University of Victoria | Graduate Studies

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

of

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BSc (Central South University, 2012)

"Defining Megathrust Tsunami Sources at Northernmost Cascadia Using Thermal and Structural Information"

School of Earth and Ocean Sciences

Tuesday, July 26, 2016
2:00 P.M.
Bob Wright Centre
Room A319

Supervisory Committee:
Dr. Kelin Wang, School of Earth and Ocean Sciences, University of Victoria (Co-Supervisor)
Dr. Stan Dosso, School of Earth and Ocean Sciences, UVic (Co-Supervisor)
Dr. Thomas James, School of Earth and Ocean Sciences, UVic (Member)

External Examiner:
Dr. Yan Jiang, Natural Resources Canada, Geological Survey of Canada

Chair of Oral Examination:
Dr. Terri Lacourse, Department of Biology, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The west coast of North America is under the threat of future great megathrust earthquakes and associated tsunamis. This dissertation addresses three urgent but unresolved issues in tsunami hazard assessment and risk mitigation at northernmost Cascadia. (1) Plate subduction is actively taking place along the Explorer segment of the northern Cascadia subduction zone and probably also its Winona fragment, and therefore their seismogenic and tsunamigenic potential should be investigated. (2) It needs to be investigated whether the shallowest portion of the Cascadia megathrust can undergo highly tsunamigenic trench-breaching rupture in great earthquakes like in the 2011 Tohoku-Oki earthquake at the Japan Trench. (3) For tsunami hazard assessment and early warning in southwestern British Columbia, high-resolution megathrust rupture models need to be systematically developed. To address the first issue, I develop finite element models for the Explorer segment to estimate thermally allowed potential seismic rupture zone of the megathrust. The results suggest a potential rupture zone of ~60 km downdip width located offshore. For the Winona fragment, a preliminary estimate by considering only the thermal effect of sedimentation on a cooling lithosphere suggests a potential rupture zone of a minimum downdip width of 35 km. I address the second issue by reanalyzing seismic survey images off Vancouver Island with a focus on secondary faults around the accretionary wedge deformation front. No strong evidence suggests trench-breaching megathrust rupture being a dominant mode of fault behaviour at northern Cascadia, although the possibility cannot be excluded from tsunami hazard assessment. Buried rupture and coseismic activation of secondary faults may be more important at Cascadia. To address the third issue and also to investigate how the different secondary faults can contribute to tsunami generation, I compile a new Cascadia megathrust geometry and develop 21 tsunami sources using a three-dimensional (3D) dislocation model, including hypothetical models of frontal thrust, back-thrust, and splay fault. The dislocation models indicate that the buried rupture, splay-faulting rupture, and trench-breaching rupture can result in large seafloor uplift and coastal subsidence, and hence will lead to tsunamis that seriously affect the local coastal area. Back-thrust rupture near the deformation front is unimportant for tsunami generation. The model results also show that properly configured land-based Global Navigational Satellite System (GNSS) monitoring can distinguish between ruptures along the Cascadia megathrust and along the strike-slip Nootka fault and between megathrust ruptures of difference strike lengths and therefore can effectively contribute to real-time tsunami early warning. However, the results also reveal that these land-based measurements are not sensitive to the slip behaviour of the shallow portion of the megathrust farther offshore, demonstrating urgent need for near-trench, seafloor observations.