SE01: Geophysical studies of structure and tectonics of the Canadian Cordillera

Conveners: Pascal Audet[1], David Eaton[2], Roy Hyndman[3,4], and Andrew Schaeffer[5]

Co-chairs: Pascal Audet[1], David Eaton[2], Roy Hyndman[3,4], and Andrew Schaeffer[5]

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Session Description

The Canadian Cordillera exhibits highly variable past and present tectonic interactions along its western margin with important consequences on the structure, geology and deformation of the crust and uppermost mantle. Despite past (e.g., Lithoprobe) and current (e.g., Earthscope Transportable Array) large-scale efforts to image crust and upper mantle structure in this area, several key scientific questions remain to be addressed. Example questions include: What is the nature of the Cordillera-Craton transition at crustal and upper mantle depth? How is current deformation distributed within the Cordillera? What is the importance of tectonic inheritance in controlling Cordilleran evolution? An opportunity is currently emerging to expand the coverage of geophysical monitoring sensors (seismic, GNSS) and supporting geoscience activities all across the Canadian Cordillera, from the Beaufort Sea to the US borders – the Canadian Cordillera Array (CCArray) initiative. This session aims to bring together Earth scientists who work on deciphering the structure and processes associated with the evolution and current deformation of the Canadian Cordillera, in anticipation of CCArray. We seek contributions from geophysics, seismology, geodynamics, tectonics, structural geology, petrology, geochronology and related fields that yield constraints on the thermal and compositional structure as well as active deformation of the crust and mantle through field observations, laboratory studies and numerical modeling.

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NOTE: THIS DOCUMENT CONTAINS INFORMATION FOR ALL SESSION SUB-SECTIONS. PRESENTER ABSTRACTS ARE FOUND AT THE END OF THE DOCUMENT.

SCHEDULE MAY BE SUBJECT TO CHANGE

ORAL SESSION SE01a

Chairs: Pascal Audet, David Eaton, Roy Hyndman, and Andrew Schaeffer

Room: ESB 2012, Monday, May 29th

TIME	AUTHORS	TITLE
9:00	P. J.A. McCausland	Assembly of the Northern Cordillera: Mesozoic to present terrane motions and their evolving relationship with North America
9:15	A. Graham*, K. Morell, L. Leonard, V. Levson & C. Regalla	Field mapping, LiDAR analysis and shallow geophysical methods define the geometry and kinematics of the Leech River fault
9:30	G. Li*, Y. Liu, C. Regalla & K. Morell	Fault Structure and Seismic behavior revealed by earthquake relocations near the Leech River Fault, southern Vancouver Island
9:45	G. Rogers, R. Meldrum, M. Heesemann & M. Scherwath	Ocean Networks Canada's underwater and coastal geophysical monitoring on the Canadian Cordillera's Pacific edge
10:00	R. Hyndman, D. Chapman & W. Thatcher	Temperatures in the crust and upper mantle of the North American Cordillera
10:15	C.A. Currie, H. Wang & R. D. Hyndman	Lower crustal flow in western North America

ORAL SESSION SE01b

Chairs: Pascal Audet, David Eaton, Roy Hyndman, and Andrew Schaeffer

Room: ESB 2012, Monday May 29th

TIME	AUTHORS	TITLE
14:00	M. Unsworth	Magnetotelluric studies of the Canadian Cordillera
14:15	A. Farahbod & J.F Cassidy	Coda Q Determination Across Western Canada: From a Region of Active Subduction to a Stable Craton
14:30	T. Zaporozan*, A. W. Frederiksen, A. Bryksin & F. Darbyshire	Surface-Wave Images of Western Canada: Lithospheric Variations Across the Cordillera/Craton Boundary
14:45	Y. Chen*, Y. J. Gu, S.-H. Hung, C. Currie, A. Schaeffer & P. Audet	Along-strike Variations in the Cordillera-Craton Boundary in Southwestern Canada
15:00	A. Schaeffer, P. Audet, D. Mallyon, C. Currie & J. Gu	Transient tectonic transition from Canadian Cordillera to stable shield?

