

THE NATIONAL ACADEMIES
DIVISION ON EARTH AND LIFE STUDIES
BOARD ON EARTH SCIENCES AND RESOURCES

COMMITTEE ON SEISMOLOGY AND GEODYNAMICS

Award Number G10AP00151

**Final Technical Report
September 24, 2010 to September 23, 2013**

Anne Linn
500 Fifth Street N.W., Keck 667
Washington, DC 20001
Phone: (202) 334-2744, Fax: (202) 334-1377
E-mail: alinn@nas.edu

Abstract. The Committee on Seismology and Geodynamics (COSG) provides an impartial forum for discussing geophysical issues of importance to federal agencies and scientists and also oversees specialized panels of experts, which carry out scientific studies. The COSG is charged with the following tasks:

1. To foster and encourage understanding of the structure, dynamics and evolution of the Earth.
2. To review and define basic and applied research activities in seismology, geodesy and geodynamics that contribute to federal agency missions.
3. To address the transfer of seismological and geodynamics knowledge to areas of public welfare and national need including topics such as earthquake science; geological hazards; energy, mineral, and water resources; national security; global climate change; land-use planning; and public education.
4. To foster long-term national efforts to collect, store and openly disseminate seismological, geodetic, and geodynamical data of all types.
5. To foster long-term national efforts to monitor geodynamical events as well as nuclear testing treaties using geophysical technologies.
6. To serve as the U.S. member of the Inter-Union Commission on the Lithosphere.

During the reporting period, the committee held 3 meetings, oversaw the completion of 4 National Research Council (NRC) reports, and developed several concepts for future NRC studies.

COMMITTEE

The tasks of the COSG are carried out by a committee of experts who volunteer their time, supported by NRC staff. Experts typically serve a 3-year term and their appointments are staggered to maintain continuity while allowing evolution. Individuals who served on the COSG between 2010 and 2013 are as follows:

Louise H. Kellogg, *Chair*, University of California, Davis
David T. Sandwell, *Chair and member*, Scripps Institution of Oceanography, University of California, San Diego
Michael E. Wyession, *Vice Chair*, Washington University, St. Louis, Missouri
J. Ramón Arrowsmith, Arizona State University, Tempe
Emily E. Brodsky, University of California, Santa Cruz
James L. Davis, Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York
Stuart P. Nishenko, Pacific Gas and Electric Company, San Francisco, California
Peter L. Olson, Johns Hopkins University, Baltimore, Maryland
Nancy L. Ross, Virginia Polytechnic Institute & State University, Blacksburg
Charlotte A. Rowe, Los Alamos National Laboratory, New Mexico
Brian W. Stump, Southern Methodist University, Dallas, Texas
Aaron A. Velasco, University of Texas, El Paso

MEETINGS

COSG meetings are held to assess emerging issues in seismology, geodynamics, and geodesy; to review progress of study panels working under the purview of the committee; to develop new study concepts; and to brief the community on newly released COSG reports. The scientific and technical sessions are public and are commonly organized around a few themes to enable participants to examine the issues in some detail. Major themes of meetings held during the reporting period are summarized below and the associated agendas are given in Attachment A.

September 26-27, 2011, Washington, D.C.

The meeting included briefings on three reports carried out under the auspices of the COSG: *Precise Geodetic Infrastructure: National Requirements for a Shared Resource*; *National Earthquake Resilience: Research, Implementation, and Outreach*; and *Grand Challenges in Earthquake Engineering Research: A Community Workshop Report*. In addition, sponsor agencies (USGS, NASA, and NSF) gave briefings about their earth science programs, and a committee member presented an overview of the J-FAST rapid response drilling project, which aimed to drill through the fault that caused the 2011 Tohoku earthquake and tsunami. Following the open session, the committee spent a half day planning the next meeting and potential future studies.

March 6-7, 2012, Tempe, Arizona

The meeting was organized around a roundtable on explosive volcanism and volcanic hazards. Speakers covered a wide range of topics, including the activities of the USGS Volcano Hazards Program, volcano monitoring and modeling, the impact of volcanic eruptions, and basic research in volcanology. An important outcome of the roundtable was a draft discussion paper intended to raise key issues and to begin formulating a long-term vision for physical volcanology in the United States. This white paper led to a concept for an NRC study, which is currently being considered by the USGS and other federal agencies.

