Seismic Tomography of the Nechako Basin, British Columbia, Using Ambient Seismic Noise

***O.A. Idowu, *A.W. Frederiksen, and +J. Cassidy**

*Department of Geological Sciences, 125 Dysart road, University of Manitoba, Winnipeg, MB. Canada. R3T 2N2

+Geological Survey of Canada, Pacific Geoscience Centre 9860 West Saanich Road, Sidney, BC V8L 4B2, Canada

BACKGROUND

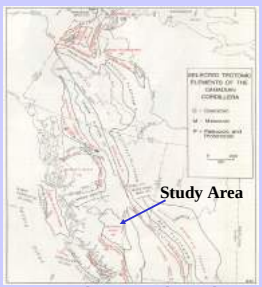
• The Nechako Basin in British Columbia, Canada has been the focus for hydrocarbon and mineral exploration for decades. The Geological Survey of Canada suggested that the basin may contain as much as a trillion cubic meters of gas and a billion cubic meters of oil.

• An extensive blanket of Eocene and Neogene volcanic rock covers the major part of the basin. The volcanic has a strong velocity inversion at its base, making it difficult to use conventional seismic methods for exploring the basin.

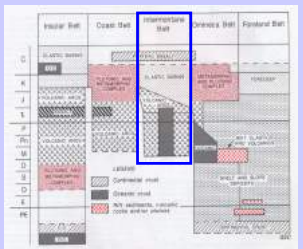
• An alternative approach to studying Nechako basin is a recently discovered ambient seismic noise surface wave tomography. The new passive seismic source method provides good resolution for crustal studies.

STUDY AREA

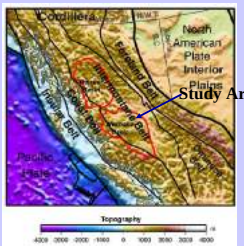
Morphogeological belts and strike slip faults of the Canadian Cordillera (Gabrielse et al, 1991)



Principal Basins, Arches, and Platforms in the Canadian Cordillera (Gabrielse et al, 1991)



Lithology Framework of the study area (Gabrielse et al, 1991)



Topographic setting of the study area (Majorowicz and Osadetz, 2007)

OBJECTIVES

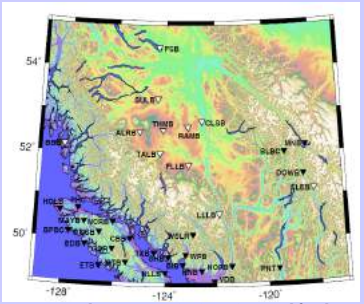
Unravel the structural composition of the Nechako region by developing:

1. 2-D maps to image lateral group velocity variations at different depths

2. 1-D depth models to determine the thicknesses of crust, volcanic, and sedimentary rocks, including the nature of basin fill sedimentary rocks

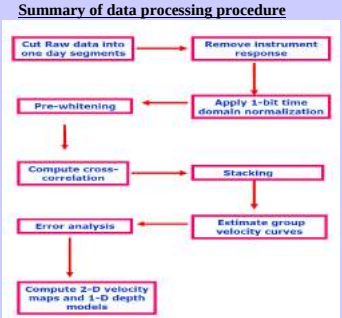
METHODOLOGY

Seismic Stations Map

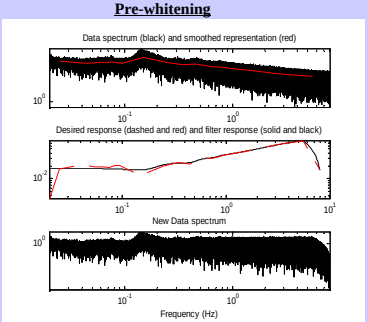


CNSN and POLARIS seismic stations used for the project are represented by white triangles

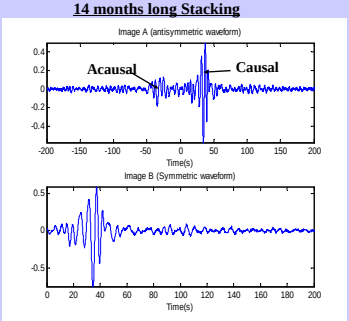
Summary of data processing procedure



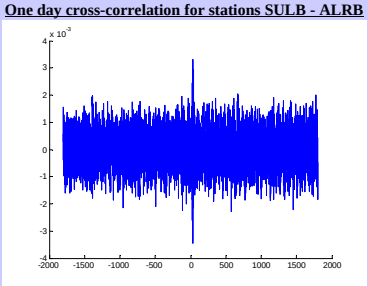
Pre-whitening



14 months long Stacking



One day cross-correlation for stations SULB - ALRB



Low Signal to Noise ratio

•One bit normalization removed high amplitude signals such as earthquake

•Prewhitening increased the bandwidth of the data spectrum

•Cross-correlation was done using two-stations method

•Cross-correlation produced Rayleigh waveform from which the Green's function was approximated

