Dr. Kelin Wang, Research Scientist
Pacific Geoscience Centre, Geological Survey of Canada
9860 West Saanich Road
Sidney, B.C. V8L 4B2, Canada
Tel: 250-363-6429 Fax: 250-363-6565
email: wang@pgc.nrcan.gc.ca
web site: http://www.pgc.nrcan.gc.ca/

Stress and Strain Regimes of the Pacific Northwest:

A Comparative Study with SW Japan

USGS Award Number: 00-HQ-GR-0061

Kelin Wang, Herb Dragert, and Roy D. Hyndman

Pacific Geoscience Centre, Geological Survey of Canada

9860 West Saanich Road, Sidney, B.C. V8L 4B2

Tel:1-250-363-6429

fax: 1-250-363-6565

email: wang@pgc.nrcan.gc.ca

http://www.pgc.nrcan.gc.ca

Element Designation: I and II

Key Words: Fault stress interactions, GPS-continous, Tectonophysics, Regional modeling

Investigations Undertaken

(1) Geodetic data collection and strain analyses in the Pacific Northwest and SW Japan. (2) Forearc stress analyses in the Pacific Northwest and SW Japan. (3) 3-D viscoelastic finite element interseismic deformation modeling for Cascadia.

Results

1. In the past year, we installed two continuous GPS monitoring stations in British Columbia as part of the PANGA network and completed processing the campaign GPS data from the Port Alberni network on Vancouver Island. GPS velocities and the resultant strain rates are consistent with a locked Cascadia subduction fault, confirming and refining findings made in previous years. Strain analysis in SW Japan was also carried out, using GPS velocities obtained from the Geographic Survey Institute (GSI) of Japan. We have successfully completed the transition to the Bernese software package and significantly improved the accuracy of the GPS data processing. The new processing procedure, being identical to what is employed in the GSI in Japan, greatly facilitates the comparative study with SW Japan.

2. A stress gradient is present across the Nankai and Cascadia forearcs. In the frontal part of the accretionary prism, the stress field is dominated by margin-normal compression as evidenced by the thrust and fold structure. Further landward, the margin-normal stress is similar to or less than the vertical stress as evidenced by the focal mechanisms of crustal earthquakes. The margin-normal stress is controlled mainly by the total shear force along the subduction fault (or the plate coupling force) and the gravitational force. Plate coupling creates compression, and gravity induces lateral tension (all relative to the lithostatic state). We modified our previous finite element model of two converging plates in frictional contact to allow plastic failure of the prism. The model reproduced the observed stress gradient, including the plastic failure in the accretionay prisms. The results show that a very weak subduction fault is required.

3. We have developed a 3-D viscoelastic finite element model for Cascadia (Fig.1). The model incorporated a local mantle viscosity value of 10^{19} Pa s recently determined from a northern Cascadia postglacial rebound analysis conducted at PGC [James et al., 2000]. The model demonstrated a strong time dependance of interseismic deformation, and the model deformation 300 years after a great earthquake agrees with GPS observations[Fig.2].

Non-technical Summary

This project is directed at quantitatively explaining the observed crustal deformation and stresses in the Pacific Northwest. Understanding the mechanism of the stress and strain regimes leads to understanding the causes and consequences of both megathrust and crustal earthquakes. The stress and strain regimes in SW Japan, as well as its tectonic setting, are very similar to those in Pacific Northwest, and a comparative study will help us understand the common processes. Much progress has been made in gathering and analyzing GPS data, modelling forearc stresses, and developing a 3-D viscoelastic fintie element model for earthquake related crustal deformation.

Reports Published

Dragert, H., T. S. James, A. Lambert, Ocean loading corrections for continuous GPS: A case study at the Canadian coastal site Holberg, *Geophys. Res. Lett., 27*, 2045-2048, 2000.

James, T. S., J. J. Clague, K. Wang, and I. I. Hutchinson, Postglacial rebound at the northern Cascadia subduction zone, *Quarternary Sci. Rev., 19*, 1527-1541, 2000.

Oleskevich, D.A., R.D. Hyndman, and K. Wang, The updip and downdip limits to great subduction zone earthquakes: Thermal and structural models of Cascadia, South Alaska, SW Japan, and Chile, *J. Geophys. Res., 104*, 14,956-14,991, 1999.

Peacock, S. M., and R. D. Hyndman, Hydrous minerals in the mantle wedge and the maximum depth of subduction thrust earthquakes, *Geophys. Res. Lett., 26*, 2517-2520, 1999.

Peacock, S. M., and K. Wang, Seismic consequences of warm versus cool subduction metamorphism: Examples from Southwest and Northeast Japan, *Science, 286*, 937-939, 1999.

Wang, K., Stress-strain "paradox", plate coupling, and forearc seismicity at the Cascadia and Nankai subduction zones, *Tectonophysics, 319*, 321-338, 2000.

Wang, K., and J. He, Mechanics of low-stress forearcs: Nankai and Cascadia, *J. Geophys. Res., 104*, 15,191-15,205, 1999.

Wang, K., and K. Suyehiro, How does plate coupling affect crustal stresses in Northeast and Southwest Japan? *Geophys. Res. Lett., 26*, 2307-2310, 1999.

Wang, K., J. He, H. Dragert, and T. James, Three-dimensional viscoelastic interseismic deformation model for the Cascadia subduction zone, *Earth Planet Space*, in press, 2000.

