S13A CC: 516 D Monday 1330h

Seismicity and Geodynamics of Eastern North America and Other Midplate Environments I *(joint with G, T)*

Presiding: **S Mazzotti,** Geological Survey of Canada Natural Resources Canada**; G Sella,** Northwestern University

S13A-01 1335h INVITED

Science, hazards, and policy questions for intraplate earthquakes in eastern North America

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Intraplate earthquakes in eastern North America and similar continental interiors pose unresolved scientific and societal issues. Resolving these issues will be challenging, and bears on our understanding of lithospheric and mantle rheology, continental evolution, and the earthquake process. Their causes can be viewed as some combination of two end-member models. In one, earthquakes occur almost randomly in a continent containing many long-lived fossil weak zones. Minor stress variations stress due to platewide driving forces and local stresses such as from glacial-isostatic adjustment and other density variations cause transient seismicity as the locus of strain release migrates. If so, present regions of seismicity do not significantly differ from similar weak zones that are less active. Alternatively, seismicity concentrates on long-lived weak zones. For example, if such a zone under the New Madrid area relaxed recently, transient release of accumulated stress could cause large earthquakes more frequently than implied by geodetic or earthquake frequency-magnitude data. Such models can explain the lack of surface strain accumulation shown by GPS data, but there is little evidence for such weak zones or their recent initiation. Assessing the resulting hazard requires assumptions about the size, recurrence rate, and ground motion resulting from the larger earthquakes, none of which is well known. Hence hazard estimates have large uncertainties and, at least for New Madrid, are near the high end of possible estimates. The uncertainties also make choosing mitigation strategies challenging. For example, the proposed upgrade of New Madrid zone building codes to California-level seems likely to impose societal costs significantly exceeding the benefits.

S13A-02 1355h INVITED

Seismicity and Seismic Hazards in Eastern Canada: Needs from Crustal Deformation Studies

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The historical earthquake catalog is the basis for many hazard assessments that explicitly use the pattern of past earthquakes to assess hazard - the current USGS maps for the eastern U.S. rely heavily on smoothed seismicity rates and even classical seismic source zones give a similar smoothing, albeit with nonobjective human insight. However, past southeastern Canadian activity has been a poor indicator of future large earthquakes. Though Charlevoix represents the site of repeated M>6 earthquakes, other M circa 6+ earthquakes in eastern Canada (Grand Banks, Timiskaming, Cornwall, Saguenay) appear to be one-off events (albeit with long aftershock sequences). Saguenay, the last large earthquake south of 60N, occurred in an essentially aseismic region (no M>3 event for over 40 years). To address the problem, Canada's 4th generation seismic hazard model, intended for the 2005 National Building Code, uses two models for Canadian earthquakes "H" and "R". "H" describes the earthquakes in their historical clusters while "R" associates seismicity clusters with continent-scale seismotectonic features like the passive Atlantic margin and the ancient margin of Iapetus. It expresses the alternative hypothesis that future large earthquakes (comparable to those named above) could occur anywhere along these features. The modeling of postglacial rebound data (to understand the relative roles of rebound and plate tectonic stresses) together with paleoseismological studies to establish the locations and rates of pre-historic earthquakes could help decide between the models. Direct horizontal strain measurements in eastern Canada will also help, but come from an extremely short period and need to be reconciled with the circa 350 year historical earthquake record. That record is, however, both (i) too short relative to likely earthquake occurrence rates and (ii) flawed by inaccurate and incomplete information especially regarding the magnitudes for the oldest, largest events. Those events are the most important for deciding the hazard and also contribute almost all of the seismic deformation. The pattern of contemporary crustal deformation could be definitive, and furthermore its rates could constrain the frequency of large earthquakes and their maximum size, both key factors in assessing the seismic hazard.

S13A-03 1415h INVITED

Effects of lateral variations in lithospheric thickness and mantle viscosity on glacially induced surface motion and seismotectonics in Eastern Canada