15:15	L. DiCaprio & D. W. Eaton	Implications of an abrupt craton edge: Conditions for extrusion of the cratonic lithosphere

POSTER SESSION SE01

Chairs: Chairs: Pascal Audet, David Eaton, Roy Hyndman, and Andrew Schaeffer

Room: ESB Atrium, Monday May 29th

Poster No.	AUTHORS	TITLE
P01-SE01	P. Audet, A. Schaeffer, M. McLellan, A. Tarayoun & C. Sole	Structure and deformation of the northern Canadian Cordillera: A broadband seismic reconnaissance study
P02-SE01	C. Esteve, A. Schaeffer, P. Audet, Louisa Murray-Berquist, S. Cairns, B. Elliott, H. Falck & D. Snyder	A preliminary teleseismic investigation of the crust and mantle lithosphere obtained from BISN in the western Canadian Arctic

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SUBMITTED ABSTRACTS

SE01-01: Assembly of the Northern Cordillera: Mesozoic to present terrane motions and their evolving relationship with North America

Phil J.A. McCausland[1,2]

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Abstract
Over the past five decades, researchers have debated the scope and amount of the mobility of crustal fragments, or terranes, along the western margin of North America from the Mesozoic-Cenozoic to the present. In the present, there is clear evidence for the relative motion of substantial Cordilleran and Alaskan crustal blocks with respect to North America, but what is the scale and timing of such motions in the past? An understanding of these past motions will likely help in interpreting the major players and processes involved in the present-day neotectonics. An overview of paleomagnetic results including recent work from terranes, geological constraints from the Cordillera and the adjacent West Canada Sedimentary Basin (WCSB) as well as recent advances in relative North America and oceanic plate motion studies leads to a new synthesis of the Mesozoic to present terrane relations with North America. Broadly speaking, the major “inboard” Stikine and Yukon-Tanana terranes, making up much of the accreted crustal volume of the Cordillera, appear to have travelled together from at least the Early Jurassic onwards in concert with oceanic plates and probably became dominantly coupled with the North American plate during the Early to mid-Cretaceous, emplaced on the margin at <1000 km south of their present Cordilleran position. Their relative along-margin Cretaceous motions also may have been recorded distally by WCSB loading evolution. Outstanding questions remain for the changes in vertical lithospheric structure of the Northern Cordillera during this period, its thermal evolution, how the relative motions of terranes with respect to North America were accommodated and for the Mesozoic to present evolution of the “outboard” terranes of the Cordillera.

Presentation type: Oral

SE01-02: Field mapping, LiDAR analysis and shallow geophysical methods define the geometry and kinematics of the Leech River fault

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Abstract
We use LiDAR imagery, shallow geophysical methods, and structural/geomorphic mapping to constrain the geometry and kinematics of the Leech River fault, an active crustal structure in the northern Cascadia outer forearc on southern Vancouver Island, British Columbia. Field mapping along a 20 km section of the fault reveals a 100 - 500 m wide zone comprising multiple sub-vertical brittle faults cutting through units on either side of the main regional lithologic contact. Electrical resistivity and GPR surveys across scarps identified in LiDAR imagery likewise reveal steeply dipping structures that appear to deform late Quaternary units to within 2 m of the surface locally. A maximum age of the most recent faulting of 6430 ± 20 14C yr B.P. is constrained by a radiocarbon date from a deformed fluvial terrace. Holocene activity on the Leech River fault indicates that major active crustal faults of the Cascadia forearc extend further north than has been previously recognized, and suggests that the Leech River fault is likely an extension of the active fault network defined in western Washington. The complex geometry of the fault zone and sub-vertical orientation of individual strands are suggestive of a strike-slip fault within a transpressive regime. Further analyses of measurements of fault plane orientations and slip sense indicators will determine whether the sense of slip on the Leech River fault is dextral or sinistral. Determining the kinematics of this prominent forearc structure is a key component in elucidating the nature of forearc deformation in northern Cascadia in response to both the ongoing bending of the Olympic orocline and the overall dynamics of the Cascadia subduction zone.

