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Seismic tectono-stratigraphic analysis of the Whatcom Sub-Basin - SW British Columbia and NW Washington

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Introduction

The Whatcom Sub-basin, located in the southeastern portion of the Georgia Basin – a Cretaceous to Cenozoic forearc basin – extends across southwestern British Columbia (Canada) and northwestern Washington (USA; Fig. 1). It contains 7.5 to 8.0 km of sedimentary strata, including Upper Cretaceous (Lower and Upper Nanaimo Group), Paleogene (Huntingdon Formation), and Neogene (Boundary Bay Formation) strata. The Lower Nanaimo Group (Gp) comprises sandstone and conglomerate deposited in continental and shallow marine settings, while the Upper Nanaimo Gp contains turbidite channel fills encased in marine mudstone (Mustard, 1994; Englert et al., 2019, Girotto et al., 2023). The Huntingdon Formation (Fm) and its USA equivalent, the Chuckanut Fm, disconformably overlie the Nanaimo Gp and are dominated by sandstone, with subordinate conglomerate, mudstone, and coal seams. The Boundary Bay Fm, which disconformably overlies the Huntingdon Fm, comprises interbedded sandstone, mudstone, conglomerate, and coal (England and Bustin, 1998; Mustard and Rouse, 1994).

While the architecture of Nanaimo Gp strata exposed in outcrops on Vancouver Island and the Gulf Islands has largely been resolved (e.g., Coutts et al., 2024; Englert et al., 2019; Girotto et al., 2024; Kent et al., 2020), subsurface strata in the Whatcom Sub-Basin remains poorly defined. This research gap is significant given the potential of strata in the Whatcom Sub-Basin for sequestering CO_2 from industrial sources in the region. Herein, interpretations of 2D seismic lines correlated to well log signatures are used to reconstruct the architecture of the subsurface below much of the Lower Mainland, British Columbia.

Data and Methods

Our database includes 48, 2D seismic reflection lines totaling approximately 850 km, and well logs from 25 wells. These lines and wells are contained mainly in the western and central regions of the Lower Mainland, in the Strait of Georgia and in northwest Washington State (Fig. 1). The 2D seismic data are time-migrated, and seismic-to-well ties are done using check-shot surveys. We interpret major faults and five key seismic horizons across the study area (from top to bottom): top Boundary Bay Fm, top Huntington Fm, top upper Nanaimo Gp, top lower Nanaimo Gp and top basement.

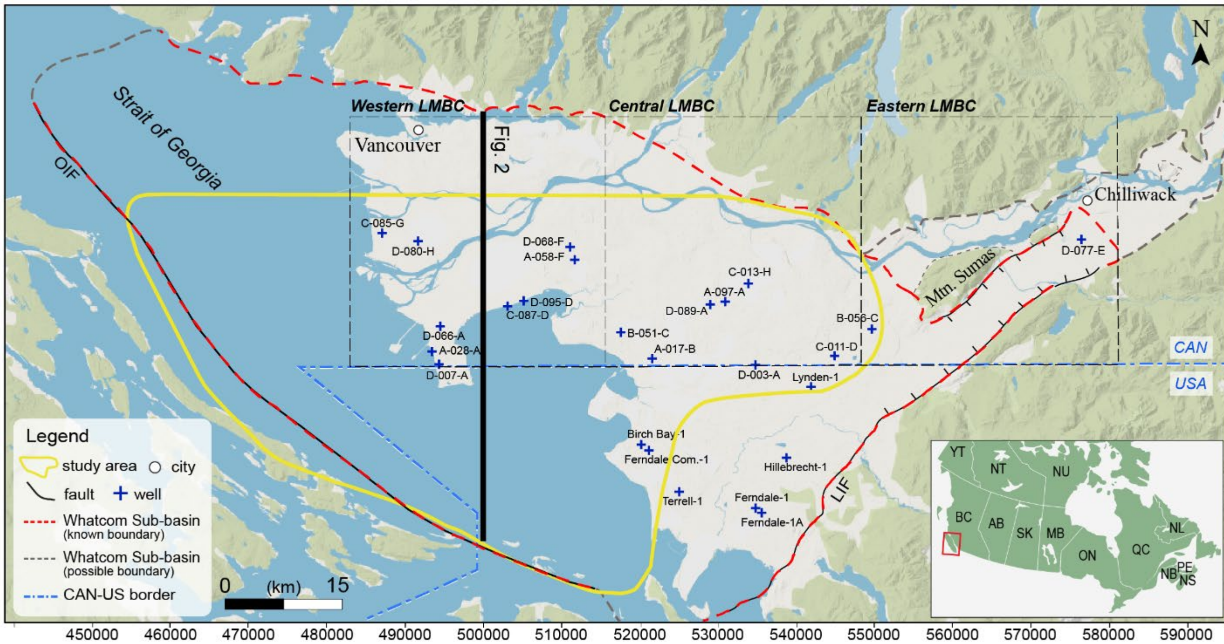

Figure 1. Topographic map of the Whatcom Sub-basin. Fault abbreviations: Outer Island Fault (OIF) and Lummi Island Fault (LIF).

