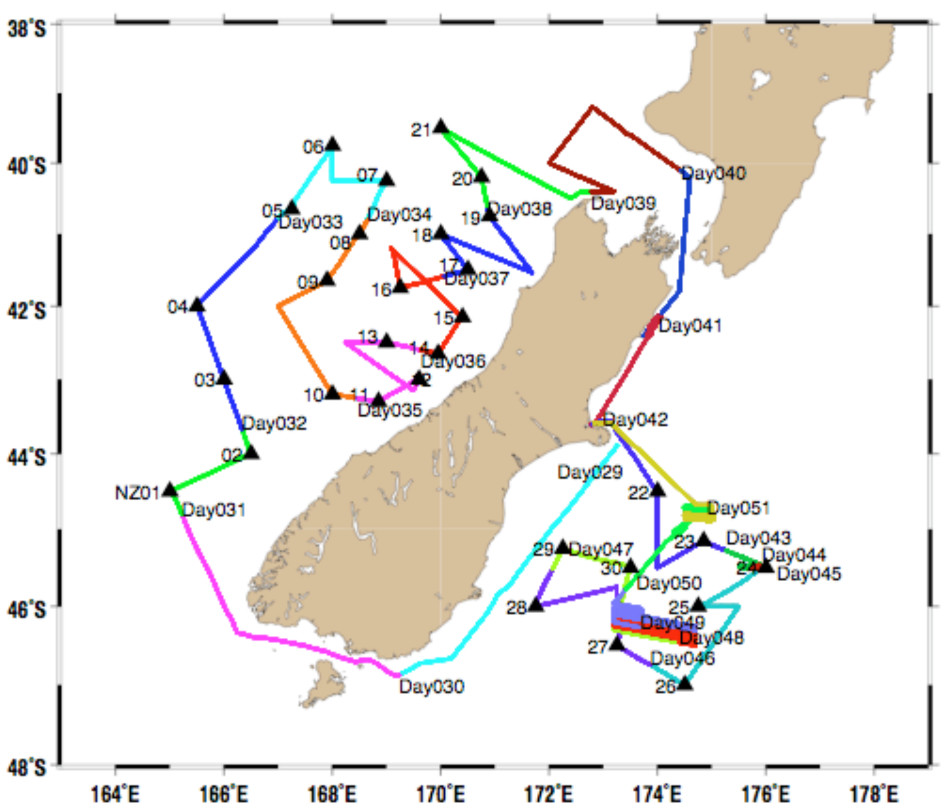
Details of installations and equipment (dates of laying, servicing, recovery; exact locations and depth):
The OBS's were deployed from R/V *Thomas Thompson* January-February of 2009 see track below.

5. Geographical Areas

5.1 Indicate geographical areas in which the project is to be conducted (with reference in latitude and longitude):
Please see chart below.

5.2 Attach chart(s) at an appropriate scale (1 page, high-resolution) showing the geographical areas of the intended work and, as far as practicable, the positions of intended stations, the tracks of survey lines, and the locations of installations and equipment.

Cruise TN229 Ship Track



6. Dates

6.1 Expected dates of first entry into and final departure from the research area of the research vessel: Approximately 24 January 2010- 22 February 2010
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6.2 Indicated if multiple entry is expected:

n/a

7. Port Calls

7.1 Dates and names of intended ports of call:
A port has not been officially designated. We are looking berthing at Tauranga, or Wellington.

7.2 Any special logistical requirements at ports of call:
Fuel, stores, provisions

7.3 Name/Address/Telephone of shipping agent (if available):
We will be contracting with ISS-McKay Ltd. Their main office is in Auckland: The Shipping Exchange, 2 Akaroa Street, Parnell Auckland 1052 However if we choose another port we will be contracting with the local office of ISS-McKay Ltd

8. Participation:

8.1 Extent to which coastal state will be enabled to participate or to be represented in the research project:
At least one New Zealand student, from Victoria University of Wellington, will sail in the cruise.