The other major agenda item at the March meeting was current and future plans for EarthScope. Following updates on the program and the status of an InSAR mission, which was a key component of the original EarthScope plan, meeting participants discussed how EarthScope may evolve beyond 2018. A major concern was the cancellation of NASA's planned InSAR mission (Deformation, Ecosystem Structure and Dynamics of Ice [DESDynI]). Based on this discussion, a committee member wrote a letter to NASA program managers describing the importance of L-band SAR data for achieving the science objectives of EarthScope.

November 19-20, 2012, Washington, DC

The meeting was organized around 3 science themes: high-performance computing, the L'Aquila earthquake, and precision geodesy. The session on high-performance computing in seismology and geodynamics began with an overview of a 1996 COSG report on the topic, then moved to current and possible future capabilities and major federal initiatives. Next, the session on the 2009 L'Aquila earthquake recounted the convictions of 7 Italian experts for downplaying the risk of a major earthquake in the area, which occurred soon after, killing 30 people. It also included a talk evaluating the way risk communication was handled by the experts. The third session focused on precision geodesy, including science applications and NASA's response to the COSG report *Precise Geodetic Infrastructure*. The committee also spent a half day discussing potential new studies and new members.

REPORTS

Reports produced under the auspices of the COSG are written by panels of experts and are funded separately from this award. The reports released during the reporting period are summarized below and their citations are given in the bibliography.

Induced Seismicity Potential in Energy Technologies, 2012

Oversight committees: Committee on Earth Resources, Committee on Geological and Geotechnical Engineering, and Committee on Seismology and Geodynamics

Sponsor: DOE

Over the past several years, some energy technologies that inject or extract fluid from the Earth have caused or been suspected to cause earthquakes. Although only a small fraction of injection and extraction activities in the United States have induced seismicity at levels noticeable to the public, understanding the potential for inducing earthquakes and for limiting their occurrence and impacts is desirable for state and federal agencies, industry, and the public at large. *Induced Seismicity Potential in Energy Technologies* notes that work is needed to build robust prediction models, to assess potential hazards, and to improve agency coordination to better understand, limit, and respond to induced seismic events. The report identifies gaps in knowledge and research needed to advance the understanding of induced seismicity; identifies gaps in induced seismic hazard assessment methodologies and the research to close those gaps; and assesses steps toward best practices with regard to energy development and induced seismicity potential.

National Earthquake Resilience: Research, Implementation, and Outreach, 2011

Oversight committee: Committee on Seismology and Geodynamics

Sponsor: NIST

The United States will experience damaging earthquakes in the future, and some of these earthquakes will occur in heavily populated and vulnerable areas. *National Earthquake Resilience* presents a roadmap for increasing our national resilience to earthquakes. Working from the goals and objectives laid out in the National Earthquake Hazards Reduction Program (NEHRP) Strategic Plan, the report assesses the activities and costs required for the nation to become resilient to earthquakes in 20 years. These activities incorporate engineering/science (physical), social/economic (behavioral), and institutional (governing) dimensions as well as pre-disaster preparedness and post-disaster response. Although the report is written primarily for the NEHRP, it also speaks to a broader audience of policy makers, earth scientists, and emergency managers.

Grand Challenges in Earthquake Engineering Research: A Community Workshop Report, 2011

Oversight committee: Committee on Seismology and Geodynamics

Sponsor: NSF

Recent earthquakes in Japan, New Zealand, Haiti, and Chile provide stark reminders of the devastating impact major earthquakes have on the lives and economic stability of people worldwide and the importance of earthquake planning, sound construction, and mitigation. *Grand Challenges in Earthquake Engineering Research: A Community Workshop Report* explores research, experimental capabilities, and cyberinfrastructure tools needed to reduce earthquake damage and improve technological preparedness. The report describes 13 grand challenges, grouped under the themes of community resilience framework, decision making, simulation, mitigation, and design tools. It also identifies 14 experimental facilities and cyberinfrastructure tools to make measurements, carry out simulations and tests, and analyze results. Finally, the report reviews how progress is made in research and development, and considers the various factors that could accelerate transformative solutions.

