



Graduate Studies

Notice of the Final Oral Examination for the Degree of Master of Science

of

MATTHEW SYPUS

BSc (University of Victoria, 2016)

“Models of Tsunamigenic Earthquake Rupture along the West Coast of North America”

School of Earth and Ocean Sciences

Friday October 18, 2019
1:30 P.M.
Bob Wright Centre
Room A319

Supervisory Committee:

Dr. Kelin Wang, School of Earth and Ocean Sciences, University of Victoria (Co-Supervisor)
Dr. Taimi Mulder, School of Earth and Ocean Sciences, University of Victoria (Co-Supervisor)
Dr. Edwin Nissen, School of Earth and Ocean Sciences, UVic (Member)

External Examiner:

Dr. Taimi Mulder, Pacific Geoscience Centre, Natural Resources Canada

Chair of Oral Examination:

Dr. Mihai Sima, Department of Electrical and Computer Engineering, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The west coast of North America faces the risk of tsunamis generated by seismic rupture in three regions, namely, the Cascadia subduction zone extending from southwestern British Columbia to northern California, the southern Queen Charlotte margin in the Haida Gwaii area, and the Winona Basin just northeast of Vancouver Island. In this thesis, I construct Tsunamigenic rupture models with a 3-D elastic half-space dislocation model for these three regions. The tsunami risk is the highest along the Cascadia coast, and many tsunami source models have been developed and used in the past. In efforts to improve the Cascadia tsunami hazard assessment, I use an updated Cascadia fault geometry to create 9 tsunami source models which include buried, splay-faulting, and trench-breaching rupture. Incorporated in these scenarios is a newly-proposed splay fault based on minor evidence found in seismic reflection images off Vancouver Island. To better understand potential rupture boundaries of the Cascadia megathrust rupture, I also model deformation caused by the 1700 C.E. great Cascadia earthquake that fit updated microfossil based paleoseismic coastal subsidence estimates. These estimates validate the well-accepted along-strike heterogenic rupture of the 1700 C.E. earthquake but suggest greater variations in subsidence along the coast. It is recognized that the Winona Basin area just north of the Cascadia subduction zone may have the potential to host a tsunamigenic thrust earthquake, but it has not been formally included in tsunami hazard assessments. There is a high degree of uncertainty in the tectonics of the area, the presence of a subduction “megathrust”, fault geometry, and rupture boundaries. Assuming worst-case scenarios and considering the uncertainties, I construct a fault geometry using seismic images and generate six tsunami sources with buried and trench breaching rupture in which downdip rupture extent is varied. The Mw 7.8 2012 Haida Gwaii earthquake and its large tsunami demonstrated the presence of a subduction megathrust and its capacity of hosting tsunamigenic rupture, but little has been done to include future potential thrust earthquakes in the Haida Gwaii region in tsunami hazard assessment. To fill this knowledge gap, I construct a new megathrust geometry using

seismic reflection images and receiver-function results and produce nine tsunami sources for Haida Gwaii, which include buried and trench-breaching ruptures. In the strike direction, the scenarios include long ruptures from mid-way between Haida Gwaii and Vancouver Island to mid-way between Haida Gwaii and the southern tip of Alaska Panhandle, and shorter rupture scenarios north and south of the main rupture of the 2012 earthquake. For all the tsunami source and paleoseismic scenarios, I also calculate stress drop along the fault. Comparison of the stress drop results with those of real megathrust earthquakes worldwide indicates that these models are mechanically realistic.