ÉCOLE DOCTORALE SCIENCES DE LA TERRE

Subject offered for a contract starting october 2014

SUBJECT TITTLE: Impact of incoming oceanic plate on subduction zone interplate coupling

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The largest and most destructive earthquakes occur in subduction zones. Water from the dehydrating subducting plates is presumed to have a critical effect on the mechanical behavior of the megathrusts and on the occurrence of intraslab earthquakes. Therefore, major effort and resources have been dedicated in the past few decades to understanding the dehydration processes in subduction zones. At the same time, relatively little effort has been directed toward quantifying the amount of water in oceanic plates entering the subduction systems. This is surprising considering that the likelihood of succeeding in constraining the amount of water in oceanic plates with the desired accuracy is far greater before they cross the trenches because the plates are much shallower and the geometry of geologic structures is much simpler in oceanic basins than in subduction zones. This Ph.D. proposal is focused on the evolution of the Juan de Fuca (JdF) plate from ridge to trench and comparison of interplate interface coupling in subduction zones with presubduction characteristics of this warm and other oceanic plates entering the global subduction system.

At the Cascadia subduction zone, the state of the down-going JdF plate is of particular interest as relatively little hydration of this young oceanic lithosphere (~6-9 Ma at the subduction zone [*Wilson,* 2002]) is expected. With the presumed warm state of the plate, hydration of the oceanic lithosphere may be confined to the crust, limiting the potential volume of water bound chemically into the plate [e.g., *Hyndman and Wang,* 1995]. However, numerous observations support the abundant presence of water within the subduction zone including reduced velocities within the mantle wedge [e.g. *Bostock et al.,* 2002], episodic tremor and slip events possibly linked to fluid overpressures along the megathrust [e.g. *Rogers and Dragert*, 2003], the intermediate-depth intraslab seismicity [*Hacker et al.,* 2003], and reflection banding above the deep megathrust [e.g., *Hyndman*, 1988]. Some of the water entering the Cascadia subduction zone is transported within the sediment section and the porous upper crust, but seismicity located below the oceanic crust [*Preston, et al.,* 2003] suggests the presence of water reaching into at least the shallowest mantle of the down-going plate. To understand the contribution of water to subduction zone processes at Cascadia, direct constraints on the state of hydration of the incoming JdF plate are needed.

To constrain the evolution of the upper crustal layers 2A and 2B with unprecedented detail and accuracy, the Ph.D. candidate will carry out 2D waveform tomography on long-streamer MCS data (e.g., Delescluse et al., 2011) spanning the area from the Endeavour ridge segment to the trench. The data for this ~300 km-long profile were collected on *R/V Ewing* and *R/V Langseth* in 2002 and 2012 using 6- and 8-km-long streamers, respectively. The first 150 km next to the ridge axis are already preprocessed for waveform tomography with starting P-wave velocity models for inversion already constructed (*Nedimović et al.*, 2008; *Newman et al.,* 2011). The produced results will also facilitate testing of the hypothesis that upflow and downflow zones of hydrothermal cells can be directly imaged using controlled source seismics (*Newman et al.,* 2011).

Constraining the evolution of the lower crust and uppermost mantle requires wide-angle OBS data collected on *R/V Langseth* in 2012. First arrival traveltime tomography for long profiles, one along the trench and two from ridge to trench, are currently being constructed. These profiles will determine the changes in velocity of the crust and uppermost mantle as plate evolves and along the trench. However, accurately relating these velocity changes to the extent of crustal alteration and mantle serpentinization is not possible without separating the effect of the crustal and mantle anisotropy. The Ph.D. candidate will achieve this by analyzing MCS and OBS data collected along short profiles perpendicular to the long ones, as well as by analysis of MCS and OBS data collected by semi-circle (fan) shooting. Both datasets were collected on crust prior and posterior to the previously determined onset of bending-related normal faulting [*Nedimović et al.*, 2009].

Global compilations show no clear correlation between plate interface locking at subduction zones and incoming oceanic plate age and convergence speed. However, other factors related to the incoming oceanic plate that may have a significant effect on interplate coupling, such as plate hydration and oceanic plate type (slow/intermediate/fast spread), have not been taken into account. The Ph.D. candidate will produce a global compilation of these two parameters and carry out a comparative analysis between estimated plate coupling and incoming plate age, convergence speed, plate hydration and plate type. Oceanic plate hydration will be estimated, where available, from published controlled source seismic studies. For areas without controlled source seismic constraints, plate hydration will be estimated from the characteristics of the incoming fault fabric (fault distribution, density, orientation and offset) [e.g., *Masson,* 1991], convergence rate and thermal models [e.g. *Delescluse and Chamot-Rooke*, 2008; *Iyer et al.,* 2012], where available. Calibration of the plate hydration estimates between the two approaches will be determined at subduction systems for which we have both seismic and fault fabric, convergence rate and thermal constraints, such as are Cascadia, Alaska and Middle America.

The Ph.D. candidate will work at the ENS Laboratoire de Géologie (M. Delescluse, C. Vigny, N. Chamot-Rooke) and is expected to be willing to travel to Halifax, Canada, carry out a part of his/her Ph.D. research there, and extensively use the Dalhousie Imaging Group (M. Nedimović) computing facilities, the core of which consist of a computer cluster (600 GHz compute power and 400 GB RAM) and data storage system (>100 TB disk space). Both groups have state-of-the-art industrial and academic software for analysis of MCS and OBS data.