Presentation type: Oral

SE01-03: Fault Structure and Seismic behavior revealed by earthquake relocations near the Leech River Fault, southern Vancouver Island

Ge Li[1*], Yajing Liu[1], Christine Regalla[2] and Kristin Morell[3]

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Abstract
We present results of microseismic relocations that delineate potentially seismogenic structures along the Leech River Fault (LRF), which has been the focus of many recent investigations, given its proximity to Victoria, the capital of British Columbia. We investigate the seismic evidence of subsurface structures near the LRF by relocating 1528 earthquakes reported by the Canadian National Seismograph Network (CNSN) catalog from 1985 to 2015 using the HypoDD [Waldhauser, F., 2001] method. This relocation procedure reveals two general northeast dipping structures representing the subsurface fractured deformation zone beneath the LRF at depth > 15km and the San Juan Islands area, respectively The subsurface structure underlying the LRF extends about 30 km along the LRF strike and has a dip of about 60°. We construct 10 clusters by linking closely spaced (<5km separation) and highly similar (cross correlation coefficient > 0.8 at >=4 stations) events. Each of these clusters reveals left lateral strike slip faulting, suggesting the LRF could be a left lateral slip fault. Relocation results also show a marked difference in seismicity between the western and eastern segments of the LRF. The 30km long eastern segment, between Leechtown and Colwood, is seismically active while the western segment, between Leechtown and Sombrio, lacks seismicity during the period of analysis (30 years). This variation in seismic behavior might reflect variations in the regional stress field [Balfour et al., 2011] or time window of investigation. The orientation of the maximum horizontal compressive stress near the LRF is rotated ~10-30° clockwise from the strike of eastern segment, which would promote left lateral slip, but is nearly orthogonal to the strike of the western segment, which would inhibit slip. Our results suggest that the LRF east and west segments may behave differently on a decadal time scale.

Presentation type: Oral

SE01-04: Ocean Networks Canada's underwater and coastal geophysical monitoring on the Canadian Cordillera's Pacific edge

Garry Rogers[1,2], Robert Meldrum[2], Martin Heesemann[3] and Martin Scherwath[3]
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Abstract
Ocean Networks Canada (ONC) is a not-for-profit society created in 2007 by the University of Victoria. ONC operates ocean and near shore observatories for the advancement of science and benefit of Canada. The observatories collect data on physical, chemical, biological, and geophysical aspects of the ocean over long time periods, supporting research on Earth processes in ways not previously possible. The 800 km offshore NEPTUNE observatory and the nearly 50 km VENUS coastal observatory - which are the main ONC observatories - stream live data from instruments at key sites off the coast of British Columbia via the Internet to scientists, policy-makers, educators and the public around the world. All ONC data are open access. The NEPTUNE seismograph network has both a regional focus, with four widely spaced broadband seismographs and their ancillary instruments, and a spreading ridge focus with closely spaced short period seismographs on the Juan de Fuca ridge. The NEPTUNE seismograph network has acted as an anchor for the SeaJade project: Japan-Canada dense deployments of autonomous ocean bottom seismographs. The NEPTUNE tsunami network consists of pressure gauges in the deep ocean and on the continental slope. These networks continue to evolve and have not yet achieved all the original deployment objectives. More recently ONC has been investigating the challenges of enhancing near field tsunami warning and ONC has been funded by the Province of British Columbia to deliver an earthquake early warning (EEW) system that integrates offshore and land-based sensors to provide alerts of incoming ground shaking from Cascadia Subduction Zone megaquakes. Installations of new offshore and onshore instruments are underway to fulfil this mandate.

Presentation type: Oral

SE01-05: Temperatures in the crust and upper mantle of the North American Cordillera

