

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

Papua New Guinea

**Date: 9/16/09
Updated**

1. General Information

1.1 Cruise name and/or #:	
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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:	James B. Gaherty
Address:	Doherty Research Scientist Columbia University Lamont-Doherty Earth Observatory 61 Rt 9W Palisades, NY 10964 USA
Telephone:	845-365-8450
Fax:	845-365-8150
Email:	Gaherty@LDEO.columbia.edu

Co PI Name:	Geoff Abers
Address:	Doherty Senior Research Scientist Columbia University Lamont-Doherty Earth Observatory 61 Rt 9W Palisades, NY 10964 USA Please view Dr. Abers CV at: http://www.ldeo.columbia.edu/~abers/
Telephone:	845-365-8539
Fax:	845-365-8150
Email:	abers@LDEO.columbia.edu

Co PI Name:	Suzanne L. Baldwin
Address:	Professor Thermochronology Department of Earth Sciences 204 Heroy Geology Laboratory Syracuse University Syracuse, NY 13244-1070 USA Please view Dr. Baldwins CV at: http://su-thermochronology.syr.edu/baldwin/baldwin.htm

Telephone:	315-443-4920
Fax:	315-443-3363
Email:	SBaldwin@syr.edu

1.4 Scientist(s) from coastal state involved in the planning of the project:	
Name(s):	See below.
Address:	

1.4 Scientific Collaborators in Papua New Guinea

The activities to be undertaken in this research cruise (deploying eight ocean-bottom seismometers) is one component of a large, international research program currently underway under the leadership of **Prof. Suzanne Baldwin** (Syracuse Univ) and **Prof. Geoff Abers** (LDEO – Columbia University). In planning for this project, Prof. Abers and Baldwin have developed collaborative relationships with several scientists within Papua New Guinea, and worked with provincial and national authorities to obtain research visas for on-shore work. The primary contacts include:

Prof. Hugh Davies (also currently Executive Manager, PNG Geological Survey)

Department of Geology
University of Papua New Guinea
University Post Office
National Capital District, PNG

Prof. Simon Kawagle

Department of Geology
UPNG

Prof. Joe Espi, Chair

Department of Geology
UPNG

Chris McKee, Director

Port Moresby Geophysical Observatory
Department of Mining
PMB PO
Port Moresby 121
Konedobu
Port Moresby, NCD, PNG

Mr. Nimrod Mark, Chair

Milne Bay Province research evaluation committee

Mr. Michael Kawagle, Environmental Liason

Milne Bay Province research evaluation committee

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:

2.1 Objectives: How did the islands of the Milne Bay Province form?

The Earth's lithosphere is divided up into plates that move relative to one another. The majority of earthquake and volcanic activity occurs on plate boundaries. Eastern Papua New Guinea formed over tens of millions of years as a result of the complicated interaction of two major plates – the Australian Plate and the Pacific Plate. First, collision between the plates formed high mountain belts underlain by thickened continental crust. Subsequently, the Woodlark Basin has opened up, stretching and extending the crust. As a consequence, the Milne Bay Province is one of the few places on Earth where a plate boundary is characterized by continental crust has pulled apart completely, transitioning to an ocean basin where new oceanic crust is created. The region's volcanic activity and seismic activity are a result of this plate boundary evolution, as its rich geology. We aim to understand how eastern Papua New Guinea formed over geologic time, and how this geologic evolution causes earthquakes and creates landforms.

Many of the islands in Milne Bay Province and mountains of the southeast Papua Peninsula show geologic features of the crust pulling apart, with rocks revealed on the surface that formed at depths deep within the crust. Our previous work in the region showed that these rock exposures corresponded to places where the deeper earth's mantle (the layer below the crust) has also been stretched, suggesting that the rifting is a deep-seated process (Abers et al., 2002). Recently, our collaborators have discovered that these deeply exhumed rocks are geologically young, 2-8 million years old, and some come from depths much greater than the crust, probably > 90 km, making them the youngest "ultra high pressure" metamorphic rocks on earth (Baldwin et al., 2004; Monteleone et al., 2007; Little et al., 2007). These rocks have since been exhumed to the surface at cm/yr rates, perhaps the highest vertical motions documented for any crustal rock. Their presence raises a major and unsolved question: how do rocks reach the earth's surface from such great depths? For example, are there large coherent faults, blobs of material ascending, or something else? How does this ascent relate to the rifting process? Similar but much older rocks have been found throughout the world, but these very young examples in Milne Bay Province provides us the best opportunity anywhere in the world to try to answer these questions. Doing this work will also tell us better how the islands and the crust beneath the waters of the Milne Bay Province formed, and will give us a better understanding of the locations and activities of earthquake-generating faults in the region, and of the origins of volcanoes in southeast Papua.

