From the editor

This edition of Risky Ground offers a mix of super eruptions, measuring shake and sharing landslide awareness. It offers a link to various upcoming events in natural hazards and risk, including a workshop sponsored by the Centre for Natural Hazard Research and which examines the staggering mega-disaster issues of our future. That workshop will be held on Friday April 26, 2013 at the Halpern Centre at the Simon Fraser University Campus in Burnaby, BC.

Bert Strauk, lstruik@sfu.ca
Centre for Natural Hazard Research, Simon Fraser University

Commentary

In light of the theme of the upcoming workshop (http://cnhr.mhrisk.ca/index5.php) at Simon Fraser University sponsored by CNHR, I’d like to comment on one type of mega-disaster, “super eruptions”. Such volcanic eruptions of extraordinary size have occurred in recent geologic time, although not historically. Nor are they likely to happen on a timescale that humans consider relevant, yet, consider the effects of an explosive release of more than 1,000 km$^3$ of ash on our crowded, highly complex world, with its interwoven economies. Not a pretty picture!

Calderas many dozens of kilometres across are produced by very rare, but extremely violent, super eruptions. Such eruptions, and the “supervolcanoes” from which they originate, are substantially larger than any in historic times—greater than 1,000 km$^3$. This volume is approximately 1,000 times the amount of ash produced by the 1980 eruption of Mount St. Helens (1 km$^3$), and enough to cover all Prince Edward Island to a depth of about 175 m. A super eruption occurs when a large volume of magma rises to shallow depths in the crust over a mantle hot spot. Pressure builds in the large and growing magma pool until the crust is unable to contain the pressure. Less commonly, super eruptions occur at convergent plate boundaries. At least ten super eruptions have occurred in the past million years, three of which were in North America. Ash deposits from such an eruption can be 100 m thick near the crater’s rim and a metre or so thick 100 km away.

Toba caldera on the Indonesian island of Sumatra is the site of the largest super eruption of the past 2 million years. The caldera is 30 km wide and 100 km long; it formed 75,000 years ago when about 2,800 km$^3$ of pyroclastic material were blown high into the atmosphere. Sulphur aerosols produced by this cataclysmic eruption lowered sea-surface temperatures by 3–3.5°C for about six years and may have caused nearly complete deforestation of southeastern Asia. Genetic evidence suggests that the human species nearly became extinct through the Toba eruption—the total number of people on Earth fell to between 2,000 and 20,000 immediately after the eruption, probably because of famine. Researchers have proposed that the eruption created population bottlenecks in human species existing at the time and accelerated differentiation of the isolated populations. Eventually, all but two species became extinct—Neanderthals (Homo neanderthalensis) and modern humans (Homo sapiens).

The largest caldera-forming eruptions in North America occurred about 600,000 years ago at Yellowstone National Park in Wyoming and about 700,000 years ago at Long Valley, California. The August 2009 issue of National Geographic describes the geology and potential impact of a Yellowstone super eruption, and an update on its recurrence history is available in the June 2011 issue of the journal Quaternary Geochronology.

John Clague
Current Research

Seismic Hazard and Risk Associated with Shallow Crustal Faulting near Greater Victoria, British Columbia

Greater Victoria, located on southern Vancouver Island in southwestern British Columbia, is subject to the highest earthquake hazard in Canada. The region is located at the Cascadia Subduction Zone, where the Juan de Fuca plate descends northeastward beneath the North America plate. The two plates are presently locked, compressing and elevating the western margin of North America. A block of continental crust underlying the Pacific Northwest region is slowly rotating in a clockwise direction (Wells et al., 1998). As it rotates, this crustal block is indenting the Coast Mountains. Crustal compression is accommodated by oblique dextral-reverse faulting and folding across northwestern Washington and extending into southwestern British Columbia (Wells et al., 1998). There are three kinds of earthquakes in this tectonic environment.

Plate boundary earthquakes at the subduction interface

The threat of “The Big One”, a colloquial term describing a rupture along the Cascadia Subduction Zone, is probably familiar to most people living in southwestern British Columbia. Great earthquakes (moment magnitudes, M, up to 9) occur here about every 500-700 years (Clague et al., 2000), with strong long-period ground motions and long durations. The last great subduction interface earthquake to strike the region occurred in 1700 (Atwater et al., 2005).

Intraslab earthquakes caused by bending and warping within the subducting slab

The 2001 Nisqually earthquake near Seattle (M 6.8) was an intraslab event (Molnar et al., 2004). Moderate to large intraslab events are the most frequent of the three earthquake types, and thus are the largest contributors to seismic hazard at southern Vancouver Island (Adams and Halchuk, 2003).

Crustal earthquakes on shallow, transpressional fault sources in the North America plate

The Victoria area experiences strong seismic shaking from active shallow crustal fault sources about once every 470 years (Blais-Stevens et al., 2011). Magnitudes are thought to be less than 7.5.