Precise Geodetic Infrastructure: National Requirements for a Shared Resource, 2010

Oversight committee: Committee on Seismology and Geodynamics

Sponsors: NASA, NSF, USGS, NGA, U.S. Naval Observatory, and NOAA

Over the past half century, the United States has been a leader in the development of geodetic techniques and instrumentation. Geodetic observing systems support a wide range of military and civilian applications, including autonomous navigation, precision agriculture, land surveying, measuring sea level change, monitoring land deformation associated with earthquakes and volcanoes, and mapping forest structure and floodplains. *Precise Geodetic Infrastructure* assesses the benefits provided by geodetic observations and networks, and examines a plan for developing and supporting the infrastructure needed to meet the demand for increasingly greater precision. The report also makes recommendations for upgrading and improving specific elements of the infrastructure, for enhancing the role of the United States in international geodetic services, for evaluating the requirements for a geodetic workforce for the coming

decades, and for coordinating the various agencies and organizations that contribute to the geodetic infrastructure.

BIBLIOGRAPHY

NRC, 2012, *Induced Seismicity Potential in Energy Technologies*, The National Academies Press, Washington, D.C., 248 pp.

http://www.nap.edu/catalog.php?record_id=13355

NRC, 2011, *National Earthquake Resilience: Research, Implementation, and Outreach*, The National Academies Press, Washington, D.C., 263 pp.

http://www.nap.edu/catalog.php?record_id=13092

NRC, 2011, *Grand Challenges in Earthquake Engineering Research: A Community Workshop Report*, The National Academies Press, Washington, D.C., 90 pp.

http://www.nap.edu/catalog.php?record_id=13167

NRC, 2010, *Precise Geodetic Infrastructure: National Requirements for a Shared Resource*, The National Academies Press, Washington, D.C., 142 pp.

http://www.nap.edu/catalog.php?record_id=12954

The websites listed above provide free access to the reports as well as to related resources, such as press releases and 4-page briefs.

ATTACHMENT

Agendas for the open sessions of COSG meetings held during the reporting period

Committee on Seismology and Geodynamics Meeting
 Keck Center, National Research Council, Room 204
 500 Fifth Street, NW, Washington, DC
 September 26-27, 2011

Agenda

Monday, September 26

8:30-12:00: Closed session discussion

12:00 Working lunch

Completed Studies Briefings

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|------|--|-----------------------|
| 1:00 | Precise Geodetic Infrastructure: National Requirements for a Shared Resource | <i>David Sandwell</i> |
| 1:45 | National Earthquake Resilience: Research, Implementation, and Outreach | <i>Stu Nishenko</i> |

Agency Briefings

- | | | |
|------|--|------------------------|
| 2:30 | DOE – NNSA and 3-D Earth Model Progress | <i>Leslie Casey</i> |
| 3:00 | Break | |
| 3:30 | NASA – Earth Science Programs Overview | <i>John LaBrecque</i> |
| 4:00 | NASA – Geodetic Imaging Focus | <i>Craig Dobson</i> |
| 4:30 | USGS – Earthquake Hazards Program update | <i>David Applegate</i> |
| 5:00 | Open discussion – future COSG activities | <i>David Sandwell</i> |
| 5:30 | Adjourn | |

Tuesday, September 27

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|------|---|-----------------------|
| 8:30 | Working continental breakfast in the meeting room | <i>David Sandwell</i> |
| 9:00 | Introductions | <i>David Sandwell</i> |

Science Briefing

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|------|--------------------------------|----------------------|
| 9:15 | J-FAST Rapid Response Drilling | <i>Emily Brodsky</i> |
|------|--------------------------------|----------------------|

Completed Studies Briefing

9:45 Grand Challenges in Earthquake Engineering Research: A Community Workshop Report *Jason Ortego*