Methodology and Field Plan

This research group uses methods of earthquake seismology. The fieldwork portion of this project will run for approximately two years, 2010-2011, and will consist of two distinct components: (1) a deployment of 8 ocean-bottom seismographs (OBS) on the seafloor in and around the D'Entrecasteaux islands, for a duration of approximately 12 months; and (2) a deployment of approximately 30 land-based seismographs on the Papuan peninsula and the islands of Milne bay province, for a duration of approximately 18 months. This permit application is focused solely on the OBS deployment, which will be lead by Dr. James Gaherty (Columbia University – Lamont-Doherty Earth Observatory). The overall earthquake seismology program, including the land deployment, is coordinated by Dr. Geoffrey Abers (Columbia University – Lamont-Doherty Earth Observatory), and the research visas for the onshore activity are being applied for separately. The project is funded by the Continental Dynamics Program of the U.S. National Science Foundation (NSF), and is coordinated closely with an ongoing geological effort led by Prof. Suzanne Baldwin of Syracuse University. The group will convene scientific progress meetings on an annual basis during the course of this collaborative study to discuss planning, field operations/logistics, results,

and publications. We plan to involve Geology faculty at the University of Papua New Guinea and will give guest lectures there during the course of this study, and to train UPNG students in seismic field techniques. A copy of all data collected will be delivered to the UPNG Geology Department and either the Minerals Resources Administration (MRA) or Port Moresby Geophysical Observatory (PMGO), as desired. Additionally, a set of processed data will be made available freely on the internet at international facilities for seismic data (see below).

OBS deployment. We will establish for approximately 12 months a temporary network of broad-band ocean-bottom seismographs (OBS) across the region, to record earthquakes both in the study region and elsewhere in the world. The OBS are passive, autonomous instruments. They consist of a broad-band seismometer that senses ground displacement produced by earthquake, and a digital recording system to catalog the displacement data. Each instrument is dropped from the ship and sinks to the seafloor at predetermined locations (triangles on the included map). After approximately one year, we will return and recover the instruments by sending them a low-power acoustic command to release their anchor, allowing the instrument to float to the surface. The recorded earthquake signals are recovered from the instrument, and these data are then distributed to all collaborating scientists, including any interested PNG scientists. The data are also archived at the IRIS Data Management Center (www.iris.edu), and will be openly available to the international seismological community after a two-year embargo period.

Our research team will analyze the earthquake recordings to detect variations in physical properties in the Earth beneath the stations, which can then be interpreted in terms of varying rock type, temperature, and magma at depth. We will also locate all nearby microearthquakes that we record, anticipated to be many hundred very small earthquakes (magnitude < 3.0), so that we can characterize typical background activity in the region. These two sources of information will provide us with a better understanding of the geological processes that exhumed the young, high-pressure rocks, and ultimately help us understand how material is transported between the earth's interior and surface.

Related Work. This OBS network comprises a subset of the total seismograph array; the bulk of the network will be deployed on shore, at approximately 30 sites in the Milne Bay region. Most of the 30 field sites will be in Milne Bay Province (see **Map**), and the deployment activities will be based out of Alotau. It is anticipated that 1-2 sites will be in nearby parts of Oro province, and perhaps one site at Amazon Bay in Central province. These stations will be operated for approximately 18 months. The recorded data is nearly identical to that recorded by the OBS, and will be distributed to the project scientists and collaborators, and archived in the IRIS DMC in an identical manner. Onshore activities also include volcanic rock sampling and geologic mapping, much of which has been underway for the last 2 years. The onshore seismic and geological efforts are lead by Geoff Abers and Suzanne Baldwin, respectively, and have been permitted separately; they are included here for completeness.

