

# **The Loma Prieta, California, Earthquake of October 17, 1989**

Tables of Contents for  
**U.S. Geological Survey Professional Papers 1550 through 1553**

Professional Paper 1550, Earthquake occurrence  
*Coordinators: William H. Bakun and William H. Prescott*

Professional Paper 1551, Strong ground motion and ground failure  
*Coordinator: Thomas L. Holzer*

Professional Paper 1552, Performance of the built environment  
*Coordinator, Thomas L. Holzer*

Professional Paper 1553, Societal response  
*Coordinator: Dennis S. Mileti*

**Contents**  
**Professional Paper 1550-A**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Main Shock Characteristics**  
**Paul Spudich, *Editor***

-----

	Page
Synopsis	
by Paul Spudich.....	A1
Rupture history of the earthquake from high-frequency strong-motion data	
by Gregory C. Beroza.....	9
Source characteristics of the earthquake from global digital seismic data	
by George L. Choy and John Boatwright .....	33
Comparison of $L_1$ and $L_2$ norms in a teleseismic-waveform inversion for the rupture history of the earthquake	
by Stephen H. Hartzell, Gordon S. Stewart, and Carlos Mendoza.....	39
Frequency-domain inversion for the rupture characteristics during the earthquake, using strong-motion data and geodetic observations	
by Stephen Horton, John G. Anderson, and Andres J. Mendez.....	59
Broadband study of the source characteristics of the earthquake	
by Hiroo Kanamori and Kenji Satake .....	75
Geodetic measurements of coseismic horizontal deformation	
by Michael Lisowski, Mark H. Murray, and Jerry L. Svarc .....	81
Elevation changes associated with the earthquake and their use to infer fault-slip geometry	
by Grant A. Marshall and Ross S. Stein.....	105
Main-shock and very early aftershock activity	
by Karen C. McNally, Gerald W. Simila, and Judy G. Brown .....	147
Downdip geometry of the Loma Prieta rupture from teleseismic-waveform inversion	
by John L. Náb_ek .....	171
Mechanical modeling of fault-fold system, with application to the earthquake	
by Ze'ev Reches and Mark D. Zoback.....	183
Are rupture models consistent with geodetic measurements?	
by Jamison H. Steidl and Ralph J. Archuleta .....	195
Long-period surface-wave observations of the earthquake	
by Aaron A. Velasco, Thorne Lay, and Jiajun Zhang.....	209
Source parameters of the earthquake, determined by using long-period seismic waves	
by Aaron A. Velasco, Thorne Lay, and Jiajun Zhang.....	215

Strong-motion and broadband teleseismic analysis of the earthquake for rupture-process modeling and hazard assessment by David J. Wald, Donald V. Helmberger, and Thomas H. Heaton .....	235
Coseismic displacements measured with the Global Positioning System by Chesley R. Williams and Paul Segall .....	263
Estimation of the rupture velocity of the main shock from the Love-wave group velocity by Francis T. Wu .....	279
Use of stress-drop models to interpret Geodelite/Global Positioning System and leveling measurements at Loma Prieta by Mingdong Wu and John W. Rudnicki.....	289

**Contents**  
**Professional Paper 1550-B**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Forecasts**  
**Ruth A. Harris, *Editor***

-----

	Page
Preface.....	III
Abstract.....	B1
Introduction.....	B1
The forecasts.....	B5
Reid.....	B5
Willis.....	B6
Tocher.....	B6
Thenhaus and others.....	B7
Ellsworth and others.....	B7
U.S. Geological Survey.....	B7
Moths and others.....	B7
Lindh and others.....	B8
Sykes and Nishenko.....	B9
Scholz.....	B10
Keilis-Borok and others.....	B10
Thatcher and Lisowski.....	B11
Wesson and Nicholson.....	B13
Working Group on California Earthquake Probabilities.....	B15
Davis (Lake Elsman earthquakes).....	B17
Kerr.....	B17
The 1989 Loma Prieta earthquake.....	B18
Comparison of the forecasts with the 1989 Loma Prieta earthquake.....	B19
Post-Loma Prieta information that might have led to different forecasts.....	B19
1906 slip models—geologic information.....	B20
1906 slip models—geodetic information.....	B21
San Andreas fault-slip-rate measurements.....	B21
Was the 1989 Loma Prieta earthquake an anticipated event?.....	B21
Summary.....	B22
Acknowledgments.....	B22
References cited.....	B23
Appendixes:	
1. Definition of an earthquake advisory.....	B25
2. The Lake Elsman advisory.....	B25
3. Peck and Pearlman correspondences.....	B26