8.2 Proposed dates and ports for embarkation/disembarkation:
Embark 23 January, disembark 20-22 February 2010

9. Access to data, samples and research results

9.1 Expected dates of submission to coastal state of preliminary reports, which should include the expected dates of submission of the final results:
No more than 30 days from the end date of the cruise.

9.2 Proposed means for access by coastal state to data and samples:
Collaborating New Zealand scientists will be provided with all data acquired on the cruise (bathymetry, navigation, etc) within 30 days of the cruise end. The seismic data will be made available when the Ocean Bottom Seismographs are recovered in 2010.

9.3 Proposed means to provide coastal state with assessment of data, samples and research results or provide assistance in their assessment or interpretation:
This experiment is a collaborative effort between US and NZ investigators. We have budgeted funds to hold three meetings with our NZ colleagues. Meetings will be held in the US and in NZ. We have travel funds for our NZ colleagues to attend one meeting in the U.S.

9.4 Proposed means of making results internationally available:
We will follow standard practice. Shortly after instrument recovery, all of the data will be archived at the Data Management Center (DMC) of the Incorporated Research

Institutions of Seismology (IRIS). The Principal Investigators and their collaborators (including those from New Zealand) will then have exclusive access to the data for a period of two years. Following this period of restricted access, the Data Management Center will then make the data available to all via electronic or physical-media transfer.

Project Description: Constraining mantle rheology, mantle flow, and crust/mantle coupling beneath New Zealand

We propose a large step toward answering a critical question in Continental Dynamics: "What is the rheology of the system"? Do rocks deform in the ductile regime, by diffusion creep, with strain rate proportional to stress, or by dislocation creep, where doubling the stress increases strain rates ~10 times? Is the lower crust relatively strong, with efficient coupling of strain between the crust and mantle, or weak, as in the classic "jelly sandwich" model? Is the upper mantle strong, as expected for dry peridotite, or weak, due to high volatile content? Is deformation in the upper mantle localized along shear zones beneath crustal faults, or distributed, as in thin viscous sheet models?

At plate boundaries the effects of plate motion dominate mantle flow. The kinematics of mantle flow at strike-slip boundaries are better constrained than elsewhere. Whether deformation in the uppermost mantle is distributed or localized depends crucially on the system's rheology. Thus, if we could determine the strain pattern at a strike-slip plate boundary, we could constrain its rheology. Seismic anisotropy appears to provide the most reliable and precise strain gauge that can be applied to the mantle. While even for ideal conditions measurements of anisotropy cannot uniquely define the strain field, combined with calculated strain fields, such measurements can test hypotheses and rule out some mutually exclusive proposed connections between strain in the crust and mantle. Anisotropy can be used most effectively where it is large, where the strain field at the earth's surface can be measured accurately, and where the simplicity of that strain field allows simple calculations to be made for hypothesized patterns of deformation in the mantle. The New Zealand region meets these requirements.

Our research requires contributions from several disciplines of the earth sciences: (1) Deployment of 30 Ocean Bottom Seismographs; (2) Measurement of seismic anisotropy using a variety of techniques (shear-wave splitting, surface wave dispersion, Pn and Sn travel times, and receiver functions); (3) Calculations of mantle finite strain fields that might be responsible for anisotropy, constrained by relative plate motions and observed strain in New Zealand and considering a variety of vertical and lateral distributions of temperature and deformation mechanisms; and (4) Combination of laboratory, theoretical and seismological constraints on anisotropy to bound the conditions under which dislocation creep occurs.

The study we plan should enhance our understanding of how anisotropy depends on strain. We will learn if the evolution of lattice preferred orientation with increasing strain during dynamic recrystallization observed under laboratory conditions is applicable and under what temperature and strain-rate conditions dislocation and diffusion creep operate. A by-product of the proposed study will be an improved image of the isotropic seismic wave speed structure beneath New Zealand, placing tight constraints on the lateral and vertical extent of a high-speed zone in the mantle beneath the South Island.