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Eastern Canada is supposedly in a stable continental region, yet it experiences intraplate earthquakes with magnitude as high as M6. Earlier investigations (Wu & Hasegawa 1996, Wu 1997, Wu & Johnston 2000) have shown that the relaxation of stress induced by late Pleistocene deglaciation events could have triggered present-day earthquakes by the reactivation of faults created by past tectonic processes. The predicted mode of failure and onset timing of paleo-earthquakes near Charlevoix and Wabash Valley was found to agree well with the observed. However, these models all assume that mantle properties vary in depth only. The purpose of this paper is to investigate the effects of lateral variations in lithospheric thickness and mantle viscosity on earthquake potential and surface motions in Eastern Canada. The input of this model consists of ice thickness history and mantle viscosity models. Here a realistic ice deglaciation model (ICE4G) with cycles of loading and unloading is used. Different viscosity models are constructed so that the individual effects of lateral lithospheric thickness variation, lateral asthenospheric viscosity variation and three-dimensional viscosity variation in the upper and lower mantle as inferred from seismic tomography, or their combination can be studied. It will be shown that lateral heterogeneity do affect surface motion and thus the strain rates in Eastern Canada. In order to study the effects of lateral heterogeneity on earthquake potential, the evolution of stress induced by deglaciation is superposed on tectonic stress and overburden stress to give the spatial-temporal variation of total stress, which is used with Mohr's failure criterion to calculate the changes in Fault Stability Margin in Eastern Canada. The effects of lateral heterogeneity on the onset timing of earthquakes will also be studied for Charlevoix and Wabash Valley where paleoearthquakes have been dated.

S13A-04 1435h

Evidence of Neotectonic Activity in the Lakebeds of the Lower Great Lakes and Possible Relation to Postglacial Isostatic Rebound

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Over the past 25 years the Geological Survey of Canada has conducted regional investigations of lakebed surficial geology and geomorphic features using high-resolution acoustic sources including sidescan sonar and subbottom profilers and bottom sediment corers. More recently new multibeam mapping techniques have been employed to generate high-resolution detailed 3D imagery of the lakebed. Key features regarded by most investigators to indicate neotectonic activity in the lake basins include bedrock pop-ups and sediment pockmarks. Pop-ups occur in areas of exposed bedrock in western Georgian Bay, eastern Lake Ontario and eastern Lake Erie. These linear bedrock ridges predominantly strike NW with conjugate sets occurring to the NE. Both fresh and oxidized surfaces along ridge crest fractures with non-existent to discontinuous sediment infill, and undisturbed sediments overlying buried pop-ups indicate these features have occurred over geologic time. Greater numbers appear to be older. Pockmarks or fluid vent features occur in areas of postglacial sediment cover in central Georgian Bay, eastern Lake Ontario and eastern Lake Erie as single features or as linear arrays of vents. Some pockmarks are still active although a greater number have mid to late Holocene sediment infill suggesting an older age of formation. A recently updated model of postglacial rebound indicates a negative exponential uplift curve with associated rapid initial crustal rebound in the early Holocene followed by declining rates that continue today. The more frequent occurrence of older pop-ups and pockmark features and the more rapid early Holocene glacial rebound would suggest these neotectonic features may be linked to glacial unloading when the crust experienced the highest rate of deformation.

S13A-05 1450h

Postglacial Faulting Within the Temiskaming Graben of Quebec and Ontario; Evidence from Lake Temiskaming

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Lake Temiskaming is a long (100 km) deep (220 m) lake within the Temiskaming Graben of Ontario and Quebec. The graben is an extension of the St. Lawrence Rift System (SLRS) that underlies the St. Lawrence and Ottawa valleys. The SLRS first formed as a Paleoproterozoic failed rift' and was reactivated during regional extension during Neoproterozic breakup of Rodinia when the Iapetus Ocean opened, and later during the Late Jurassic breakup of Pangea and the opening of the North Atlantic Ocean. The Temiskaming district lies within the Western Quebec Seismic Zone one of the most active in eastern North America characterized by frequently occurring moderate to large magnitude earthquakes such as in 1732 (M5.8; Montreal), 1935 (M6.2 Temiskaming) and 1944 (M5.6; Cornwall). Earthquakes of M> 3 occur every other year in the Temiskaming area and M6.5 temblers have a 500 yr recurrence interval. High-resolution seismic profiling of the floor of Lake Temiskaming shows that much of the bathymetric relief throughout the lake basin is the product of postglacial neotectonic faulting of the late Pleistocene and Holocene sediment fill. The onshore continuation of prominent faults is marked by linear fault scarps and by straight river valleys. The scale of neotectonic activity is highly unusual for an intracratonic setting, with implications for seismic risk analysis and public safety.

S14A CC: 516 D Monday 1530h

Seismicity and Geodynamics of Eastern North America and Other Midplate Environments II *(joint with G, T)*

Presiding: **S Stein,** Northwestern University**; T Dixon,** University of Miami

S14A-01 1530h

Characteristic and uncharacteristic earthquakes as possible artifacts: what does the seismic history actually tell us?

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