**Contents**  
**Professional Paper 1550- C**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Preseismic Observations**  
**Malcolm J.S. Johnston, *Editor***

-----

	Page
Introduction	
by Malcolm J.S. Johnston.....	C1
Seismicity in the southern Santa Cruz Mountains during the 20-year period before the earthquake	
by Jean A. Olson and David P. Hill .....	3
Analysis of low-frequency-electromagnetic-field measurements near the epicenter	
by Anthony C. Fraser-Smith, Arman Bernardi, Robert A. Helliwell, Paul R. McGill, and O.G. Villard, Jr.....	17
Seismomagnetic effects	
by Robert J. Mueller and Malcolm J.S. Johnston .....	27
Near-source short- to intermediate-period ground motions	
by Randall A. White and William L. Ellsworth .....	31
A reported streamflow increase	
by Evelyn Roeloffs .....	47
Near-field high-resolution strain measurements	
by Malcolm J.S. Johnston and Alan T. Linde.....	53
A shear-strain precursor	
by Michael T. Gladwin, Ross L. Gwyther, and Rhodes H.G. Hart .....	59
No convincing precursory geodetic anomaly observed	
by Michael Lisowski, James C. Savage, William H. Prescott, Jerry L. Svarc, and Mark H. Murray.....	67
Detection of hydrothermal precursors to large northern California earthquakes	
by Paul G. Silver, Natalie J. Valette-Silver, and Olga Kolbek.....	73
Borehole strain measurements of solid-earth-tidal amplitudes	
by Alan T. Linde, Michael T. Gladwin, and Malcolm J.S. Johnston .....	81

**Contents**  
**Professional Paper 1550- D**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Aftershocks and Postseismic Effects**  
**Paul A. Reasenber, *Editor***

-----

	Page
Introduction	
by Paul A. Reasenberg.....	D1
Aftershocks of the Loma Prieta earthquake and their tectonic implications	
by Lynn D. Dietz and William L. Ellsworth.....	5
Response of regional seismicity to the static stress change produced by the Loma Prieta earthquake	
by Paul A. Reasenberg and Robert W. Simpson .....	49
Spatial variations in stress from the first six weeks of aftershocks of the Loma Prieta earthquake	
By John W. Gephart .....	73
Loma Prieta aftershock relocation with S-P travel times from a portable array	
by Susan Y. Schwartz and Glenn D. Nelson.....	91
Empirical Green’s function study of Loma Prieta aftershocks: determination of stress drop	
by H. Guo, A. Lerner-Lam, W. Menke, and S.E. Hough .....	105
U.S. Geological Survey aftershock ground-motion data	
by Leif Wennerberg .....	121
Response of U.S. Geological Survey creepmeters to the Loma Prieta earthquake	
by K. S. Breckenridge and R.W. Simpson .....	143
Increased surface creep rates on the San Andreas fault southeast of the Loma Prieta main shock	
by Jeff Behr, Roger Bilham, Paul Bodin, Kate Breckenridge, and Arthur G. Sylvester.....	179
Effect of the Loma Prieta earthquake on fault creep rates in the San Francisco Bay region	
by Jon S. Galehouse. ....	193
Postseismic strain following the Loma Prieta earthquake from repeated GPS measurements	
by Roland Bürgmann, Paul Segall, Mike Lisowski, and Jerry L. Svarc .....	209
Shallow, postseismic slip on the San Andreas fault at the northwestern end of the Loma Prieta earthquake rupture zone	
by John Langbein. ....	245