We will collaborate with New Zealand seismologists Tim Stern (Victoria University of Wellington), Martha Savage (Victoria University of Wellington), and Ken Gledhill (GNS Science), all experienced in measuring and interpreting seismic anisotropy, and with New Zealand structural geologists Tim Little (Victoria University of Wellington), and Rupert Sutherland (Ministry of Science and Technology), who are experts in local strain and regional deformation.

Our research combining geodynamics modeling of deformation and flow, mineral physics, and seismic anisotropy, will enhance the ability of researchers to use seismic anisotropy to make inferences about deep structure, an important component of the Earthscope program. Two graduate students will be supported on this project, with the work proposed here forming the primary content of their theses. This research will support a female P.I. and a number of undergraduate students at MIT and U. Colorado. The results of this work will be incorporated directly into teaching programs at both MIT and Colorado. We propose to provide a research experience for a secondary science teacher during the Year 1 deployment cruise, web-based interactions with the science team and the teacher, and visits by scientists to the teacher's classroom. The project has strong international collaboration. Finally, following NSF guidelines, the unique ocean-bottom seismic data collected in this experiment will be available to any interested investigator 2 years following instrument recovery through the IRIS DMC.

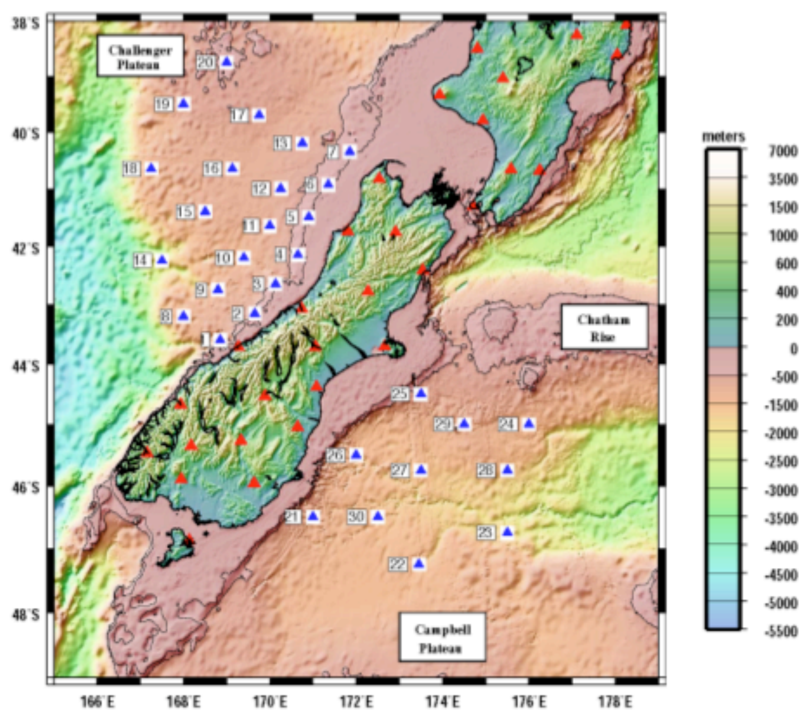

Figure 1. Locations of the proposed 30 Ocean Bottom Seismograph deployments are shown in the blue triangles. The red triangles show the locations of the seismic stations of the New Zealand Seismographic Network.

BRADFORD H. HAGER
Born: Johnstown, Pennsylvania, June 21, 1950
Education
Ph.D., Geophysics, Harvard University, 1978

Thesis: *Mantle Flow Driven by the Lithospheric Plates*
A.M., Geology, Harvard University, 1976
B.A., Physics, Amherst College, 1972, *summa cum laude*