•Stacking the waveforms over 14 months improved the signal to noise ratio

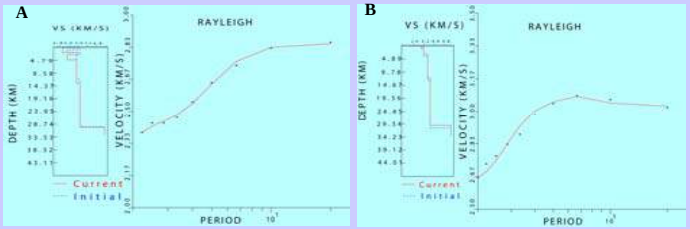
•The symmetric waveform (Image B), was the average of both causal and acausal part of the Rayleigh waveform (Image A)

•The magnitude of causal or acausal part indicates which direction the noise source is maximum

•The symmetric waveform was used as input to estimating group velocity curves

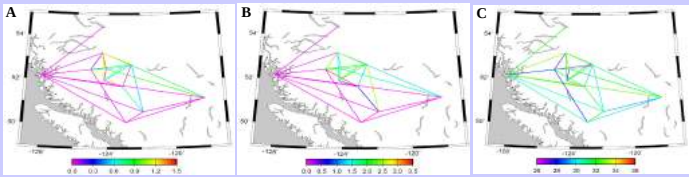
RESULTS AND DISCUSSIONS

1-D thickness Inversion models



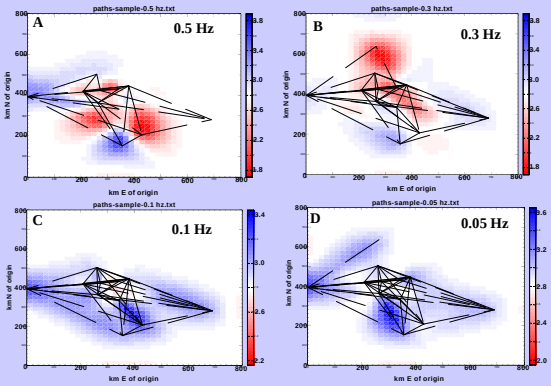
The black dots are the observed group velocities. The red lines are the predicted dispersion from the inversion. The blue dashed lines (Initial) in the thickness model boxes (left side) are the inversion starting models, while the red solid lines (Current) are the final thickness models from the inversion. A – is the average of all the station paths within Nechako basin. B – is the average of all the station paths outside Nechako basin.

Volcanic, sedimentary basin and crust thickness maps



A) The Volcanic thickness map (S-velocity is ~3.7 km/s). B) The LVL/sedimentary thickness map (S-velocity is ~ 2.9 km/s). C) The crust thickness map.

2-D group velocity maps



Maps ABC and D are 2-D velocity images of the Nechako region. The 0.5Hz and 0.3Hz maps represents velocity structures within the upper crust (average group velocity is <3.0km/s), while 0.1Hz and 0.05Hz maps represent velocity structures within the lower crust/upper mantle. At this frequencies, most rocks within the Nechako region have group velocity >3.0km/s, except at the central part of the Nechako basin, where the group velocity is lower (~ 2.8km/s).

CONCLUSIONS

The project is ongoing. There is a trade-off between velocity and thickness during the 1-D thickness inversion. A low S-velocity layer, LVL (~2.8km/s) with an average thickness of ~2km is seen within the basin, and usually below a high reflective layer (~3.7km/s) with an average thickness ~0.6km. The LVL layer is interpreted as the Nechako sedimentary basin, and the high reflective layer as the Tertiary volcanic. The average crustal thickness within the basin is ~30.5km , compared to ~31km outside the basin. Most parts of the Nechako region are covered with sediments or rocks with S-velocity <2.5km/s and average thickness of ~1.5km. The 2-D group velocity maps shows rapid lateral structural variations within the Nechako region. Given the rapid lateral variations observed, more stations will be needed for high resolution images.

ACKNOWLEDGEMENTS

The authors would like to thank the Pacific Geoscience Centre for the seismic data. Authors also gratefully acknowledge NSERC, Geoscience BC and the BC Ministry of Energy, Mines and Petroleum Resources for their financial support. One of the authors (O.A.I) acknowledges gratefully the University of Manitoba for the award of Graduate Fellowship.