Models of postseismic deformation and stress transfer associated with the Loma Prieta earthquake by M.F. Linker and J.R. Rice.....	253
A shear strain anomaly following the Loma Prieta earthquake by M.T. Gladwin, R.L. Gwyther, and R.H.G. Hart.....	277
A magnetotelluric survey of the Loma Prieta earthquake area: implications for earthquake processes and lower crustal conductivity by Randall L. Mackie, Theodore R. Madden, and Edward A. Nichols.....	289

**Contents**  
**Professional Paper 1550 - F**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Tectonic Processes and Models**  
**Robert W. Simpson, *Editor***

-----

	Page
Introduction by Robert W. Simpson.....	F1
Relations between folding and faulting in the Loma Prieta epicentral zone: Strike-slip fault-bend folding by John H. Shaw, Richard E. Bischke, and John Suppe.....	3
Geologic assessment of the relative contribution of strike-slip faulting, reverse-slip faulting, and bulk squeezing in the creation of the central Santa Cruz Mountains, California by Gianluca Valensise.....	23
Complex fault interactions in a restraining bend on the San Andreas fault, southern Santa Cruz Mountains, California by Susan Y. Schwartz, Daniel L. Orange, and Robert S. Anderson.....	49
Earthquake-induced static-stress changes on central California faults by Robert W. Simpson and Paul A. Reasenberg .....	55
Cumulative slip along the peninsular section of the San Andreas fault, California, estimated from two-dimensional boundary-element models of historical rupture by Paul Bodin and Roger Bilham.....	91
Three-dimensional lithospheric kinematics in the Loma Prieta region, California: Implications for the earthquake cycle by Kevin P. Furlong and David Verdonck .....	103



**Contents**  
**Professional Paper 1551-A**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Strong Ground Motion**  
**Roger D. Borcherdt, *Editor***

-----

	Page
Synopsis	
by Roger D. Borcherdt.....	A1
Strong-motion recordings	
by A. Gerald Brady and Anthony F. Shakal .....	9
Effect of known three-dimensional crustal structure on the strong ground motion and estimated slip history of the earthquake	
by Vernon F. Cormier and Wei-Jou Su.....	39
Simulation of strong ground motion	
by Jeffrey L. Stevens and Steven M. Day .....	53
Influence of near-surface geology on the direction of ground motion above a frequency of 1 Hz	
by John E. Vidale and Ornella Bonamassa .....	61
Effect of critical reflections from the Moho on the attenuation of strong ground motion	
by Paul G. Somerville, Nancy F. Smith, and Robert W. Graves.....	67
Influences of local geology on strong and weak ground motions recorded in the San Francisco Bay region and their implications for site-specific building-code provisions	
by Roger D. Borcherdt and Gary Glassmoyer .....	77
Ground response on Treasure Island	
by Kyle M. Rollins, Michael D. Mchood, Roman D. Hryciw, Matthew Homolka, and Scott E. Shewbridge.....	109
Ground-response studies at the Alameda Naval Air Station	
by Harvey Carlisle and Kyle M. Rollins.....	123
Behavior of young bay mud from the Marina District of San Francisco under static and cyclic simple shear	
by Nicholas Sitar and Rodrigo Salgado.....	145
Deep instrumentation array at the Treasure Island Naval Air Station	
by Pedro de Alba, Jean Benoît, Daniel G. Pass, John J. Carter, T. Leslie Youd, and Anthony F. Shakal .....	155
Site response in Oakland, California, near the failed section of the Nimitz Freeway	
by E.H. Field, Susan E. Hough, Klaus H. Jacob, and Paul A. Friberg.....	169

