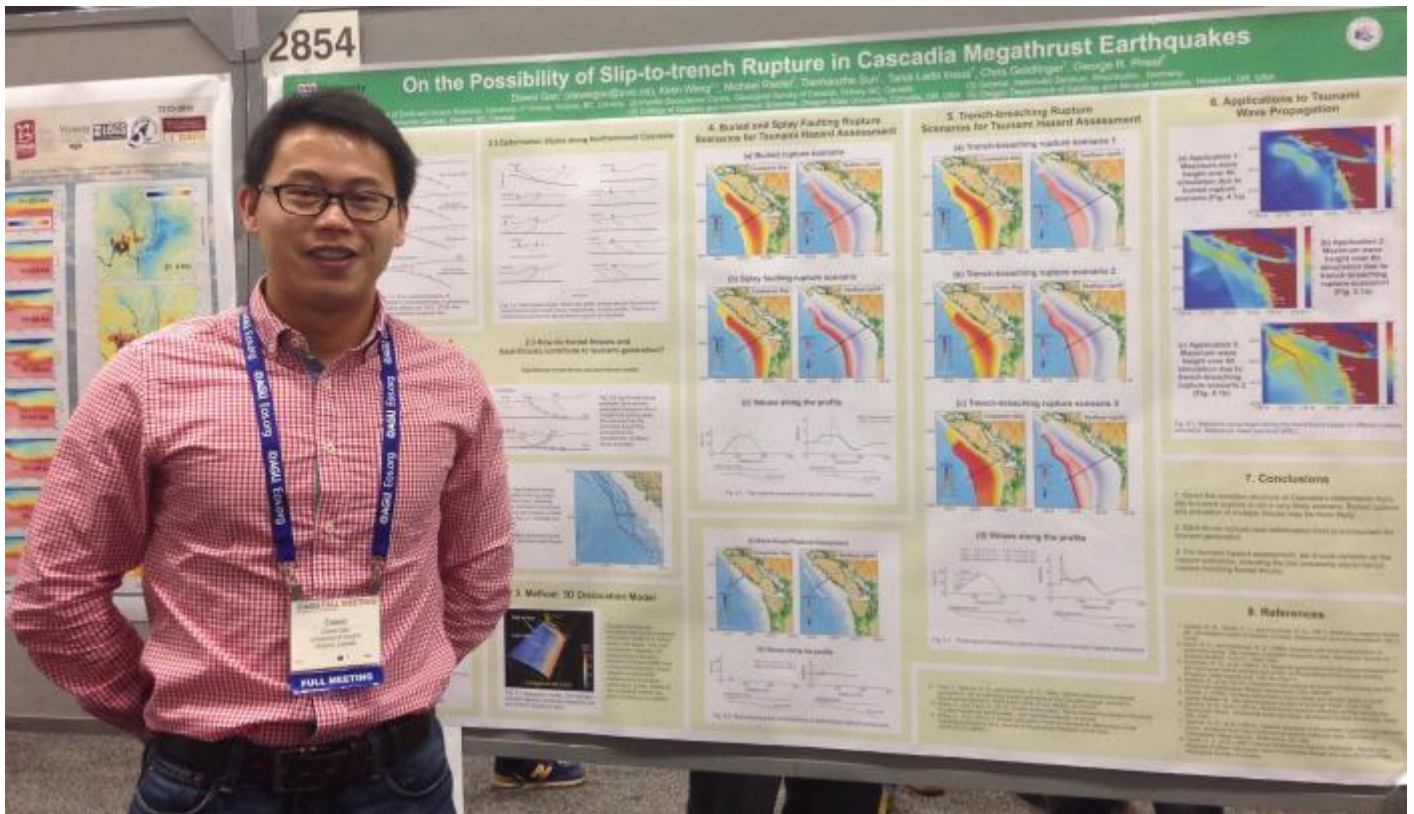


Award-winning study compares the Cascadia subduction zone to offshore Japan

Submitted by Virginia Keast Sun, 2016-02-28 10:34

In January 2016, University of Victoria Master's student, Dawei Gao, won an Outstanding Student Poster Award at the 2015 American Geophysical Union Fall meeting. His co-authored paper on earthquake dynamics explores the question: What would happen if the Cascadia subduction fault (off the west coast of Canada) ruptured, or broke, in the same way as the 2011 Tohoku earthquake?



Dawei Gao stands ready to answer questions beside his award-winning student poster at the

2015 Fall Meeting of the American Geophysical Union.

Dawei developed profiles of the Cascadia subduction zone and compared them with those offshore Japan. His award-winning paper demonstrates various rupture scenarios along the Cascadia fault, and uses this knowledge to demonstrate tsunami wave propagation.

Given the complex structure at the leading edge or trench of Cascadia's fault line, Dawei shows that the slip-to-trench rupture that occurred in Japan is not very likely to happen on North America's west coast. "But for tsunami hazard assessment, we should still consider all of the scenarios, including the slip-to-trench rupture," says Dawei.

"The incoming tectonic plate at Cascadia is blanketed by approximately three kilometres of sediment near the deformation front. This is in sharp contrast to the sediment-starved Japan trench where one continuous fault extends all the way to the trench, a configuration that facilitates slip-to-trench rupture."