The analysis of seismic hazard in the region is inherently difficult. The record of historic seismicity is comparatively short, thus there are relatively few events upon which to base a tectonic model. Glaciation has obscured surface evidence that could otherwise be studied to yield paleoseismologic information. In short, the existing data set is not large enough to construct reliable frequency-magnitude relationships for individual fault sources. Accordingly, Adams and Halchuk (2003) employed areal earthquake sources in the national probabilistic ground motion model developed for the 2005 National Building Code of Canada (NBCC). The seismic hazard is averaged across broad geographic areas with similar styles of faulting and earthquake occurrence. As a consequence, the results pertaining to shallow crustal fault sources may underestimate the local hazard, particularly in areas proximal to potentially seismogenic faults.

New techniques have been applied in recent years to identify active faults in the region. LiDAR has been successfully used to identify active scarps along the Seattle fault (Haugerud et al., 2003), scarps along the South Whidbey Island fault zone (Sherrod et al., 2008), and three active structures near Bellingham, Washington (Kelsey et al., 2012). Seismic reflection and aeromagnetic geophysical surveys have been used to refine fault models (e.g. Kelsey et al., 2012; Mace and Keranen, 2012). Improved historic earthquake locations have been correlated with potential fault sources (Balfour et al., 2012). Use of these techniques may help guide researchers to field sites where there is potential for identification and dating of prehistoric large earthquakes (e.g. Kelsey et al., 2012). It may be possible to characterize earthquake recurrence on individual faults, although much work remains.

Holocene faults capable of generating strong ground motions at Victoria have been discovered in northwestern Washington using these techniques. Holocene activity has been documented for the Devil’s Mountain (Johnson et al., 2003). LiDAR is a laser-light mapping tool that measures distance from the light source to high accuracy, and which, when used from an aircraft is useful for accurate elevation measures and therefor topographic mapping.
al., 2001), South Whidbey Island (Johnson et al., 1996) and Boulder Creek (Barnett et al., 2006) fault zones, all of which may be capable of earthquakes larger than M 7.0. Kelsey et al. (2012) investigated active faults around Bellingham, bounding the southeastern margin of the Georgia Basin, and speculated that additional active structures may be present around the margin of the basin. The Geological Survey of Canada has investigated structures below the seafloor around southern Vancouver Island and has tentatively identified structures that might connect offshore portions of the Devils Mountain or South Whidbey Island fault zones to the onshore trace of the Leech River fault (J. Bednarski, personal communication, 2012). The Leech River fault is of particular significance, as the onshore trace passes through the communities of Langford and Colwood, and the offshore portion reaches to within 2 km of downtown Victoria. Preliminary ground-motion analyses for a Leech River fault earthquake scenario suggest peak ground acceleration (PGA) in excess of 0.5 g adjacent to the onshore trace, and over 0.3 g in areas underlain by soft soil or fill around downtown Victoria (Figure 1).

A HAZUS 2 earthquake model is being developed to understand the risk posed by faults within 100 km of Victoria. This model will facilitate loss estimates for several deterministic earthquake scenarios and enable comparison against NBCC probabilistic models and Cascadia rupture scenarios. We will attempt to quantify risk using weighted alternative frequency-magnitude estimates for these fault sources to provide comparisons with probabilistic scenarios. We will propose several alternative models to partition the areal-source seismicity to individual fault sources. We can apply relative weighting to these models to produce a pseudo-probabilistic set of hazard maps. These will be suitable for comparison against NBCC ground motions. The results will illustrate the differences in how losses are distributed for different earthquake sources and may identify vulnerabilities that are hidden in a strictly probabilistic framework.

Figure 1. Median peak ground acceleration predicted for a M 7.2 earthquake rupturing the onshore portion of the Leech River fault.

References


Balfour, N.J., Cassidy, J.F. & Dosso, S.E. (2012). Identifying active structures using double-

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2 HAZUS is an Arc Map plugin that calculates losses from model earthquakes, floods and hurricanes. see [http://www.fema.gov/hazus](http://www.fema.gov/hazus)


Marty Zaleski, Earth Sciences Department, Simon Fraser University, Burnaby, BC. martyz@sfu.ca

Geohazards and tourism development in mountain areas

Some of the most popular tourist destinations are located in geologically and geomorphologically active areas. Natural processes such as volcanic eruptions, landslides and floods continuously shape natural environments, contributing to their appeal. Such processes pose significant hazards and thus can impact tourism. Yet, natural hazardous processes provide interesting opportunities for the development of tourism and an opportunity to inform the public about environmental processes and natural hazards. They can also serve as “open air laboratories” for students of all ages (e.g. “GeoNatHaz” Project, http://www.geonathaz.unito.it/; see this Newsletter, September 2012).

The Canadian Cordillera and Italian Alps share breathtaking landscapes in dynamic mountain environments, a variety of hazardous processes, and a common attitude towards tourism. Hazardous natural processes that are relevant to tourism are not necessarily the same as those that affect urban areas. The most common types of hazards that interface with tourist activities in the Canadian and Italian mountains are glacier...
failure/ice avalanches, snow avalanches, rock avalanches in the glacial environment, rock falls, debris flows, and floods. A recent example in Canada is the Ghost Glacier icefall, which occurred in Jasper National Park, Alberta, on August 10, 2012. Much of the glacier detached and fell into a lake on the valley floor below. A displacement wave containing much debris damaged a popular tourist parking lot, a road, and a picnic area. It was fortunate that the event occurred during the night; otherwise it probably would have caused many fatalities. In 1997, in the Brenva glacial basin in the Italian Alps, a rock-ice avalanche trapped and killed two skiers on the valley floor.