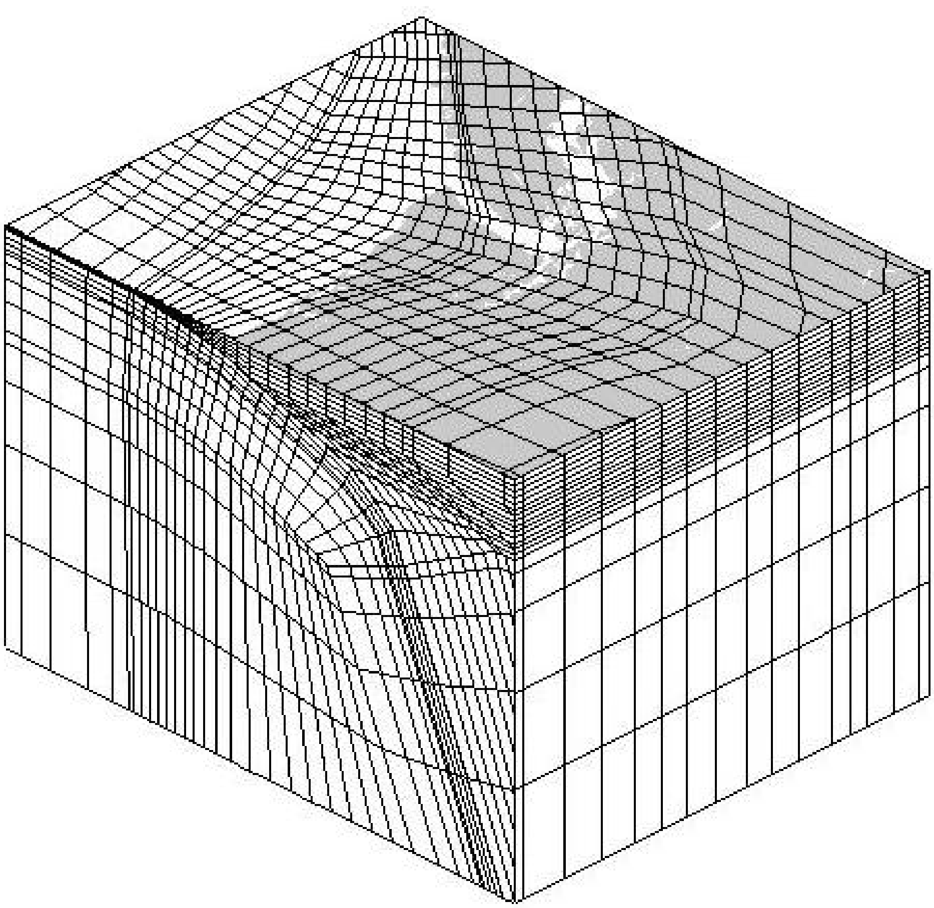

Figure 1. A small portion (around the Pudget Sound) of the finite element mesh used for the Cascadia subduction zone, viewed from southwest.

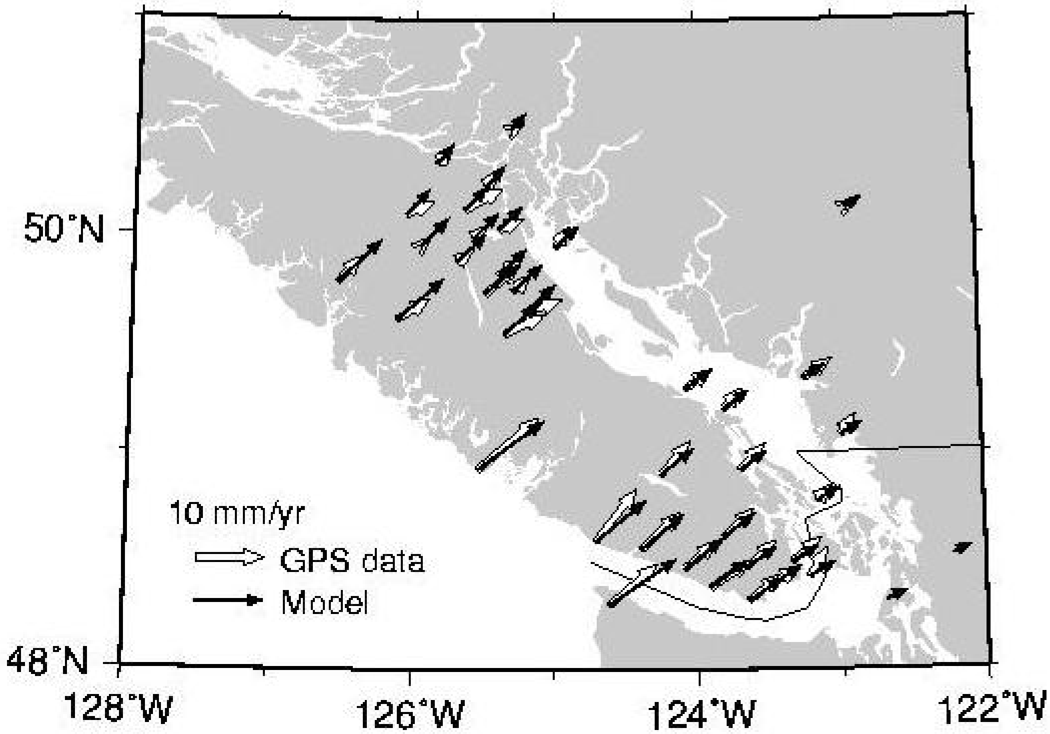

Figure 2. Comparison of velocities predicted by the 3-D viscoelastic finite element model and those measured using the Global Positioning System (GPS) in the region of southern Vancouver Island.