Aftershock observations from a dense array in Sunnyvale, California by Arthur Frankel, Susan E. Hough, Paul Friberg, and Robert Busby.....	181
A three-dimensional simulation of seismic waves in the Santa Clara Valley, California, from an aftershock by Arthur Frankel and John E. Vidale.....	197
Site-response models from high-resolution seismic reflection and refraction data recorded in Santa Cruz, California by Robert A. Williams, Edward Cranswick, and Kenneth W. King.....	217
Variation of seismic site effects in the Santa Cruz Mountains, California by Grant T. Lindley and Ralph J. Archuleta.....	243
A post-earthquake reevaluation of seismic hazard in the San Francisco Bay region by Janice M. Murphy and Steven G. Wesnousky .....	255

**Contents**  
**Professional Paper 1551- B**  
**The Loma Prieta, California, Earthquake of October 17,**  
**1989—Liquefaction**  
**Thomas L. Holzer, *Editor***

-----

	Page
Introduction	
by Thomas L. Holzer.....	B1
Liquefaction characteristics of San Francisco bayshore fills	
by Jean Lou A. Chameau, G. Wayne Clough, J. David Frost, and Fernando A.M. Reyna .....	9
Soil liquefaction in the east bay during the earthquake	
by Robert E. Kayen, James K. Mitchell, Raymond B. Seed, and Shin'ya Nishio .....	61
Analysis of liquefaction-induced damage on Treasure Island	
by Maurice S. Power, John A. Egan, Scott E. Shewbridge, John deBecker, and J. Richard Faris.....	87
Sand boils and settlement on Treasure Island after the earthquake	
by Michael J. Bennett .....	121
Liquefaction at Moss Landing	
by Lelio H. Mejia .....	129
Observations of multiple liquefaction events at Soda Lake, California, during the earthquake and its aftershocks	
by John D. Sims and Cristofer D. Garvin .....	151
Postearthquake investigations at liquefaction sites in Santa Cruz and on Treasure Island	
by Roman D. Hryciw, Scott E. Shewbridge, Alan Kropp, and Matthew Homolka .....	165
Direct measurement of liquefaction potential in soils of Monterey County, California	
by Wayne A. Charlie, Donald O. Doehring, Jeffrey P. Brislawn, and Hassen Hassen.....	181
Comparison of computed and measured liquefaction-induced settlements in the Marina District, San Francisco, California	
by Kyle M. Rollins and Michael D. McHood .....	223
Improved-ground performance during the earthquake	
by James K. Mitchell and Frederick J. Wentz, Jr.....	241
Evaluation of liquefaction hazard mapping in the Monterey Bay Area, Central California	
by William R. Dupré and John C. Tinsley, III.....	273
Appendix: Maps and descriptions of liquefaction and associated effects	

by John C. Tinsley, III, John A. Egan, Robert E. Kayen,  
Michael J. Bennett, Alan Kropp, and Thomas L. Holzer.....287

Plates

1. Locations of ground failure features and distress to facilities on Treasure Island from the earthquake.
2. Liquefaction and associated effects in the San Francisco Bay area from the earthquake.
3. Liquefaction and associated effects in the Monterey Bay area from the earthquake.

**Contents**  
**Professional Paper 1551- C**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Landslides**  
**David K. Keefer, *Editor***

-----

	Page
Introduction	
by David K. Keefer.....	C1
Regional distribution and characteristics of landslides generated by the earthquake	
by David K. Keefer and Michael W. Manson.....	7
Coastal-bluff failures in northern Monterey Bay induced by the earthquake	
by Gary B. Griggs and Nathaniel Plant.....	33
Landslide dams in Santa Cruz County, California, resulting from the earthquake	
by Robert L. Schuster, Gerald F. Wiczorek, and David G. Hope II.....	51
Large landslides near the San Andreas fault in the Summit Ridge area, Santa Cruz Mountains, California	
by David K. Keefer, Gary B. Griggs, and Edwin L. Harp .....	71
Origin of fractures triggered by the earthquake in the Summit Ridge and Skyland Ridge areas and their relation to landslides	
by Edwin L. Harp .....	129
Evaluation of coseismic ground cracking accompanying the earthquake: Trenching studies and case histories	
by Jeffrey M. Nolan and Gerald E. Weber .....	145
Analysis of earthquake-reactivated landslides in the epicentral region, central Santa Cruz Mountains, California	
by William F. Cole, Dale R. Marcum, Patrick O. Shires, and Bruce R. Clark .....	165