Aerial view of debris flood damage below Ghost Glacier in Jasper National Park. Credit: Jasper National Park

In a few instances, both in Canada and Italy, sites of catastrophic landslides have been exploited for touristic and educational purposes. Landslides are probably the most suitable type of process for these purposes, because morphological and sedimentological features related to large mass movements can persist for a long time. The Frank Slide Interpretive Centre (http://www.history.alberta.ca/frankslide/default.aspx) and the Vajont dam tour are among the best examples of how tragic events can become tourist attractions, while providing opportunities to teach people about the causes and dynamics of landslides, early-warning strategies, and consequences of natural instability processes.
The creation of educational centres of this type requires significant economic investment and results in some environmental impact. Such centres, however, can capitalize on modern geomatic tools and make available to the large public GPS (Global Positioning Systems) and GIS (Geographical Information Systems) that enrich the learning experience. It is possible now to use such technologies to disseminate scientific information at low cost and with only minor environmental impacts (http://www.parcodolomitifriulane.it/sentiero-interattivo-vajont/).

Sites suitable for such communication and educational activities have been identified near Hope, BC (Hope landslide), in Garibaldi Provincial Park, BC (Rubble Creek landslide), and near Houston, BC (China Nose landslide).

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Marta Chiarle, CNR-IRPI Torino,

Upcoming Events

European Geosciences Union General Assembly 2013
Vienna, Austria, 07 – 12 April 2013

The EGU General Assembly 2013 will bring together geoscientists from all over the world into one meeting covering all disciplines of the Earth, Planetary and Space Sciences. Especially for young scientists, it is the aim of the EGU to provide a forum where they can present their work and discuss their ideas with experts in all fields of geosciences. The EGU is looking forward to cordially welcoming you in Vienna.

The Natural Hazards Session includes presentations on the L’Aquila court decision and its implications.

Fighting Mega-disasters
Halpern Centre, Simon Fraser University,
Burnaby Campus, 8:00 am – 4:00 pm, April 26, 2013.
Centre for Natural Hazard Research
This workshop examines our relationship with the potential of mega-disasters. We have empirical evidence of our response to some actual mega-disaster events, yet, do we have a collective approach to prepare for and mitigate mega-disasters? Do we understand the scope and nature of some predicted mega-disasters that have never occurred in historical time (example: comet impact)? What is the threshold between a “regular” disaster and a mega-disaster? Why do we work to mitigate the affects of some mega-disasters and not others?

In the light of decreasing resources what is the priority of fighting a mega-disaster?

Space is still open for those interested in being part of the presentations and discussion on this topic (registration will be stopped at 80 participants). To register email Bert.Struik@nrcan.gc.ca with your contact information and expression of interest. See the workshop website for details of the program and background information.

http://www.sfu.ca/cnhr/workshops.html

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**Canadian Risk and Hazards Network**

**10th Annual Symposium**

**Regina, Saskatchewan, November 5 - 8, 2013, Radisson Hotel**

For updates about CRHNet 2013 visit http://www.chrnet.ca under the Annual Symposium tab.

**World Landslide Forum 3**

**Beijing, China, June 2-6, 2014**

The World Landslide Forum brings together government officials, scholars, international research and development communities, NGO representatives and numerous segments of the private industries to present their latest results on geo-hazard mitigation, especially, on landslide reduction, and to exchange ideas on how to improve geo-environmental safety around the world. The abstract submission deadline is May 31, 2012.

http://www.wlf3.org/
Risky Ground

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**Centre Director**  
John Clague  
jclague@sfu.ca

**Managing editor**  
Bert Struik  
lstruik@sfu.ca

**Content editor**  
Nick Roberts  
nickr@sfu.ca

**Centre for Natural Hazard Research**  
[http://www.sfu.ca/cnhr](http://www.sfu.ca/cnhr)  
Department of Earth Sciences  
Simon Fraser University  
8888 University Drive  
Burnaby, British Columbia,  
Canada V5A 1S6

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**Centre for Natural Hazard Research**  

The Centre for Natural Hazard Research (CNHR) is an SFU-based institute housed in the Department of Earth Sciences. Its mandate is to conduct innovative research on geophysical processes that are a threat to the population and economic infrastructure of Canada. CNHR has a western Canada focus, but the research findings and developed methodologies are applicable to the whole of Canada and to the international community. A key element of the Centre is the inclusion of public policy research on how to effectively transfer the results of scientific research to the people who need and can use it.

CNHR hosts talks at SFU by hazard and risk researchers and practitioners. We welcome your suggestions for potential speakers for the winter and spring of 2013. The Centre sponsors or co-sponsors workshops on a variety of topics of interest to professionals and students in British Columbia.

We welcome short updates from readers and members on their research activities and meetings of interest.

*John Clague*  
Director, Centre for Natural Hazard Research