Roy Hyndman[1], David Chapman[2], Wayne Thatcher[3]
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Abstract
Temperature in the deep crust and upper mantle influences many properties and geological processes, including lithosphere strength, susceptibility to deformation and earthquakes, volcanism and plutonism, metamorphism and regional geothermal energy potential. Deep temperatures have most commonly been estimated from borehole and other heat flow data combined with upper crust radioactive heat generation, but with considerable uncertainties. There are, however other constraints not yet commonly used: (1) Temperature dependence of upper mantle seismic velocities; (2) Temperature-pressure (depth) from upper mantle xenoliths; (3) Thermal control of elevation, allowing for crustal thickness and density; (4) Lithosphere thickness, taking the base of the lithosphere to be thermally controlled; and (5) The temperature dependent effective elastic thickness, Te. Semi-quantitative estimates also come from the maximum depth of seismicity and depth to the magnetic Curie temperature. Temperature estimates with these additional constraints are generally in good agreement but there is the potential for improvements in accuracy with future work. Lateral temperature variations are evident in the Cordillera, but most are small compared to the large contrast with stable areas. Except for the current and recent forearcs and the foreland thrust belt, the North American Cordillera is surprisingly uniformly hot from Mexico to Alaska, in common with most other global backarcs. Moho temperatures are 800-850C, in contrast to 400-500C in the adjacent craton. Some consequences of the high temperatures are: (1) the lithosphere is thin, 60-70 km, compared to about 200 km for the craton; (2) the Cordillera is a very weak mobile belt susceptible to deformation from plate boundary forces; (3) most continental earthquakes occur in the Cordillera; (4) temperatures are sufficiently high for lower crust regional detachment and channel flow; (5) Cordillera deep temperatures are comparable to the conditions for regional high grade Barrovian metamorphism; and (5) most geothermal energy potential is in the Cordillera.

Presentation type: Oral

SE01-06: Lower crustal flow in western North America

Claire A. Currie[1], Huilin Wang[2] and Roy D. Hyndman[3,4]

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Abstract
There is now strong evidence for lower crust channel flow in most of the North America Cordillera. Notably, seismic studies show the crustal thickness is remarkably uniform, 33±3 km depth from Mexico to Alaska in spite of a complex history of extensional faulting, shortening deformation, and terrane accretion. The flat Moho is evident over distances of 10's of km from multichannel seismic reflection and 100's of km from seismic refraction, tomography, and receiver functions. The constant crustal thickness and flat Moho are argued to be a result of lower crustal channel flow. In this study, we examine the conditions required for flattening the Moho. The Moho marks the boundary between low density crust and higher density underlying mantle. Perturbations to this boundary will undergo gravitational relaxation, with a timescale depending primarily on the viscosity of the crust and mantle at the boundary. Our theoretical analysis and numerical models show relaxation to a subhorizontal Moho in less than 20 Ma for lower crustal viscosities less than $5*10^{19}$ Pa s. A strong mantle lithosphere increases the time by a factor of 2 or more, if its viscosity is greater than 10^{22} Pa and/or its thickness is greater than 25 km. The North America Cordillera is characterized by high surface heat flow, low mantle seismic velocity, high surface elevation, low elastic thickness, and an electrically conductive mantle. These observations indicate a Moho temperature of 800-850°C. Based on laboratory data, these temperatures imply viscosities of $\sim 10^{19}$ Pa s in the lower ~10 km of the crust and a weak, thin mantle lithosphere. We conclude that the observed flat Moho is the consequence of ductile flow of the hot lower crust. In contrast, a more rugged Moho topography can be maintained in areas of cooler, thicker lithosphere.

Presentation type: Oral

SE01-07: Magnetotelluric studies of the Canadian Cordillera

Martyn Unsworth[1]

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Abstract

Magnetotellurics is a geophysical imaging technique which uses natural radio waves to image the electrical resistivity of the Earth. This is a parameter which is sensitive to the presence of aqueous fluids and partial melt. In addition to commercial exploration, magnetotellurics (MT) can also be used in tectonic studies to complement seismic imaging. In this presentation I will review prior MT studies in the Canadian Cordillera and discuss what could be learned from future studies. Some of the first applications of MT to study tectonics took place in the Canadian Cordillera in the 1970s and 1980s, revealing details of the subducting Juan de Fuca plate and defining the presence of a shallow asthenosphere. More detailed studies took place during the Lithoprobe project when the crustal structure of both the Southern and Northern Cordillera was investigated with MT. These studies have recently been extended to mantle depths with long-period MT data collected by the University of Alberta on (a) two transects extending from the Pacific Ocean to the Alberta basin and (b) a grid that covers most of Alberta and which is being extended across Southern British Columbia. These new data sets have generated resistivity models which have (a) defined the pathways of fluids transported by the subducting plate and released into the overlying crust and mantle wedge (b) provided quantitative constraints on the composition and rheology of the upper mantle beneath the Southern Cordillera and (c) defined the geometry of the Cordillera-craton transition. In addition to these regional studies, local MT surveys have been applied to a range of mineral, hydrocarbon and geothermal exploration projects. Continued MT exploration, with a focus on a fully 3-D approach, integrated with other geophysical techniques, have the potential to reveal new aspects of the structure and dynamics of this plate boundary.