Plates

1. Landslides and ground cracks generated by the 1989 Loma Prieta earthquake in the Santa Cruz Mountains and along adjacent sections of the California coast.
2. Landslides and ground cracks generated by the 1989 Loma Prieta earthquake in the Laurel and Loma Prieta quadrangles.
3. Large landslides, coseismic ground cracks, and geology in the summit ridge area, Santa Cruz Mountains, California.
4. Landslide features and coseismic fissures in the Summit Ridge and Skyland areas generated by the 1989 Loma Prieta earthquake.

**Contents**  
**Professional Paper 1551-E**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Hydrologic Disturbances**  
**Stuart Rojstaczer, *Editor***

-----

	Page
Introduction by Stuart Rojstaczer .....	E1
The origin of the tsunami excited by the earthquake—faulting or slumping by Kuo-Fong Ma, Kenji Satake, and Hiroo Kanamori .....	3
Stream-channel adjustment in Fern Canyon near Watsonville, California, after the earthquake by Deborah R. Harden and Dennis Fox.....	11
Effects of the earthquake on surface waters in Waddell valley by Robert O. Briggs.....	21
Sources and magnitudes of increased streamflow in the Santa Cruz Mountains for the 1990 water year after the earthquake by Robert R. Curry, Brett A. Emery, and Tom Gentry Kidwell.....	31
Hydrologic changes associated with the earthquake in the San Lorenzo and Pescadero drainage basins by Stuart Rojstaczer and Stephen Wolf .....	51

**Contents**  
**Professional Paper 1551-F**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Marina District**  
**Thomas D. O'Rourke, *Editor***

-----

	Page
.....	
Introduction	
by Thomas D. O'Rourke.....	F1
Geologic and historical factors affecting earthquake damage	
by M.G. Bonilla .....	7
Ground-motion amplification	
by John Boatwright, Linda C. Seekins, Thomas E. Fumal, Hsi-Ping Liu, and Charles S. Mueller .....	35
Observation of local site effects at a downhole-and-surface station	
by Hsi-Ping Liu, Richard E. Warrick, Robert E. Westerlund, Eugene D. Sembera, and Leif Wennerberg.....	51
Determination of the dynamic shear modulus of Holocene bay mud for site-response analysis	
by Harry E. Stewart and Ashraf K. Hussein.....	75
Site-response analyses	
by J.-P. Bardet, M. Kapuskar, G.R. Martin, and J. Proubet.....	85
Behavior of the seawalls and shoreline during the earthquake	
by H.T. Taylor, J.T. Cameron, S. Vahdani, and H. Yap .....	141
Lifeline performance and ground deformation during the earthquake	
by Thomas D. O'Rourke, Jonathan W. Pease, and Harry E. Stewart .....	155
Effects of ground conditions on the damage to four-story corner apartment buildings	
by Stephen K. Harris and John A. Egan.....	181
Performance of emergency-response services after the earthquake	
by Charles R. Scawthorn, Keith A. Porter, and Frank T. Blackburn.....	195

**Contents**  
**Professional Paper 1552-A**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Lifelines**  
**Anshel J. Schiff, *Editor***