Professional Experience

Cecil and Ida Green Professor of Earth Sciences, MIT, 1989 -
Professor of Geophysics, Caltech, 1989
Associate Professor of Geophysics, Caltech, 1985 - 1989
Assistant Professor of Geophysics, Caltech, 1980 - 1985
Assistant Professor, Department of Earth and Space Science, SUNY Stony Brook, 1979 - 1980
Chaim Weizmann Postdoctoral Fellow, Harvard University, 1978 - 1979
Teaching and Research Fellow, Geology, Harvard University, 1974 - 1977
Teacher, Physics and Mathematics, Cushing Academy, Ashburnham, Massachusetts, 1972 - 1974

Selected Professional Activities

NASA Geodynamics Working Group, 1983
Associate Editor, Physics of the Earth and Planetary Interiors, 1983 -1992
NASA Geopotential Research Mission Science Steering Group, 1985 - 1987
NASA GPS-Based Geodetic Systems Science Working Group, 1986 - 1989
NRC U. S. Geodynamics Committee Member, 1988 - 1992; chair 1996 - 2000.
NRC Geodesy Committee, Global Fiducial Network Subcommittee, 1989 - 1991
NEPEC Parkfield Earthquake Prediction Experiment Evaluation Working Group (chair) 1992 - 1993
University GPS Consortium Steering Committee, 1984 - 1989; 1994 - 1996
Southern California Integrated GPS Array Coordinating Board, 1994 - 1997; Advisory Board, 1999 – 2005.
NRC Review Committee for NASA's Earth Science Enterprise Research Strategy for 2000-2010, 2000.
University of Southern California Department of Earth Sciences Visiting Committee, 2000.
Southern California Earthquake Center 2, Fault Systems Working Group Chair, 2001 – 2006.
EarthScope Plate Boundary Observatory Standing Committee, 2003 – 2005.
Jet Propulsion Laboratory Earth and Space Sciences Division Visiting Committee, 2004 –
NRC Committee to Review NASA’s Solid-Earth Science Strategy, 2004.
NRC “Earth Science and Applications from Space: A Community Assessment and Strategy for the Future,” member of Executive Committee and chair, Solid Earth Hazard, Resources, and Dynamics Committee, 2004 - 2007.
Jet Propulsion Laboratory Advisory Council, 2006 – 2008.
Computational Infrastructure for Geodynamics, Executive Committee, 2006 – 2008.

Awards and Honors

National Merit Scholar, 1968-1972
Alfred P. Sloan Foundation Fellow, 1982 - 1986
American Geophysical Union - James B. Macelwane Award, 1986
American Geophysical Union - Fellow, 1986
Distinguished Visiting Scientist, Jet Propulsion Laboratory, 1992 -
Orson Anderson Scholar, Los Alamos National Laboratory, 1996
Woollard Award, Geological Society of America, 2001
Hewitt Dix Memorial Lecture, California Institute of Technology, 2002

Principal Research Interests
The physics of geologic processes; mantle convection and crustal deformation; precision modern geodesy using GPS; plate tectonics.

Refereed Publications

Large-scale heterogeneities in the lower mantle: correlation with the gravity field, Adam M. Dziewonski, Bradford H. Hager and Richard J. O'Connell, *J. Geophys. Res., 82,* 239-255, 1977.

Subduction zone dip angles and flow driven by plate motion, Bradford H. Hager and Richard J. O'Connell, *Tectonophysics, 50*, 111-133, 1978.

Oceanic plate motions driven by lithospheric thickening and subducted slabs, Bradford H. Hager, *Nature, 276,* 156-159, 1978.

Kinematic models of large-scale flow in the Earth's mantle, Bradford H. Hager and Richard J. O'Connell, *J. Geophys. Res., 84,* 1031-1048, 1979.

On the thermal state of the earth, Richard J. O'Connell and Bradford H. Hager, in Adam M. Dziewonski and E. Boschi, eds, *Physics of the Earth's Interior,* Soc. Italiana di Fisica, Bologna, 270-317, 1980.

Lithospheric thickening and subduction, plate motions and mantle convection, Bradford H. Hager and Richard J. O'Connell, in Adam M. Dziewonski and E. Boschi, eds., *Physics of the Earth's Interior,* Soc. Italiana di Fisica, Bologna, 464-492, 1980.