Presentation type: Oral

SE01-08: Coda Q Determination Across Western Canada: From a Region of Active Subduction to a Stable Craton

Amir Farahbod[1] and John F. Cassidy[2]

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Abstract
In this study we investigate the spatial variation in coda-wave attenuation (QC) across western Canada, covering a wide range of tectonic settings – from a seismically active subduction zone in the west, through a volcanic belt, to the stable craton of North America – a region of slow lithospheric deformation in the east. Our dataset is made up of more than 2500 earthquakes recorded at 85 Canadian seismic stations across the region. We employ the single back scattering approximation with a range of ellipse parameter (a2) from 20 km to 100 km. We find a very clear attenuation pattern across the study area. The lowest Q0 (Q at 1 HZ) values (e.g., Q0 of 39, a2=33 km) are in the vicinity of Nazko Cone in the Anahim volcanic Belt (AVB), the highest Q0 values (e.g., Q0 of 165, a2=90 km) are on the stable craton, and intermediate values of Q0 are determined across the Cascadia subduction zone. Our results showing low Q0 throughout the AVB provides additional support for an interpretation of magma injection into the lower crust during the 2007 Nazko earthquake swarm, fracturing of the crust, and resulting high seismic attenuation. Also, low Q0 estimates in the Horn River basin and Montney Basin can be partially attributed to Hydraulic fracture related seismicity. Within the subduction zone, Q0 is lowest closest to the active faults off the coast and in the vicinity of the only known large crustal earthquakes (1918, M~7 and 1946, M~7.3) on Vancouver Island, and Q0 increases moving inland. The highest Q0 values we determine are in the regions of slow lithospheric deformation.

Presentation type: Oral

SE01-09: Surface-Wave Images of Western Canada: Lithospheric Variations Across the Cordillera/Craton Boundary

Taras Zaporozan[1], Andrew W. Frederiksen[1], Alexei Bryksin[1], and Fiona Darbyshire[2]

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Abstract
The transition between Cordilleran and cratonic lithosphere in western Canada corresponds to one of the sharpest velocity transitions visible in tomographic models of the upper mantle. We examine this transition using a data set of 106 two-station Rayleigh-wave dispersion curves measured between stations of the Canadian National Seismograph Network, which were first inverted tomographically to form dispersion maps of western Canada, and then depth-inverted to form cross sections that sample the Cordillera/craton transition as well as adjacent tectonic provinces. Results show a clear distinction between the Cordilleran and cratonic lithospheres. The Cordilleran lithosphere is low in velocity, with values ranging from -2% to -5% relative to IASP91, while the cratonic lithosphere shows a high-velocity perturbation with values ranging from 3% to 9%. The boundary is present down to at least 200 km depth and dips NE under the cratonic lithosphere. A higher-velocity anomaly within the cratonic lithosphere is present under Great Slave Lake and is interpreted as preserved Precambrian slab material. Many small high-velocity perturbations, reaching about 4%, are present at depths of 300+ km throughout the survey, possibly related to remnants of the Kula or Farallon plates.

Presentation type: Oral

SE01-10: Along-strike Variations in the Cordillera-Craton Boundary in Southwestern Canada

Yunfeng Chen[1], *, Yu Jeffrey Gu[1], Shu-Huei Hung[2], Claire Currie[1], Andrew Schaeffer[3] and Pascal Audet[3]