10:15 Break

Agency Briefings

10:45 DOE: Office of Science *Nick Woodward*

11:15 NSF – EAR Programs and Activities *Jim Whitcomb*

11:45 Open discussion – future COSG activities *David Sandwell*

12:30 Working lunch

1:30-4:00: Closed session discussion

Committee on Seismology and Geodynamics Meeting
 Dietz Museum, Physical Sciences F-wing
 Arizona State University, Tempe
 March 6-7, 2012

Agenda

Tuesday, March 6

Roundtable on Explosive Volcanism and Volcanic Hazards

- 8:30 Welcome to SESE *Kip Hodges, SESE Director*
- 8:40 Welcome and Introductions *David Sandwell, Chair*
- 9:00 Roundtable background and objectives *Emily Brodsky*
- 9:15 Vision and grand challenges *Bruce Houghton (Roundtable Moderator)*
University of Hawaii at Manoa; HI State Volcanologist
- 10:00 Break
- 10:30 USGS Volcano Hazards Program – Activities and future plans *John Eichelberger*
Coordinator, USGS Volcano Hazards Program
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- 11:00 Volcanoes and climate and related broader impacts *Stephen Self*
Washington State University [U.S. NRC]
-
- 11:30 Overview of NSF-supported volcanology research *Jim Whitcomb*
NSF-EAR
- 12:00 Working lunch
- 1:00 Remote sensing and gas monitoring *Simon Carn*
Michigan Technological University
- 1:30 VHUB and large-scale computing in volcanology *Marcus Bursik*
SUNY University at Buffalo
- 2:00 Open discussion—discussants: *Amanda Clarke, Arizona State University*
Joe Dufek, Georgia Institute of Technology
David Fee, University of Alaska, Fairbanks
Jeff Freymueller, University of Alaska, Fairbanks
Larry Mastin, Cascades Volcano Observatory, USGS
Tom Murray, Alaska Volcano Observatory, USGS
Darcy Ogden, Scripps Institution of Oceanography

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*Diana Roman, Carnegie Institution of Washington
Tom Sisson, Volcano Science Center, USGS*

3:00 Break

3:30 Open discussion (cont.): Is there community agreement on a vision for the future?

5:30 Adjourn

Wednesday, March 7

8:30 Introductions

David Sandwell

Earthscope – Present Status, Future Plans, and What Follows?

9:00 EarthScope 2012-2018

*Greg Anderson
NSF-EAR*

9:30 InSAR / DESDynI

David Sandwell

10:00 Break

10:30 Open discussion – What is the vision for post-2018?

12:30 Working lunch

1:30-3:00: Closed session discussion

Committee on Seismology and Geodynamics Meeting
 National Academies Keck Center, Room 109
 500 Fifth Street, NW, Washington, D.C.
 November 19-20, 2012

Agenda

Monday, November 19

8:00-10:15: Closed session discussion

10:15 Session 1. High-Performance Computing in Seismology and Geodynamics

Welcome and introductions *Dave Sandwell*

10:20 Summary of *High Performance Computing in Seismology* (NRC, 1996) *Char Rowe*

10:35 High-performance computing in seismology: Current and possible future capabilities *Jeroen Tromp
Princeton*

11:20 High performance computing in geodynamics: Current and possible future capabilities (via webcast) *Louise Kellogg
UC Davis*

12:00 Working lunch

1:00 EAR's high performance computing and related initiatives *Eva Zanzierka
NSF*

1:30 Sequoia, HPC, and advancing seismology and geodynamics *Steve Bohlen
LLNL*

2:00 Discussion *All*

2:30 Session 2. L'Aquila Earthquake

2:30 Overview of events: Recorded SSA talk *Tom Jordan [recorded]
University of Southern California*

3:00 Critique of the earthquake commission's risk communication *Tim Sellnow
University of Kentucky*

3:30 Break

3:45 Session 3. Precision Geodesy

3:45 NASA Space Geodesy Project: Responding to recommendations of *Precise Geodetic Infrastructure* (NRC, 2010) *Stephen Merkowitz
NASA GSFC*

ATTACHMENT

Videos on VLBI and geodesy

4:15 Earth science applications of precise geodesy (20 minutes)

Dave Sandwell

4:35 Discussion about the contents of a possible COSG video

All

5:00 Adjourn

Tuesday, November 20

8:00-1:00: Closed session discussion