Rheology, plate motions and mantle convection, Bradford H. Hager and Richard J. O'Connell, in S. K. Runcorn, ed., *Mechanisms of Continental Drift and Plate Tectonics,* Academic Press, London, 199-223, 1981.

A simple global model of plate dynamics and mantle convection, Bradford H. Hager and Richard J. O'Connell, *J. Geophys. Res., 86,* 4843-4867, 1981.
Melt segregation for partially molten source regions: the importance of melt density and source region size, Edward Stolper, David Walker, Bradford H. Hager, and James F. Hays, *J. Geophys. Res., 86,* n. B7, 6261-6271, 1981.

Subduction, back-arc spreading and global mantle flow, Bradford H. Hager, Richard J. O'Connell, and Arthur Raefsky, *Tectonophysics, 99,* 165-189, 1983.

Global isostatic geoid anomalies for plate and boundary layer models of the lithosphere, Bradford H. Hager, *Earth Planet. Sci. Lett., 63,* 97-109, 1983.

Subducted slabs and the geoid: constraints on mantle rheology and flow, Bradford H. Hager, *J. Geophys. Res., 89,* 6003-6015, 1984.

The distribution of earthquakes with depth and stress in subducting slabs, Marios S. Vassiliou, Bradford H. Hager, and Arthur Raefsky, *J. Geodyn., 1,* 11-28, 1984.

Convection experiments in a centrifuge and the generation of plumes in a very viscous fluid, Henri-Claude Nataf, Bradford H. Hager and Ron F. Scott, *Annales Geophysicae,* *2,* 303-310, 1984.

Geoid anomalies in a dynamic Earth, Mark A. Richards and Bradford H. Hager, *J. Geophys. Res., 89,* 5987-6002, 1984.

A tomographic image of mantle structure beneath Southern California, Eugene D. Humphreys, Robert W. Clayton and Bradford H. Hager, *Geophys. Res. Lett., 11,* 625-627, 1984.

Lower mantle heterogeneity, dynamic topography and the geoid, B. H. Hager, R. W. Clayton, Mark A. Richards, Robert P. Comer, and Adam M. Dziewonski, *Nature, 313*, 541-545, 1985.

A critical assessment of viscous models of trench topography and corner flow, J. Zhang, B. H. Hager, and A. Raefsky, *Geophys. J., R. astr. Soc., 83,* 451-475, 1985.

Finite elements and the method of conjugate gradients on a concurrent processor, G. A. Lyzenga, A. Raefsky and B. H. Hager, 1985 *ASME International Computers in Engineering Conference & Exhibit, August 4-8, Boston, Conference Proceedings.*

A dynamic model of Venus's gravity field, Walter S. Kiefer, Mark A. Richards, Bradford H. Hager and Bruce G. Bills, *Geophys. Res. Lett., 13,* 14-17, 1986.

The Earth's geoid and the large-scale structure of mantle convection, Mark A. Richards and Bradford H. Hager, in S. K. Runcorn, ed., *The Physics of Planets*, John Wiley and Sons, Ltd., 247-272, 1988.
An improved method of Nusselt number calculation, Phyllis Ho-Liu, Bradford H. Hager and Arthur Raefsky, *Geophys. J., R. astr. Soc., 88,* 205-215, 1987.

Constraints on the structure of mantle convection using seismic observations, flow models and the geoid, Bradford H. Hager and Robert W. Clayton, in W. R. Peltier, ed., *Mantle Convection*, Gordon and Breach, 657-763, 1989.

Dynamically supported geoid highs over hotspots: Observation and theory, Mark A. Richards, Bradford H. Hager and Norman H. Sleep, *J. Geophys. Res., 93*, 7690-7708, 1988.

Onset of mantle plumes in the presence of pre-existing convection, Norman H. Sleep, Mark A. Richards and Bradford H. Hager, *J. Geophys. Res*., *93,* 7672-7689, 1988.

