FINAL TECHNICAL REPORT

USGS Award Number: G10AP00019

Workshop on the Applications of Precarious Rocks and Related Phenomena to US National Hazards Maps

Investigators:

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Term covered by the award: (January 2010 through December 2011)

Title and Dates of workshop: Applications of Precarious Rocks and Related Fragile Geological Features to U.S. National Hazard Maps, October 4-5, 2011.

Agenda: See first attachment.

Participant List:

John Anderson, Abdolrasool Anooshehpoor, Jack Baker, Paolo Bazzurro, Celine Beauval, Glenn Biasi, James Brune, Rebecca Brune, Ned Field, Arthur Frankel, Tom Freeman, Lisa Grant-Ludwig, Robert Graves, David Haddad, Thomas Hanks, Stephen Harmsen, Tom Jordan, John Louie, Chuck Mueller, Corrie Neighbors, Dan O'Connell, Mark Petersen, Matthew Purvance, Dylan Rood, Woody Savage, Norman Sleep, Mark Stirling, Zhenming Wang, Ivan Wong, Ilia Zaliapin, and Yuehua Zeng.

Workshop highlights or summary of workshop

The **Workshop on the Applications of Precarious Rocks and Related Fragile Geological Features to US National Hazard Maps** met at the University of Nevada Reno on October 4-5, 2010. The goal was to develop recommendations to the USGS on the use of precariously balanced rocks (PBRs) and other fragile geological features (FGFs) to improve the national seismic hazard maps. The context is the recognition that hazard curves, and the derived hazard maps, are the calculated output of hazard models that should be tested, and that FGFs currently provide the only data to validate the calculated hazard curves at low probabilities (~10^{-4} or less).

There was a rough consensus that FGFs can help improve the national hazard model in a few general ways. Locally, PBRs may require changes to models of seismicity, where geologically a fault may be considered active, but the PBR suggests not. Within a hazard assessment they can identify inconsistent branches in the logic tree. FGFs that have survived recent earthquakes can test ground motion prediction equations (GMPEs) or synthetic seismograms proposed as models for that event. FGF survival also highlights the distinction between site-specific hazard curves, with which FGFs must be consistent, and hazard curves developed for the national hazard maps using a generic site condition. The GMPEs used for the national maps include the full variability of site response for sites with VS30=760 m/s, while the variability (single-station sigma) at FGFs can be smaller and sometimes measured. Since hazard estimates at small probabilities are sensitive to sigma, some inconsistency of FGFs and national hazard maps may be the cost of the lack of knowledge of specific site response. The workshop also suggested research needed to increase the usefulness of FGFs in the future, and guidelines for archiving the data.

A detailed report on the workshop has been published to Seismological Research Letters (Anderson et al, 2011).

Publications

Publication supported by this project

Anderson, John G., James N. Brune, Glenn Biasi, Abdolrasool Anooshehpoor, and Matthew Purvance (2011). Workshop Report: Applications of Precarious Rocks and Related Fragile Geological Features to U.S. National Hazard Maps, Seismological Research Letters 82, 431-441.

Publication and presentation related to this project:

Anderson, J. G., Brune, J. N., Purvance, M. D., Biasi, G. P., Anooshehpoor, A. (2011). Benefits of the use of precariously balanced rocks and other fragile geological features for testing the predictions of probabilistic seismic hazard analysis. In M. H. Faber, J. Köhler & K. Nishijima (Ed.), *Applications of Statistics and Probability in Civil Engineering* (pp. 744-752 (Paper # 91 on CD)). London: Taylor &Francis Group. (travel to meeting not supported by USGS).

Abstracts:

Anderson, J. G., Biasi, G. P., Brune, J. N., SCEC Annual Meeting, Academic, "FUTURE DIRECTIONS FOR STUDIES OF PRECARIOUSLY BALANCED ROCKS", Southern California Earthquake Center. (September 13, 2011).

Anderson, J. G., SSA Annual Meeting, Academic, "Results of the Workshop on Applications of Precarious Rocks and Related Fragile Geological Features to US National Hazard Maps", Seismological Society of America. (April 14, 2011).

Workshop on the Applications of Precarious Rocks and Related Fragile Geological Features to US National Hazard Maps.

Reno, Nevada, on October 4-5, 2010.