Results and Conclusions

The Whatcom Sub-basin has a wedge-shaped geometry and deepens and thickens to both the south and west where it terminates at the Outer Island Fault (west) or Lummi Island Fault (south) (Figs. 1 and 2). The thickest strata occur east of the Outer Island Fault in the Strait of Georgia, and thicknesses decrease onshore and towards the north and eastern extents of the sub-basin. Basin depocenters are controlled by NE-SW to SE-NW trending basement normal faults with throws up to 2,250 m.

The sedimentary infill of the Whatcom Sub-Basin is divded by four regional disconformities that correlate to the tops of the Boundary Bay Fm, Huntington Fm, upper Nanaimo Gp and lower Nanaimo Gp. The depocenters for the Nanaimo Gp are structurally controlled by northwest-southeast and northeast-southwest trending normal faults. In contrast, the Huntingdon Fm and Boundary Bay Fm are largely undeformed and exhibit more tabular geometries compared to the wedge-shaped geometries of the Nanaimo Gp (Fig. 2). Erosional truncations and angular unconformities within the lower Nanaimo Group, and the Huntingdon and Boundary Bay formations indicate internal depositional hiatuses within these units.

These findings reveal a multi-phase history of basin filling influenced by syn-depositional tectonism, and separated by periods of non-deposition, structural deformation, and erosion. Regarding CO_2 sequestration potential, the Huntingdon Fm, and especially the Boundary Bay Fm, are favorable targets due to their broad areal extent, consistent thickness, and limited faulting, which enhances their storage capacity and containment integrity.

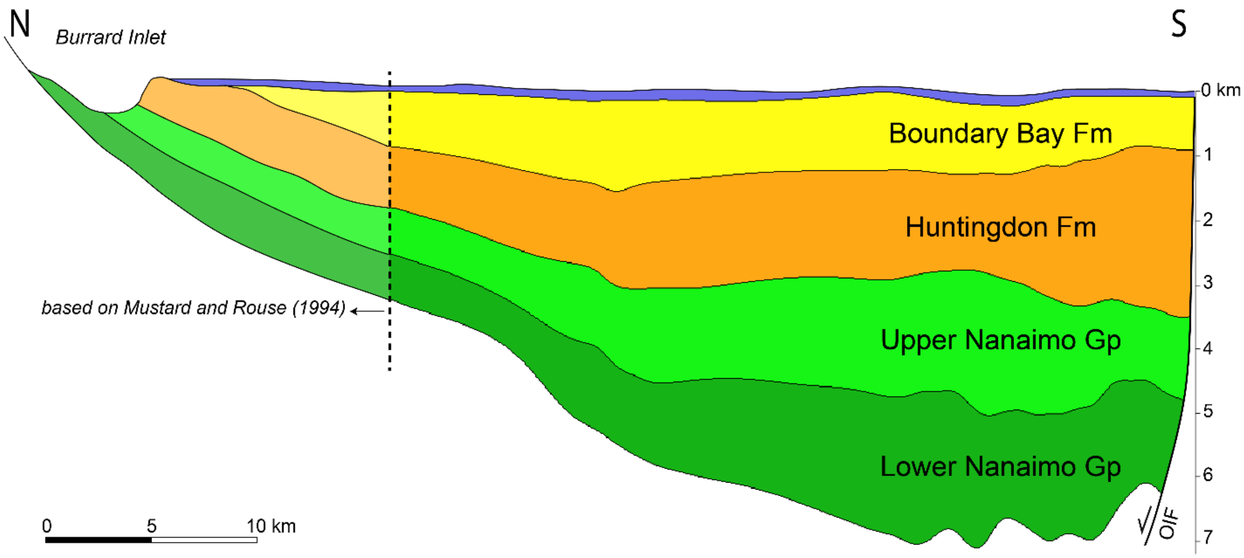

Figure 2. North-south cross section of the Whatcom Sub-basin (see figure 1 for location).

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