Mantle convection and the state of the Earth's interior, Bradford H. Hager and Michael C. Gurnis, *Rev. Geophys., 25,* 1277-1285, 1987.

Subduction zone earthquakes and stress in subducted slabs, Mario S. Vassiliou and Bradford H. Hager, *Pure Appl. Geophys*., *128,* 547-624, 1988.

Effects of long-wavelength lateral viscosity variations on the geoid, Mark A. Richards and Bradford H. Hager, *J. Geophys. Res*., *94*, 10,299-10,313, 1989.

Finite element solution of thermal convection on a hypercube concurrent computer, Michael C. Gurnis, Arthur Raefsky, Gregory A. Lyzenga, and B. H. Hager, in G. Fox,

ed., *The Third Conference on Hypercube Concurrent Computers and Applications, Volume II - Applications*, The Association for Computing Machinery, New York, 1176-1179, 1988.

Long-wavelength variations in Earth's geoid: Physical models and dynamical implications, Bradford H. Hager and Mark A. Richards, *Phil. Trans. Roy. Soc. Lond. A.*, *328,* 309-327, 1989.

Controls on the structure of subducted slabs and the viscosity of the lower mantle, Michael C. Gurnis and Bradford H. Hager, *Nature*, *335*, 317-321, 1988.

Coupling of mantle temperature anomalies and the flow pattern in the core: Interpretation based on simple convection calculations, Scott D. King and Bradford H. Hager, *Phys. Earth Planet. Int.*, *58*, 118-125, 1989.

ConMan: Vectorizing a finite element code for incompressible two-dimensional convection in the Earth's mantle, Scott D. King, Arthur Raefsky and Bradford H. Hager, *Phys. Earth Planet. Int.*, *59*, 195-207, 1990.
A kinematic model for the late Cenozoic development of southern California crust and upper mantle, Eugene D. Humphreys and Bradford H. Hager, *J. Geophys. Res.*, *95*, 19, 747-19,762, 1990.

The June 1986 Global Positioning System (GPS) experiment in southern California, T. Dixon, D. Agnew, G. Blewitt, B. Hager, P. Kroger, K. Larson, L. Skrumeda, and W. Strange, *EOS, Trans. Amer. Geophy. Union, 71,* 1051-1056, 1990.

Mantle downwelling and crustal convergence: A model for Ishtar Terra, Venus, Walter S. Kiefer and Bradford H. Hager, *J. Geophys. Res.*, *96*, 20,967-20,980, 1991.

A Benchmark comparison of numerical methods for infinite Prandtl number thermal convection in two-dimensional Cartesian geometry, B. J. Travis, C. Anderson, J. Baumgardner, C. W. Gable, B. H. Hager, R. O'Connell, P. Olson, A. Raefsky, and G. Schubert, *Geophysical and Astrophysical Fluid Dynamics, 55*, 137-160, 1990.

The relationship between plate velocity and trench viscosity in Newtonian and power-law subduction calculations, Scott D. King and Bradford H. Hager, *Geophys. Res. Lett.*, *17*, 2409-2412, 1990.

Geoid anomalies and dynamic topography from convection in cylindrical geometry: Applications to mantle plumes on Earth and Venus, W. S. Kiefer and B. H. Hager, *Geophys. J. Int.*, *108*, 1, 198-214, 1992.

Short-term earthquake hazard assessment for the southern San Andreas fault, southern California, D. Agnew, C. Allen, R. Bilham, M. Ghilarducci, B. Hager, E. Hauksson, K. Hudnut, D. Jackson, and A. Sylvester, *U.S. Department of the Interior U.S. Geological Survey,* USGS Open-file Report 91-32, 1991.

A mantle plume model for the Equatorial Highlands of Venus, W. S. Kiefer and B.H. Hager, *J. Geophys. Res.*, *96*, 20,947-20,966, 1991.

