GSC Scientific Presentation 132 – Presenter's notes

Slide 3

Generally, we see earthquakes occurring at plate boundaries, like those along the West Coast of Canada. There, the subducting Juan de Fuca plate dives beneath the North American plate along the Cascadia subduction zone.

Ottawa, shown here on a map of seismic hazard for Eastern Canada, is in the Canadian shield, a stable continental interior far from any tectonic plate boundaries or subduction zones.

Slide 4

But we know that earthquakes can and do occur near Ottawa and Montreal, including the 1732 magnitude 5.8 earthquake and a magnitude 5.6 event in Cornwall in 1944. In fact, evidence suggests that there may have been 1 or 2 larger (M7-8) earthquakes that occurred even closer to Ottawa around 7000 and 4500 years ago, according to interpretations of landslide deposits in the Ottawa Valley. Around 450 earthquakes occur in the Western Quebec Seismic Zone per year, with about 25 of those being felt. So why do these earthquakes occur?

Slide 5

Ottawa sits in the Western Quebec Seismic Zone, an area of high seismicity that trends NW-SE along the Ontario-Quebec border from the Adirondacks in New York to the Laurentian Uplands in Quebec. It's thought that earthquakes may occur preferentially here because of the passage of the Great Meteor Hot Spot track. A hot spot is an area of the earth's mantle that is extra hot, causing volcanism and the intrusion of melted rock into the earth's crust. It's the same process that forms the Hawaiian Islands. Here, the hot spot either emplaced intrusions of rock that changed the stress field or that heated up and reactivated ancient faults associated with mountain building (the Grenville and Appalachian Orogenies) or failed ocean forming rift events along the St. Lawrence River (the Iapetan Rift) from hundreds of millions of years ago.

Generally, earthquakes in Canada are also commonly affected by postglacial rebound. This process refers to the earth's crust slowly springing back after the weight of the ice from the last ice age was removed. This has been occurring for thousands of years and its signal is most noticeable where the Laurentide ice sheet was thickest – near Hudson's Bay. The final factor affecting seismicity in eastern Canada today are previous geologically "recent" earthquakes. Seismic events in the stable continental interior tend to be felt over larger distances and have much longer aftershock sequences than their counterparts at plate boundaries. Therefore, earthquakes today can sometimes be traced back to major events from tens, hundreds, or even thousands of years ago.

Slide 6

The other two seismicity zones in Ontario are the Northern Ontario and Southern Great Lakes seismic zones. Northern Ontario, from Sudbury to the Manitoba border, has a very low activity rate. The only magnitude greater than 5 earthquake in this area on the Canadian side was in 1928 near Kapuskasing. Generally this region is sparsely populated, with remote communities that could become isolated in the event of an earthquake.

Slide 7

The Southern Great Lakes, on the other hand, are home to millions of Canadians. This region has low to moderate seismicity, although to date all magnitude greater than 5 earthquakes have occurred on the US side of the border.

In total, large earthquakes in Ontario and Southern Quebec appear to happen on the order of tens to hundreds of years apart.

Slide 8

Likely impacts from major earthquakes in the region would include damage to buildings, interruption to roadways, disruption of critical infrastructure, landslides, and injuries. These impacts will likely be the greatest where soil is thicker, as it can amplify shaking, and where soils can fail in landslides or liquefaction, where saturated soils behave like a liquid during shaking. Critical infrastructure impacts can include leaking of gas, oil, water, or sewage pipes; snapping of power transmission or telecommunications lines; and interruption of supply chains. Injuries would be expected if there is appreciable building damage, as well as needs for mass care including food, water, shelter, and medical response.

Immediately after the event, it will take some time to gather situational awareness. This will be especially true for places that are not accessible, or if road damage or debris prohibits movement even within an urban or suburban area.

Slide 9

For illustration purposes, I will present the modelled impacts of a scenario earthquake. It is not a real event, but it is based on the 2010 magnitude 5.0 Val des Bois earthquake north of Ottawa. For the scenario, we have bumped the magnitude up to 7.5 – a very large earthquake. An event like this is forecast to occur only once every 4000 years in this area, with an even smaller chance of occurring in this location right next to Ottawa. Therefore, we consider this scenario to be more aligned with a ‘worst case scenario’ in that it is low probability but high impact.

The shaking from this earthquake would be felt across much of Ontario, Quebec, and the Maritimes. Shaking in Toronto would be classed as light, but in Ottawa and Gatineau shaking would be violent or extreme. It would be very difficult to walk around during shaking this strong, highlighting the need for awareness of ‘Drop, Cover, and Hold On’ recommended protective actions. The loud and violent shaking would last a couple of minutes.

Slide 10

Economic losses from this event would be around $75 billion, which would make it the most expensive natural disaster in Canadian history. It's also worth noting that residential losses make up an estimated $50 billion of that total. In Quebec, only 2-5% of residential properties are insured for earthquakes, which would leave upwards of $47 billion in uninsured losses.

Because this event impacts the major metropolitan regions of Ottawa, Montreal, and Toronto, over 4 million people would be impacted. Sadly, our model predicts that about 6000 lives would be lost. We estimate that the number of people requiring hospital care would be 24,000, with 3000 of those in critical care. First aid treatment would be required for 61,000 people.

Slide 11

Outside of the demand on medical systems and first responders, there will likely be considerable need for mass care services like food, water, sanitation, and shelter. Specifically, we anticipate that a quarter of a million households may be displaced, although probably the majority of those will find their own living arrangements.

These images from other earthquakes show examples of the kinds of building damage to be expected.

Slide 12

This event would cause significant and wide-spread damage to buildings. Our model predicts that around 35,000 buildings would be rendered uninhabitable or red-tagged. Another 20,000 would be conditionally habitable or yellow-tagged – meaning that residents would be allowed into only part of their building or granted temporary access to retrieve supplies. Although true collapses are rare, completely damaged buildings would account for 5-6% of the total building stock in Ottawa and Gatineau. Pre-1970's buildings are the most susceptible, and in terms of construction materials we expect to see a lot of complete damage to wood, unreinforced masonry, and steel buildings.

Slide 13

All of these results are going to be published in a Geological Survey of Canada Open File Report later this year. We are also working on a web application called 'RiskProfiler' that should launch in early 2022 to allow practitioners to explore their risk through a number of scenarios and probabilistic (statistical) measures. Thank you for your time and I look forward to taking any questions.