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Abstract
The boundary between stable North American craton and tectonically active Cordillera extends over a distance of more than 5000 km from Gulf of Alaska to northern Mexico. In southwestern Canada, this boundary zone marks a major change in tectonic affinity, from the Mesozoic Canadian Cordillera to the adjacent Precambrian basement of the Western Canada Sedimentary Basin (WCSB) along the Cordilleran Deformation Front. In the subsurface, the contrast in lithospheric architecture across this boundary has been recognized by the observed variations in numerous geophysical properties, most notably temperature, electrical conductivity and seismic velocities. In this study, we utilize the most up-to-date seismic station coverage available for the WCSB to produce a high-resolution 3-D velocity model across this region. The P- and S-wave structures from finite-frequency travel-time tomography offer new seismological constraints on the velocity and morphology (i.e., location and geometry) of the mantle lithosphere at the Cordillera-Craton boundary zone. Our mantle image reveals a P (S) velocity increase of 4% (6%) toward the craton at depths of 100-200 km, with an average gradient of ~1.8% over a distance of 100 km beneath the southern WCSB. The steepest velocity contrast occurs ~200 km west of the Cordilleran Deformation Front, which is in excellent agreement with the craton margin location inferred from surface heat flow and crustal thickness estimates. The morphology of the craton margin is highly complex, showing significant along-strike variations in velocity, dip and lithospheric thickness. These distinctive structures may reflect secular tectonic modifications, potentially involving episodic lithospheric shortening, extension, underthrusting and persistent convective erosion of the Precambrian cratonic mantle.

Presentation type: Oral

SE01-11: Transient tectonic transition from Canadian Cordillera to stable shield?

Andrew Schaeffer[1], Pascal Audet[1], Deirdre Mallyon[2]; Claire Currie[2]; Jeff Gu[2]

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Abstract
Geologically recent activity within North America has been largely confined to its western margin—the Cordillera. Unlike a typical plate boundary fault, the Cordillera is characterized by a broad zone of distributed deformation as much as 800 km in lateral extent, and is observed to have elevated heat flow, high topography, and a thin and weak lithosphere. Juxtaposed immediately to the east and thought to act as a rigid backstop to deformation, is the strong and thick Canadian Shield. Both the location and nature of the Cordillera-Craton transition have been a subject of much study and debate. Past results suggest that the Cordilleran Deformation Front may mark the western extent of the cratonic lithosphere, whereas others indicate it extends further west, up to the Tintina Fault-Rocky Mountain Trench system. In the Mackenzie and Richardson Mountains of the northern Canadian Cordillera, this boundary likely becomes more complex and elusive due to the arcuate nature of the predominant tectonic structures. Despite high levels of seismicity across much of the region, detailed study has been limited by insufficient coverage of seismological infrastructure. With an abundance of new high quality seismic data resulting from the deployment of several large scale arrays over the last several years, new studies are now able to achieve improved resolutions across large regions of western Canada and the craton-Cordillera transition. We present a new vertically polarized shear speed model of the lithospheric mantle and crust across western North America, and examine key features associated with the complex crust and lithosphere of dynamics of western North America. These include the location and nature of the Cordillera-Craton transition throughout the Cordillera, and what role the apparent step-change in lithospheric thickness has on the deformation, seismicity, and pattern of crustal fabrics around major faults. We present the results from numerical simulations investigating the longevity and stability of certain craton leading-edge configurations, and compare these with observations from seismic tomography.

Presentation Type: Oral

SE01-12: Implications of an abrupt craton edge: Conditions for extrusion of the cratonic lithosphere

Lydia DiCaprio, David W. Eaton[1]

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Abstract
Mobile belts surrounding cratons are thought to have shielded them from erosion contributing to their longevity, but can lithospheric instabilities within the mobile belt induce cratonic deformation? In the southern Canadian Cordillera, a profound east-west transition from cold, thick lithosphere beneath the North American craton to hot, thin lithosphere in the Cordilleran backarc environment is inferred to be roughly coincident with the physiographically defined Rocky Mountain trench and the reconstructed Laurentian margin. This step-like boundary also juxtaposes domains of contrasting rheologic strength, heatflow and buoyancy. Geodynamic models of this transition have shown vigorous edge driven convection can erode the craton boundary. However, recent work has shown that, in some cases, this lateral boundary can result in the extrusion of cratonic mantle lithosphere towards the mobile belt. Seismic tomographic images seem to support this and shows cratonic mantle lithosphere dipping toward the mobile belt. There is compelling evidence that autochthonous mantle lithosphere beneath the former Proterozoic passive margin underwent some form of convective removal to create the present-day Cordilleran backarc (mobile belt). This process has been geodynamically modeled and tied to heatflow and uplift observations. Any proposed mechanism for mantle lithosphere thinning would reduce the integrated strength of the unstable mantle lithosphere and change its resistance to lateral flow. Here we build on the concept of lateral density contrasts driving flow using visco-plastic thermo-mechanical numerical models to evaluate the implications of the removal of the mobile belt mantle lithosphere on the cratonic keel. We find that when the cratonic keel is buoyant, instabilities in the adjacent lithosphere allow the craton to advance.