Plains tectonism on Venus: The deformation belts of Lavinia Planita, S. W. Squyres, D.

G. Jankowski, M. Simons, S. C. Solomon, B. H. Hager, and G. E. McGill, *J. Geophys. Res.*, *97*, 13,579-13,599, 1992.

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Topographic core-mantle coupling and fluctuations in the Earth's rotation, R. Hide, R. W. Clayton, B. H. Hager, M. A. Spieth, and C. V. Voorhies, *Geophys. Monog. Am. Geophys. Un., 76*, 107-120, 1993.

Detection of crustal deformation from the Landers earthquake sequence using continuous geodetic measurements, Y. Bock, D. C. Agnew, P. Fang, J. F. Genrich, B. H. Hager, T. A. Herring, K. W. Hudnut, R. W. King, S. Larsen, J.-B. Minster, K. Stark, S. Wdowinski, and F. K. Wyatt, *Nature, 361*, 337-340, 1993.

Earthquake research at Parkfield, 1993 and beyond – Report of the NEPEC Working Group to Evaluate the Parkfield Earthquake Prediction Experiment, B. H. Hager, C. A. Cornell, W. M. Medigovich, K. Mogi, R. M. Smith, L. T. Tobin, J. Stock, and R. Weldon, *U.S. Department of the Interior U.S. Geological Survey,* USGS Open-file Report 93622, 1993.

Earthquake research at Parkfield, 1993 and beyond – Report of the NEPEC Working Group to Evaluate the Parkfield Earthquake Prediction Experiment, B. H. Hager, C. A. Cornell, W. M. Medigovich, K. Mogi, R. M. Smith, L. T. Tobin, J. Stock, and R. Weldon, *U. S. Geological Survey Circular 1116*, 1994.

Space geodetic measurement of crustal deformation in central and southern California 1984-1992, K. L. Feigl, D. C. Agnew, Y. Bock, D. Dong, A. Donnellan, B. H. Hager, T. A. Herring, D. D. Jackson, T. H. Jordan, R. W. King, S. Larsen, K. M. Larson, M. H. Murray, Z-K Shen, and F. H. Webb, *J. Geophys. Res.*, *98*, 21,677-21,712, 1993.

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Subducted slabs and the geoid: 1. Numerical calculations with temperature-dependent viscosity, S. D. King and B. H. Hager, *J. Geophys. Res., 99,* 19843-19852, 1994.

Compositional versus thermal buoyancy and the evolution of subducted lithosphere, J. B. Gaherty and B. H. Hager, *Geophys. Res. Lett., 21*, 141-144, 1994.

Global variations in the geoid/topography admittance of Venus, M. Simons, B. H. Hager, and S. C. Solomon, *Science, 264*, 798-803, 1994.

Characterization of mantle convection experiments using two-point correlation functions, P. Puster, T. H. Jordan and B. H. Hager, *J. Geophys. Res*., *100*, 6351-6365, 1995.

A singularity free approach to post glacial rebound calculations, M. Fang and B. H.

Hager, *Geophys. Res. Lett*., *19*, 2131-2134, l994.

The singularity mystery associated with a radially inhomogeneous Maxwell viscoelastic structure, M. Fang and B. H. Hager, *Geophys. J. Int*., *123,* 849-865, 1995.

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Co-seismic displacements of the 1994 Northridge, California, Earthquake, K. W. Hudnut, Z. Shen, M. Murray, S. McClusky, R. King, T. Herring, B. Hager, Y. Feng, P. Fang, A. Donnellan, Y. Bock, *Bull. Seismo. Soc. Amer., 86*, S19 - S36, 1996.

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The elastic response of the earth to interannual variations in Antarctic precipitation, C. P. Conrad and B. H. Hager, *Geophys. Res. Lett*., *22*, 3183-3186, 1995.

Surface deformation caused by pressure changes in the fluid core, M. Fang, B. H. Hager, and T. A. Herring,*Geophys. Res. Lett*., *23*, 1493-1496, 1996.

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