-----

	Page
Introduction.....	1
By Anshel J. Schiff	
Electrical-power systems.....	5
By Anshel J. Schiff, Sam Swan, and Edward N. Matsuda	
Communication systems.....	23
By Anshel J. Schiff, Alex Tang, Lawrence F. Wong, and Luis Cusa	
Modeling the impact of the earthquake on telecommunication services.....	37
By Michael L. Cohen	
The media: Radio, television, and newspapers.....	43
By Richard J. Rapaport	
Water and wastewater systems.....	47
By LeVal Lund, John McLaughlin, Curt Edwards, Gordon Laverty, Holly Cornell, Alvin R. Guerrero, Michael Cassaro, Andries Godshack, George Brodt, Donald B. Ballantyne, Ronald Eguchi, Mary Pickett, Omar Abu-Yasein, Chenwun Lay, Anshel J. Schiff, James R. Blacklock, and Steven French	
Water-distribution system.....	63
By John M. Eidinger	
Water- and wastewater-treatment plants.....	79
By William Heuback and Donald B. Ballantyne	
Lessons learned by water and wastewater utilities.....	87
By Mark Pickett and Gordon L. Laverty	
Transportation systems.....	99
By Joel Markowitz	
Transportation systems—airports.....	103
By Anshel J. Schiff and Luis Cusa	
Transportation systems—seaports.....	111
By Charles R. Farrar and A. Claude Griffin	
Transportation systems—passenger railways and buslines.....	121
By Stuart D. Werner and Anshel J. Schiff	



Residential natural-gas piping and appliances.....	125
By Peter W. McDonough	
Repair patterns for the gas-distribution system in San Francisco.....	129
By Douglas G. Honegger	

**Contents**  
**Professional Paper 1552-B**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Highway Systems**  
**Mark Yashinsky, *Editor***

	Page
Abstract.....	1
Introduction.....	1
References.....	6
Bridge damage.....	6
References.....	10
Major damage in the city of Oakland.....	13
San Francisco-Oakland Bay Bridge:	
East Bay Crossing.....	13
Description of bridge.....	13
Bridge damage.....	14
Analysis of damage.....	14
Bridge repair.....	16
References.....	17
Cypress Street Viaduct.....	19
Description of bridge.....	19
Bridge damage.....	19
Rescue efforts.....	19
Testing and demolition.....	22
New bridge construction.....	26
References.....	26
Route 980 Southbound Connector.....	29
Description of bridge.....	29
Bridge damage.....	29
Bridge repair.....	31
References.....	32
Port of Oakland Overcrossing.....	32
Description of bridge.....	32
Bridge damage.....	35
Bridge repair.....	35
References.....	35
Distribution structure.....	37
Description of bridge.....	37
Bridge damage.....	39
Bridge repair.....	39
References.....	39
Fifth Avenue Overhead.....	42
Description of bridge.....	42
Bridge damage.....	42

**Contents**  
**Professional Paper 1552- C**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Building Structures**  
**Mehmet Celebi, *Editor***

-----

	Page
Introduction	
by Mehmet Celebi.....	C1
Performance of building structures—A summary	
by Mehmet Celebi.....	5
Measured response of two tilt-up buildings	
by Sharon L. Wood and Neil M. Hawkins.....	77
Seismic response of a six-story reinforced concrete building	
by James C. Anderson and Vitelmo V. Bertero.....	91
Seismic respons of a 42-story building	
by James C. Anderson and Vitelmo V. Bertero .....	113
A summary of unreinforced masonry building damage patterns—Implications for improvements in loss-estimation methodologies	
by Bret Lizundia, Weimin Dong, William T. Holmes, and Robert Reitherman.....	141
Housing repair and reconstruction after the earthquake	
by Mary C. Comerio .....	161
Impact of the earthquake on habitability of housing units	
by Jeanne B. Perkins and Ben Chuaqui.....	169

**Contents**  
**Professional Paper 1552-D**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Earth Structures and**  
**Engineering Characterization of**  
**Ground Motion**  
**Mark Yashinsky, *Editor***

	Page
Introduction.....	D1
By Thomas L. Holzer	
Performance of earth dams during the Loma Prieta earthquake.....	3
By L.F. Harder, J.D. Bray, R.L. Volpe, and K.V. Rodda	
Analysis of soil-nailed excavations stability during the 1989 Loma Prieta earthquake.....	27
By Mladen Vucetic, Mark R. Tufenkjian, Guy Y. Felio, Pirooz Barar and K. Ronald Chapman	
Empirical analysis of peak horizontal acceleration, peak horizontal velocity, and modified mercalli intensity.....	47
By Kenneth W. Campbell	
Attenuation of vertical and horizontal response spectra of the Loma Prieta earthquake.....	69
By Yousef Bozorgnia and Mansour Niazi	