Dawei's work is a vital piece in the development of a comprehensive earthquake and tsunami early warning and response system for the west coast. With funding from Emergency Management BC (March 2015), Ocean Network Canada's tsunami project is using 75 of Dawei's simulated tsunami models to help produce earthquake-generated tsunami inundation maps, showing the amount of flooding expected at different areas along the coast.

That information will help people living along the coast respond quickly to future megathrust earthquakes and the tsunamis that follow.

On the Possibility of Slip-to-trench Rupture in Cascadia Megathrust Earthquakes

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1. Introduction

Tsunamis may be generated by subduction zone earthquakes in four ways, as summarized in Fig. 1.1.

Cascadia megathrust rupture models previously developed for tsunami hazard assessment include scenarios (a) and (b). The 2011 Mw 9.0 Tohoku-Oki earthquake raised a new question: Can the shallow portion of the Cascadia megathrust also slip to trench or great earthquakes as in the Tohoku-Oki earthquake (c) or would it normally resist extensional rupture but creep asymmetrically afterwards as in the 2010 Mw 8.7 Chile earthquake (d)? To answer this question, we re-analyzed seismic images from modern multichannel seismic surveys conducted in 1985 and 1989 with a new focus on the accretionary wedge deformation front.

2. Structures near Deformation Front

Fig. 2.1 The 1985 (black lines) and 1989 (red lines) seismic profiles along the deformation front. The 1985 profile shows a dominant thrust fault (red line) and a back-thrust fault (black line). The 1989 profile shows a dominant thrust fault (red line) and a back-thrust fault (black line).

2.1 Comparison with Japan

Fig. 2.2 Seismic image crossing the Japan trench. See the sketch in Fig. 1.1c.

2.2 Deformation Styles along Northernmost Cascadia

Fig. 2.4 Deformation styles. Black and green arrows indicate the dominant thrust fault and back-thrust, respectively, in each profile. There is no convincing evidence for slip-to-trench rupture at Cascadia.

2.3 How do frontal thrusts and back-thrusts contribute to tsunami generation?

Hypothetical frontal thrust and back-thrust models

Fig. 2.5 (a) Frontal thrust example. Blue arrows indicate extensional slip in megathrust earthquakes. The dominant thrust F2a connects to the back-thrust F2b. (b) Back-thrust example.

Fig. 2.6 Hypothetical frontal thrust rupture (red line) and back-thrust rupture (black line) obtained using the dominant thrust-back-thrust model. The rupture from each seismic profile shown in Fig. 2.4. Change the slip fault.

Red triangles: dominant thrust. Red circles: dominant back-thrust.

3. Method: 3D Dislocation Model

Fig. 3.1 Example of seismic profiles at Cascadia.

Tsunami records are simulated with a 3D numerical dislocation model in a uniform medium. The code numerically integrates the point-source dislocation over a three-dimensionally curved megathrust and strike displacement of surface observation points. Details of the modeling method are given by Wang et al. (2015).

4. Buried and Splay Faulting Rupture Scenarios for Tsunami Hazard Assessment

(a) Buried rupture scenario

(b) Splay faulting rupture scenario

(c) Values along the profile

Fig. 4.1 Two rupture scenarios for tsunami hazard assessment.

(a) Back-thrust Rupture Component

(b) Values along the profile

Fig. 4.2 Tests showing the decomposition of back-thrust rupture component.

5. Trench-breaching Rupture Scenarios for Tsunami Hazard Assessment

(a) Trench-breaching rupture scenario 1

(b) Trench-breaching rupture scenario 2

(c) Trench-breaching rupture scenario 3

(d) Values along the profile

Fig. 5.1 Three trench-breaching rupture scenarios for tsunami hazard assessment.

6. Applications to Wave Propagation

(a) Application 1: Maximum wave height over 6h simulation due to buried rupture scenario (Fig. 4.1a)

(b) Application 2: Maximum wave height over 6h simulation due to trench-breaching rupture scenario 2 (Fig. 5.1b)

(c) Application 3: Maximum wave height over 6h simulation due to trench-breaching rupture scenario 3 (Fig. 5.1c)

Fig. 6.1 Maximum wave height during the first scenario. Reference: mean sea level (MSL).

7. Conclusions

- Given the complex structure at Cascadia, slip-to-trench rupture is not a very likely and activation of multiple thrusts may occur.
- Back-thrust rupture near deformation front may contribute to tsunami generation.
- For tsunami hazard assessment, we propose two rupture scenarios, including the low probability rupture involving frontal thrusts.

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Dawei Gao, Kelin Wang, Michael Riedel, Tianhaozhe Sun, Tania Lado Insua, Chris Goldfinger, and George R. Priest (2015), On the possibility of slip-to-trench rupture in Cascadia megathrust earthquakes, presented at 2015 AGU Fall meeting, San Francisco, California.

Congratulations Dawei! We'll be following your progress and look forward to working with you in the future.

For more information about research in plate tectonics and earthquake dynamics at Ocean Networks Canada, please contact: [Martin Heeseman](#), staff scientist.

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