All data will be integrated by **tectonic synthesis** to test end-member models proposed for the tectonic evolution of the region and address how eastern Papua New Guinea formed. Results will contribute to an improved understanding of the processes governing the origin, structure, composition, and dynamic evolution of continental building blocks. These processes include how the crust deforms, how previously subducted rocks are exhumed, and the fundamental processes by which the Earth's tectonic plates rift and rupture.

2.2 Relevant previous or future research cruises:

A number of previous research cruises have investigated extension in the D'Entrecasteaux and Woodlark region. The most relevant previous cruise was an OBS deployment associated with the WoodSeis seismic experiment in 1999-2000. Team leader Geoffrey Abers was a co-investigator on that experiment.

2.3 Previously published research data relating to the project:

Literature, including results from past research in PNG

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- Davies, H.L., and Smith, I.E., 1971, Geology of eastern Papua: *Bulletin of the Geological Society of America*, v. 82, p. 8299-8312.
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- Davies, H.L., and Jacques, A.L., 1984, Emplacement of ophiolite in Papua New Guinea: *Geological Society of London Special Publication*, v. 12, p. 341-350.
- Davies, H.L., Symonds, P.A., and Ripper, I.D., 1984, Structure and evolution of the southern Solomon Sea region: *Bureau of Mineral Resources Journal, Geology and Geophysics*, v. 9, p. 49-68.
- Davies, H.L., and Warren, R.G., 1988, Origin of eclogite-bearing, domed, layered metamorphic complexes (core complexes) in the D'Entrecasteaux Islands, Papua New Guinea: *Tectonics*, v. 7, p. 1-21.
- Davies, H.L., and Warren, R.G., 1992, Eclogites of the D'Entrecasteaux Islands: *Contributions to Mineralogy and Petrology*, v. 112, p. 463-474.
- Ferris, A., Abers, G.A., Zelt, B., Taylor, B., and Roecker, S., 2006, Crustal structure across the transition from rifting to spreading: the Woodlark rift system of Papua New Guinea: *Geophys. J. Int.*, v. 166, p. 622-634.
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- calculating the densities, seismic wave speeds, and H₂O contents of minerals and rocks at pressure and temperature: *Geochemistry, Geophysics, and Geosystems*, v. 5, p. Q01005, doi: 10.1029/2003GC000614.
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- Little, T. A., S. L. Baldwin, P. G. Fitzgerald, and B. Monteleone, 2007, Continental rifting and metamorphic core complex formation ahead of the Woodlark spreading ridge, D'Entrecasteaux Islands, Papua New Guinea, *Tectonics*, 26, TC1002, doi:10.1029/2005TC001911.
- Martinez, F., Goodliffe, A.M., and Taylor, B., 2001, Metamorphic core complex formation by density inversion and lower-crust extrusion: *Nature*, v. 411, p. 930-934.
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- Monteleone, B.D., Baldwin, S.L., Webb, L.E., Fitzgerald, P.G., Grove, M., and Schmitt, A., 2007, Evidence for late Miocene to Pliocene HP metamorphism in eclogites from the D'Entrecasteaux Islands, SE Papua New Guinea, *J. metamorphic Geol.*, 2007, 25, 245-265.
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- Smith, I.E.M., 1981, Young volcanoes in eastern Papua: *Geological Survey of Papua New Guinea Memoir*, v. 10, p. 257-265.
- Stolz, A.J., Davies, G.R., Crawford, A.J., and Smith, I.E.M., 1993, Sr, Nd, and Pb isotopic compositions of calc-alkaline and peralkaline silicic volcanics from the D'Entrecasteaux Islands, Papua New Guinea, and their tectonic significance: *Contributions to Mineralogy and Petrology*, v. 47, p. 103-126.
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Taylor, B., and Huchon, P., 2002, Active continental extension in the western Woodlark Basin: A synthesis of Leg 180 results, in Huchon, P., Taylor, B., and Klaus, A., eds., Proc. ODP, Sci. Results, 180, 1-36 [Online]. Available from: http://www-odp.tamu.edu/publications/180_SR/VOLUME/SYNTH/SYNTH.pdf.