**Contents**  
**Professional Paper 1553- A**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Loss Estimation and Procedures**  
**Susan K. Tubbesing, *Editor***

-----

	Page
Introduction by Susan K. Tubbesing.....	A1
Review, evaluation, and revision of the ATC-20 post-earthquake building safety evaluation procedures to include the Loma Prieta earthquake by Robert A. Bruce.....	3
Casualties and emergency medical response by Michael E. Durkin, Charles C. Thiel Jr., and James E. Schneider .....	9
Study methods and progress report: A case-control study of physical injuries associated with the earthquake in the county of Santa Cruz by Robin M. Wagner, Nicholas P. Jones, Gordon S. Smith, and Frederick Krimgold.....	39
Preliminary statistics on losses associated with ground deformation by Craig E. Taylor, Hope A. Seligson, David Fowler, and Craig W. Tillman .....	63

**Contents**  
**Professional Paper 1553- B**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Public Response**  
**Patricia A. Bolton, *Editor***

-----

	Page
Introduction	
by Patricia A. Bolton .....	B1
Human behavior during and immediately after the earthquake	
by Linda B. Bourque, Lisa A. Russell, and James D. Goltz.....	3
Citizen participation in emergency response	
by Paul W. O'Brien and Dennis S. Mileti .....	23
Public response to aftershock warnings	
by Dennis S. Mileti and Paul W. O'Brien .....	31
Emergency sheltering and housing of earthquake victims: the case of Santa Cruz County	
by Robert C. Bolin and Lois M. Stanford .....	43
Building content hazards and behavior of mobility-restricted residents	
by Mansour Rahimi and Glenn Azevedo.....	51
Earthquake preparedness behavior of students and nonstudents	
by John-Paul Mulilis and T. Shelley Duval.....	63

**Contents**  
**Professional Paper 1553- C**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Fire, Police,**  
**Transportation and Hazardous Materials**  
**Craig Van Anne and Charles Scawthorn, *Editors***

-----

	Page
Introduction by Craig Van Anne and Charles Scawthorn .....	C1
The first day’s response by the Oakland Fire Department to the earthquake—the Cypress Freeway collapse by Reginald Garcia, Neil Honeycutt, and Craig Van Anne.....	3
Recovery in the midst of disaster—managing access to the Cypress Freeway collapse by Anthony J. Hare, Robert W. Nichelini, and Peter C. Sarna 11	
Bay Area emergency ferry service—transportation relief after the earthquake by Richard M. Fahey and George E. Gray .....	17
Hazardous materials problems due to the earthquake by Jeanne B. Perkins and G. Edward Wyatt .....	29
Earthquake and hazardous materials—a state emergency management perspective focusing on the earthquake by Paul J. Penn .....	39

**Contents**  
**Professional Paper 1553-D**  
**The Loma Prieta, California, Earthquake of**  
**October 17, 1989—Recovery, Mitigation, and Reconstruction**  
**Joanne M. Nigg, *Editor***

	Page
Introduction.....	D1
<i>By Joanne M. Nigg</i>	
Macroeconomic effects of the earthquake.....	3
<i>By Raymond J. Brady and Jeanne B. Perkins</i>	
Sheltering and housing of low-income and minority groups in Santa Cruz County after the Loma Prieta earthquake.....	17
<i>By Brenda D. Phillips</i>	
Hazards mitigation and housing recovery—Watsonville and San Francisco one year later.....	29
<i>By Mary C. Comerio</i>	
Local earthquake mitigation programs—perceptions of their effectiveness following the Loma Prieta earthquake.....	35
<i>By Patricia A. Bolton and Carlyn E. Orians</i>	
Rebuilding after the earthquake in areas of ground failure, Santa Cruz Mountains summit area.....	53
<i>By Martha Blair Tyler and George G. Mader</i>	
The State of California’s response to the Loma Prieta earthquake.....	63
<i>By Charles C. Thiel, Jr., George W. Housner, and L. Thomas Tobin</i>	
Earth science, earthquake response, and hazard mitigation: lessons from the Loma Prieta earthquake.....	81
<i>By William M. Brown III and Carl E. Mortensen</i>	