Location: Ballroom C, Crowley Student Union, University of Nevada, Reno

Goal: The goal of this workshop is to develop recommendations to the USGS on the use of precariously balanced rocks and related fragile geological features to improve the national seismic hazard maps.

Key Questions to be addressed by the Workshop

1. What is the national distribution and sensitivity of precariously balanced rocks (PBRs) and related fragile geological features (FGFs)?
2. To what extent are the new (2008) hazard maps consistent with known PBRs and FGFs?
3. How will the PBR and FGF data be used as input to the next national hazard maps? Possible pathways to incorporate these data include to: constrain/modify earthquake rupture forecasts (ERFs), constrain/modify the attenuation curves for near-source, hard rock, large earthquakes, improve the handling of uncertainties in ground motion prediction equations (i.e. the ergodic assumption), and/or weight hazard curves by the PBR/FGF fragilities.
4. How should information about precarious rocks be archived and made available to the general user community?
5. Are there any research recommendations?

Preliminary Agenda

Date & Time	Activity	
Monday, October 4		
8:00	Registration	CSU, Ballroom C
8:30 AM-6:00 PM	Meetings, Lunch, Breaks	
8:30 AM	Welcome / Purpose of the Workshop	John Anderson
8:35	USGS Perspective	Mark Petersen
9:00	Perspective on Testing Probabilistic Seismic Hazard Analysis	John Anderson
9:20	History and applications of precarious rock research	Jim Brune
9:40	Measuring fragility of precarious rocks	Rasool Anooshehpoor
10:00	Break	
10:20	Life cycle and exposure dating of precariously balanced rocks	Dylan Rood

10:40	Using Precariously Balanced Rocks, Historic Records And Paleoseismology To Constrain Rupture Patterns And Rupture Potential Of The San Andreas And San Jacinto Faults In The Los Angeles Region	Lisa Grant-Ludwig
11:00	Methodology to test the probability of precarious rocks surviving, given thehazard curves	Matt Purvance
11:20	Testing the survival of precarious rocks via random fields of spatially correlated ground motion intensities	Paolo Bazzurro and Matt Purvance
11:40	Using precarious rocks to compute points in hazard space and update seismic hazard analysis logic tree weights.	Jack Baker
12:00	Lunch	
1:00	Use of precarious rocks to test simulations of earthquake ground motions	Robert Graves
1:20	Cybershake	Tom Jordan
1:40	Use of PBRs to test PSHA in New Zealand – application in a temperate environment	Mark Stirling cancelled due to NZ earthquake - intends to send slides
2:00	Probabilistic thoughts on the use of precarious rocks	Dan O'Connell
2:20	The ergodic assumption and ground motion prediction equations used in PSHA	John Anderson
2:40	Rules of the Rocks	Tom Hanks
3:00	Break	
3:30 – 5:30	Discussion of Workshop Objectives. Can we come to consensus yet on any issues?	All
7:00 PM	Dinner	We will identify an interesting restaurant for those who want to go together
Tuesday, October 5		
8:00 AM – 3:00 PM	Meetings, Lunch, Breaks	CSU, Ballroom C

8:00 AM – 8:30	Summary of (partial?) consensus (?), status of progress towards workshop goals, outstanding issues, and general discussion	
8:30	Optional brief statements. Reactions and thoughts on how USGS can use precarious rocks. Research needs. Organizational needs. Implementation issues.	Celine Beauval Ned Field Art Frankel Tom Freeman David Haddad Ken Hudnut Corrie Neighbors Dan O'Connell Norm Sleep Gabe Toro Zhenming Wang Ivan Wong Yuehua Zeng
	Issues in eastern North America	Zhenming Wang
	Various thoughts	Norm Sleep
	Other fragile geological features	TBD
10:00	Break	
10:30	Status Report on the Precarious Balanced Rock Archive	Glenn Biasi
10:50	Proposal for the preservation of precarious rocks	John Anderson
11:10	Are we moving towards meeting USGS goals for the workshop?	Ned Field Mark Petersen
11:45	Lunch	
1:00 PM-3:00 PM	Closing discussion. Recommendations. Can we come to a consensus and make recommendations to USGS? Workshop concludes.	
2:45	Conclusion	John Anderson