Taylor, G.A.M., 1958, The 1951 eruption of Mount Lamington, Papua, Bureau of Mineral Resources Bulletin, Volume 38, Bureau of Mineral Resources, p. 129.

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Wallace, L.M., Stevens, C., Silver, E., McCaffrey, R., Hasiata, S., Stanaway, R., Curley, R., Rosa, R., and Taugaloida, J., 2004, GPS and seismological constraints on active tectonics and arc-continent collision in Papua New Guinea: implications for mechanics of microplate rotations in a plate boundary zone: Journal of Geophysical Research, v. 109, p. doi: 10.1029/2004JB003241.

Wallace, L.M., McCaffrey, R., Beavan, J., and Ellis, S., 2005, Rapid microplate rotations and backarc rifting at the transition between collision and subduction: Geology, v. 33, p. 857-860.

Webb, L.E., S.L., B., Little, T.A., and Fitzgerald, P.G., 2005, A pivoting microplate model for subduction eversion and exhumation of UHP terranes, Seventh International Eclogite Conference, Volume 150: Seggau, Austria, Mitt. Österr. Miner. Ges.

Zelt, B.C., Taylor, B. and Goodliffe, A.M., 2001. 3-D crustal velocity structure at the rift tip in the western Woodlark Basin. Geophys. Res. Lett., 28(15): 3015-3018.

3. Methods and Means to be Used

3.1 Particulars of vessel:	
Name:	<i>R/V Roger Revelle</i>
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. <hr/> 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
Continuous time-series of three-component ground velocity	Autonomous ocean-bottom seismograph deployed on the seafloor for approx. 1 year	Nanometrics seismometer, SIO datalogger
Differential pressure	Differential pressure measured at the seafloor	SIO differential pressure gauge
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:
No

3.5 Indicate whether drilling will be carried out:
No

3.6 Indicate whether explosives will be used:
No

4. Installations and Equipment

Details of installations and equipment (dates of laying, servicing, recovery; exact locations and depth):

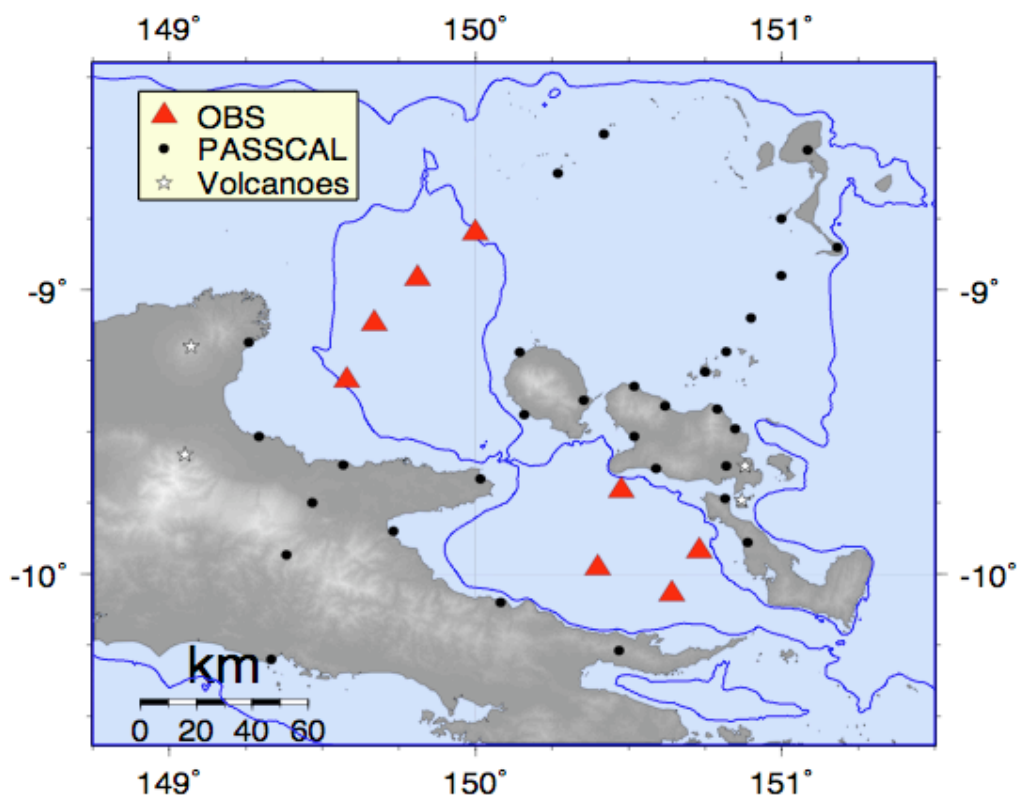
OBS will be deployed during a 2-3 day period in within 22 Feb – 16 March, 2010. They will be recovered approximately 12 months later. The approximate location and depth of each instrument are listed in a table on the attached chart.
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5. Geographical Areas