## References, U.S. Geological Survey Professional Papers 1550 through 1553

- Bolton, P.A., ed., 1993, The Loma Prieta, California, Earthquake of October 17, 1989—Public response: U.S. Geological Survey Professional Paper 1553-B, 69 p.
- Borcherdt, R.D., ed., 1994, The Loma Prieta, California, Earthquake of October 17, 1989—Strong ground motion: U.S. Geological Survey Professional Paper 1551-A, 272 p.
- Çelebi, Mehmet, ed., 1998, The Loma Prieta, California, Earthquake of October 17, 1989—Building structures: U.S. Geological Survey Professional Paper 1552-C, 186 p.
- Harris, R.A., ed., 1998, The Loma Prieta, California, Earthquake of October 17, 1989—Forecasts: U.S. Geological Survey Professional Paper 1550-B, 28 p.
- Holzer, T.L., ed., 1998, The Loma Prieta, California, Earthquake of October 17, 1989—Liquefaction: U.S. Geological Survey Professional Paper 1551-B, 314 p.
- Johnston, M.J.S., ed., 1993, The Loma Prieta, California, Earthquake of October 17, 1989—Preseismic observations: U.S. Geological Survey Professional Paper 1550-C, 85 p.
- Keefer, D.K., ed., 1998, The Loma Prieta, California, Earthquake of October 17, 1989—Landslides: U.S. Geological Survey Professional Paper 1551-C, 185 p.
- Nigg, J.M., ed., 1998, The Loma Prieta, California, Earthquake of October 17, 1989—Recovery, mitigation, and reconstruction: U.S. Geological Survey Professional Paper 1553-D, 90 p.
- O'Rourke, T.D., ed., 1992, The Loma Prieta, California, Earthquake of October 17, 1989—Marina District: U.S. Geological Survey Professional Paper 1551-F, 215 p.
- Reasenber, P.A., ed., 1997, The Loma Prieta, California, Earthquake of October 17, 1989—Aftershocks and postseismic effects: U.S. Geological Survey Professional Paper 1550-D, 312 p.
- Rojstaczer, Stuart, ed., 1994, The Loma Prieta, California, Earthquake of October 17, 1989—Hydrologic disturbances: U.S. Geological Survey Professional Paper 1551-E, 64 p.
- Schiff, A.J., ed., 1998, The Loma Prieta, California, Earthquake of October 17, 1989—Lifelines: U.S. Geological Survey Professional Paper 1552-A, 133 p.
- Simpson, R.W., ed., 1994, The Loma Prieta, California, Earthquake of October 17, 1989—Tectonic processes and models: U.S. Geological Survey Professional Paper 1550-F, 131 p.
- Spudich, Paul, ed., 1996, The Loma Prieta, California, Earthquake of October 17, 1989—Main shock characteristics: U.S. Geological Survey Professional Paper 1550-A, 297 p.
- Tubbesing, S.K., ed., 1994, The Loma Prieta, California, Earthquake of October 17, 1989—Loss estimation and procedures: U.S. Geological Survey Professional Paper 1553-A, 77 p.
- Van Anne, Craig, and Scawthorn, Charles, eds., 1994, The Loma Prieta, California, Earthquake of October 17, 1989—Fire, police, transportation and hazardous materials: U.S. Geological Survey Professional Paper 1553-C, 44 p.
- Yashinsky, Mark, ed., 1998, The Loma Prieta, California, Earthquake of October 17, 1989—Highway systems: U.S. Geological Survey Professional Paper 1552-B, 191 p.
- Yashinsky, Mark, ed., 1998, The Loma Prieta, California, Earthquake of October 17, 1989—Earth structures and engineering characterization of ground motion: U.S. Geological Survey Professional Paper 1552-D, 80 p.