Presentation type: Oral

SE01-13: Structure and deformation of the northern Canadian Cordillera: A broadband seismic reconnaissance study

Pascal Audet[1], Andrew Schaeffer[1], Morgan McLellan[1], Alizia Tarayoun[2], Christian Sole[1]

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Abstract
The northern Canadian Cordillera is one of the most seismically active regions in North America, yet lithospheric structure is poorly constrained due to a historical lack of infrastructure. Increased coverage in broadband seismic stations in the past few years now allows detailed models of the crust and mantle. We analyse data from all available broadband stations in northwestern Canada to investigate the structure and anisotropy of the crust and upper mantle using a suite of complementary techniques that are sensitive to scale lengths of ~10 to 1000 km: Rayleigh-wave tomography, receiver functions and shear-wave splitting. Surface-wave velocity models show lower bulk crustal velocities of metasedimentary packages making up the crust in the central Cordillera, with higher crustal velocities on the adjacent Canadian Shield to the east and accreted oceanic terranes to the west of the Tintina Fault. Upper mantle is characterized by low velocities beneath the Cordillera and high velocities beneath the Canadian Shield. The Cordillera-Craton boundary appears to extend into the Cordillera at upper mantle depths. Receiver function data reveal a flat Moho at 32 +/- 4 km, and a sub-Moho layer characterized by 10% anisotropy that may be associated with eclogitized material. Seismic anisotropy data from all three data sets show large lateral and vertical variations in the amplitude and orientation of anisotropy. Upper mantle seismic fast axes are associated with the large shear zones, indicating a clear distinction in lithosphere and sub-lithosphere fabric between ancestral North America and that of allochtonous terranes. Crustal seismic anisotropy results are more ambiguous and may be related with pervasive cracks and/or mica-rich mylonites. Our results support the orogenic float model where thin crust of the Cordillera is supported by elevated mantle temperature, although the relation between crustal structure and stress transfer across the Cordillera remains unresolved.

Presentation Type: Poster

SE01-14: A preliminary teleseismic investigation of the crust and mantle lithosphere obtained from BISN in the western Canadian Arctic

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Abstract
The tectonic evolution of the Beaufort Sea continental margin has contributed to establish this region as a major petroleum reservoir. Recent shallow off-shore data suggest that Banks Island represents the western edge of the rifted margin established during the opening of the Arctic Ocean. In this case, rifting of the western margin caused Banks Island to subside and accumulate sediments rich in petroleum source material. The cooling and further subsidence of these sediments is important for understanding the thermal maturation of petroleum products. Recently published surface-wave velocity models of North America indicate seismic velocity at 100-150 km depths similar to those beneath Canada's diamond mines in the central Slave craton north of Yellowknife. These results suggest that Banks Island is part of the Canadian Shield and any kimberlites found thereon would be promising candidates to contain diamonds. However, the high velocities are inconsistent with this being a tectonically disrupted and thinned lithosphere along the Arctic margin of the Canada Basin. The problem is therefore to reconcile mantle structure typical of the Canadian Shield with crust typical of a rifted passive margin. Furthermore, seismicity located within the Mackenize River Delta and offshore in the Beaufort Sea has been previously observed, however its origin is currently unknown, though may potentially be related to incipient subduction of oceanic lithosphere beneath the North American craton. Resolving these questions requires high-resolution seismic models obtained from an array of broadband seismograph stations. Here we present preliminary results on the structure of the crust and uppermost mantle underlying the western Canadian Arctic. These results are generated using new data from the Banks Island Seismograph Network (BISN), an array of 3 stations installed over the summer of 2014 and 2015; these are augmented with several USArray Transportable Array stations and older POLARIS and CNSN stations on neighbouring Arctic Islands.

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