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

South and west of Fergusson and Normanby islands, within approx. 30 km of 10S, 150.5E Northwest of Goodenough island, within approx. 30 km of 9S, 149.8E

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.



Map of planned ocean-bottom seismograph (OBS) sites to be deployed on this research cruise (large red triangles), as well as associated on-shore PASSCAL deployment (small black dots). All OBS sites are in relatively deep water south and west of the D'Entrecasteaux Islands. Blue contour represents 400 m water depth. The on-shore PASSCAL deployment will be lead by Dr. Geoff Abers (LDEO -- Columbia University) and is being permitted separately.

Approximate OBS station locations:

Longitude (deg E)	Latitude (deg N)	Depth (m)
150.475	-9.707	889.
150.73	-9.92	797.
150.64	-10.07	1370.
150.3991	-9.98	1389.
149.58	-9.32	444.
149.67	-9.12	590.
149.81	-8.96	544.
150.00	-8.80	409.

6. Dates

6.1 Expected dates of first entry into and final departure from the research area of the research vessel:

This cruise is will be carried out during a planned transit from Wellington, New Zealand to Kaohsiung, Taiwan 20 February -18 March 2010. We will make an intermediate stop to transfer personnel in a Papua New Guinea port and date to be determined.

6.2 Indicated if multiple entry is expected:
Not likely.

7. Port Calls

7.1 Dates and names of intended ports of call:
To be determined

7.2 Any special logistical requirements at ports of call:
None

7.3 Name/Address/Telephone of shipping agent (if available):
To be determined.

8. Participation:

8.1 Extent to which coastal state will be enabled to participate or to be represented in the research project:
Berth(s) will be available for any PNG scientists interested in participating. Observers will also be accommodated as desired.

8.2 Proposed dates and ports for embarkation/disembarkation:
Personnel exchange mid cruise (no entry into port)

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:
June 30, 2010

9.2 Proposed means for access by coastal state to data and samples:
Direct delivery of computer disks by the scientist in charge. Open access to all data via the internet will also be available if that is preferred.

9.3 Proposed means to provide coastal state with assessment of data, samples and research results or provide assistance in their assessment or interpretation:
Results and reports will be delivered to the coastal state and PNG personnel as requested. Tools for data analysis will also be made available if there is interest.

9.4 Proposed means of making results internationally available:
Publication in internationally recognized journals. Data will be openly available to the international community via the IRIS data management center (www.iris.edu) two years after completion of the experiment.

James B. Gaherty



Doherty Research Scientist

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Palisades, NY 10964
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A. PROFESSIONAL PREPARATION

Brown University Sc.B., <i>Geology-Physics/Math</i>	1986
University of Michigan M.S., <i>Geology</i>	1990
Massachusetts Institute of Technology Ph.D., <i>Geophysics</i>	1995
Massachusetts Institute of Technology Post Doctoral Associate, <i>Geophysics</i>	6/95-12/97
Co-chief Scientist, EW0106, R/V <i>Maurice Ewing</i>	June, 2001
Chief Scientist, SCOoba-I, R/V <i>New Horizon</i>	October, 2005
Chief Scientist, SCOoba-II, R/V <i>New Horizon</i>	October, 2006

B. APPOINTMENTS

Lamont-Doherty Earth Observatory of Columbia University <i>Doherty Research Scientist</i>	7/06-present
Lamont-Doherty Earth Observatory of Columbia University <i>Doherty Associate Research Scientist</i>	9/03-6/06
Georgia Institute of Technology <i>Assistant Professor</i>	1/98-8/03

C. PUBLICATIONS

(i) 5 most relevant to this proposal

*Hansen, S.E., J.B. Gaherty, S.Y. Schwartz, A.J. Rodgers, and A.M.S. Al-Amri, Seismic velocity structure and depth-dependence of anisotropy in the Red Sea and Arabian Shield from surface-wave analysis, *J. Geophys. Res.*, 113, B10307, doi:10.1029/2007JB005335, 2008.

Delorey, A.A., R.A. Dunn, and J.B. Gaherty, Surface Wave Tomography of the Upper Mantle Beneath the Reykjanes Ridge with Implications for Ridge-Hotspot Interaction, *J. Geophys. Res.*, 112, B08313, doi:10.1029/2006JB004785, 2007.

Gaherty, J.B. and R.A. Dunn, Evaluating hotspot-ridge interaction in from Atlantic from regional-scale seismic observations, *Geochem. Geophys. Geosyst.*, 8, Q05006, doi:10.1029/2006GC001533, 2007.

Gu, Y.J., S.C. Webb, A. Lerner-Lam, and J.B. Gaherty, Upper-mantle structure beneath the eastern Pacific Ocean ridges, *J. Geophys. Res.*, 110, B06305, doi:10.1029/2004JB003381, 2005.

Gaherty, J.B., A surface-wave analysis of seismic anisotropy beneath eastern North America, *Geophys. J. Int.*, 158, 1053-1066, 2004.

(ii) 5 other publications

Gaherty, J.B., Seismic evidence for hotspot-driven buoyant upwelling beneath the Reykjanes Ridge, *Science*, 293, 1645-1647, 2001.

Gaherty, J.B., D. Lizarralde, J. Collins, G. Hirth, and S. Kim, Mantle deformation during slow seafloor spreading constrained by observations of seismic anisotropy in the western Atlantic, *Earth Planet. Sci. Lett.*, 228, 255-265, 2004.

Lizarralde, D., J.B. Gaherty, J.A. Collins, G. Hirth, and S. Kim, Spreading-rate dependence of melt extraction at mid-ocean ridges from far-offset seismic data, *Nature*, 432, 744-747, 2004.

Gaherty, J.B., M. Kato, and T.H. Jordan, Seismological structure of the upper mantle: A regional comparison of seismic layering, *Phys. Earth Planet. Inter.*, 110, 21-41, 1999.

Gaherty, J.B., T.H. Jordan, and L.S. Gee, Seismic structure of the upper mantle in a central Pacific Corridor, *J. Geophys. Res.*, 101, 22,291-22,309, 1996.

D. SYNERGISTIC ACTIVITIES

Associate Editor, <i>G-cubed</i>	5/03-present
Proposal-review Panel, NSF MG&G, Geophysics, MARGINS Programs	2002, 2003, 2005
Incorporated Research Institutions in Seismology:	
Vice-Chair, Board of Directors	1/09-present
Board of Directors	1/07-1/09
Standing Committee, Global Seismic Network	1/01-1/04

E. COLLABORATORS AND OTHER AFFILIATIONS

(i) Collaborators (non-LDEO)

S. Baldwin (Syracuse)
M. Bostock (U. British Columbia)
P. Chen (U. Wyoming)
J. Collins (WHOI)
C. Dalton (Boston U.)
P. Fitzgerald (Syracuse)
E. Garnero (Arizona State)

B. Hacker (UCSB)
V. Levin (Rutgers)
P. Mann (Texas)
J. Revenaugh (U. Minnesota)
M. Roy (UNM)
L. Zhao (Academia Sinica, TW)

(ii) Graduate and Post-Doctoral Advisors

Ph.D. and Post-Doc: Thomas H. Jordan
M.S.: Thorne Lay

(iii) Student Advisees

Graduate: Anna Foster, Charles George, Praseon Gupta, Sangmyung Kim, Kori Newman,
Yongcheol Park, Ashley Shuler, Danielle Stroup

Undergraduate: Jessica Demoise, Alex Hutko, Katie Kirsch, Amanda Markee, Steve
Scharf

